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Final

Master Quality Assurance Project Plan

Environmental Restoration Program

Vieques, Puerto Rico

NAVFAC
Naval Facilities Engineering Command

Prepared for

Department of the Navy

Atlantic Division

Naval Facilities Engineering Command

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8 General Data Flow and Evaluation Schematics

Abbreviations and Acronyms

AFWTF	Atlantic Fleet Weapons Training Facility
bls	below land surface
CA	corrective action
CCV	continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CLP	contract laboratory program
CoC	chain of custody
CRQL	Contract required quantitation limit
DMP	Data Management Plan
DO	Dissolved oxygen
DOI	Department of Interior
DQI	Data quality indicator
EIS	Environmental Information System
EM	Electromagnetic induction
EMA	Eastern Maneuver Area
ERA	Ecological Risk Assessment
ERP	Environmental Restoration Program
ft	foot (or feet)
FY	fiscal year
GPR	Ground penetration radar
HHRA	Human Health Risk Assessment
HSP	Health and Safety Plan
IDWMP	Investigation-derived Waste Management Plan
LCS	Laboratory control sample
LRS	low range standard
MDL	Method detection limit
mg/kg	milligrams per kilogram
MPC	Measurement performance criteria
MRP	Munitions Response Program

NASD	Naval Ammunition Support Detachment
NAVFAC, Atlantic	Naval Facilities Engineering Command, Atlantic
Navy	U.S. Navy
NOAA	National Oceanic and Atmospheric Administration
NOSSA	Naval Ordnance Safety and Security Activity
NPL	National Priorities List
NSRR	Naval Station Roosevelt Roads
ORP	oxidation reduction potential
OVM	organic vapor meter
PCBs	polychlorinated biphenyls
PQO	Project quality objective
PR	Puerto Rico
PREQB	Puerto Rico Environmental Quality Board
QAPP	Quality Assurance Project Plan
QL	Quantitation limit
RCRA	Resource Conservation and Recovery Act
RPD	Relative percent difference
SMP	Site Management Plan
SOP	Standard Operating Procedure
SOW	Statement of Work
SVOC	semi-volatile organic compound
TAL	Target analyte list
TLC	Target compound list
TPH	total petroleum hydrocarbon
TPH-DRO	total petroleum hydrocarbon-diesel range organics
TPH-GRO	total petroleum hydrocarbon-gasoline range organics
TPH-ORO	total petroleum hydrocarbon-oil range organics
TSS	Total suspended solids
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plan
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VNTR	Vieques Naval Training Range
VOC	volatile organic compound
µg/L	micrograms per Liter
µg/Kg	micrograms per Kilogram

Introduction

The U. S. Navy (Navy), Naval Facilities Engineering Command (NAVFAC), Atlantic, is conducting an Environmental Restoration Program (ERP) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) at the former U. S. Naval Ammunition Support Detachment (NASD) and the former Vieques Naval Training Range (VNTR) on Vieques Island, Puerto Rico. The CERCLA work is being conducted with the U. S. Environmental Protection Agency (USEPA) Region II as the lead regulatory agency and the Puerto Rico Environmental Quality Board (PREQB) in a regulatory support role. The intent of the ERP is to appropriately assess the nature and extent of contamination associated with any releases of hazardous wastes, solid wastes, and/or hazardous constituents at sites on the former Navy lands, and implement remedies, as appropriate, to control or eliminate unacceptable levels of human and/or ecological risks associated with these releases.

The Navy is submitting this Master Quality Assurance Project Plan (QAPP) to provide a general guideline for the systematic data collection and analysis associated with conducting environmental investigations under CERCLA on Vieques. Site-specific QAPPs will be prepared in conjunction with site-specific work plans. Information shown as "to be determined," "Project Specific," or comparable in this Master QAPP is site- or project-specific and therefore is not applicable to the Master QAPP. This information will be filled in as part of site-specific QAPP preparation.

In accordance with the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP, March 2005), the Master QAPP includes 37 worksheets that detail various aspects of the environmental investigation process along with 8 attachments (Field Standard Operating Procedures (SOPs), Analytical Laboratory SOPs, Health and Safety Plan (HSP), Investigation-derived Waste Management Plan (IDWMP), Data Management Plan (DMP), Human Health Risk Assessment (HHRA) protocol, Ecological Risk Assessment (ERA) protocol), and Forms, Checklists, and Templates which document standard procedures or processes that are in common to most or all ERP investigations.

The U.S Navy is the lead agency for the ERP and, thus, author of the Master QAPP. This document will help ensure that environmental data collected or compiled for environmental investigations are scientifically sound, of known and documented quality, and suitable for their intended uses.

This Master QAPP consists of the following plans:

- Master QAPP Worksheets, which document the procedures to ensure that information, data, and resulting decisions are technically sound, statistically valid, and properly documented. The information contained on the Worksheets is generic to most or all ERP investigations. Additions or changes to this information required by specific sites, projects, or tasks will be supplied in the project-specific QAPPs.

- Field SOPs (Attachment 1), which document the field collection procedures to ensure that samples and data are collected in the field in a technically sound and consistent manner.
- HSP (Attachment 2), which discusses the health and safety requirements for performing fieldwork at the sites.
- IDWMP (Attachment 3), which provides procedures on handling and disposing of investigation-derived waste.
- DMP (Attachment 4), which documents and tracks investigation data and results.
- HHRA (Attachment 5), which documents the standard process by which quantitative human health risk assessments are conducted under the ERP. This process conforms to both Navy and USEPA policy and guidance.
- ERAs (Attachment 6), which documents the standard process by which quantitative ecological risk assessments are conducted under the ERP. This process conforms with the Navy Policy for Conducting Ecological Risk Assessments (CNO, 1999) and the Navy guidance for implementing this ERA policy (NAVFAC, 2001).

Laboratory SOPs, which document the procedures to ensure that laboratory information and data are collected in a technically sound manner, are not included in this Master QAPP because laboratories are selected on a project-specific basis and therefore subject to change. Therefore, laboratory SOPs will be provided in each project-specific QAPP.

Introducción

La Marina de los E.E.U.U., Facilidades Navales del Comando de Ingeniería, (NAVFAC, por sus siglas en ingles), División del Atlántico, está llevando a cado un Programa de Restauración Ambiental (ERP, por sus siglas en ingles) bajo la Ley de Respuesta Ambiental, Responsabilidad y Compensación Comprensiva, (CERCLA, por sus siglas en ingles) en el Antiguo Destacamento Naval de Apoyo de Municiones (NASD, por sus siglas en ingles) y el Antiguo Campo de Entrenamiento Naval (VNTR, por sus siglas en ingles) en la isla de Vieques, Puerto Rico. El trabajo de CERCLA se conduce con la Agencia de Protección Ambiental de los E.E.U.U. (USEPA, por sus siglas en ingles) Región II como la agencia reguladora líder y la Junta de Calidad Ambiental de Puerto Rico (PREQB, por sus siglas en ingles) con la función de apoyo regulatorio. La intención del ERP es determinar adecuadamente la naturaleza y extensión de la contaminación asociada con cualquier escape de desperdicios peligrosos, desperdicios sólidos y/o componentes peligrosos en sitios de los antiguos terrenos de la Marina, e implementar remedios, adecuadamente, para controlar o eliminar niveles ecológicos no aceptables para la salud humana asociados a estos escapes.

La Marina está sometiendo este Plan Maestro de Control de Calidad (QAPP, por sus siglas en ingles) para proveer una guía general para la colección y análisis sistemáticos de datos asociados con las investigaciones ambientales bajo CERCLA en Vieques. Los QAPPs para sitios específicos se prepararán en conjunto con los planes de trabajo para esos sitios específicos. La información que se presenta "ha ser determinada", "Específico del Proyecto", o comparable en este QAPP Maestro, es sitio o proyecto específico y por lo tanto no es aplicable al QAPP Maestro. Esta información será completada como parte de la preparación QAPP para el sitio específico.

De acuerdo con la Política Federal Uniforme para los Planes de Proyectos de Control de Calidad (UFP-QAPP, marzo 2005), el Plan Maestro incluye 37 hojas de trabajo que detallan varios aspectos de procesos de investigación ambiental con ocho anejos (Procedimientos Estándares de Campo Operativos (SOPs), SOPs de Laboratorio Analíticos, Plan de Salud y Seguridad (HSP), Investigaciones derivadas del Plan de Manejo de Desperdicios (IDWMP), Plan de Manejo de Datos (DMP), Protocolo de Evaluación de Riesgo Ecológico (ERA) y Formularios, Listas y Formatos que documentan procedimientos estándares o procesos comunes a la mayoría o a todas las investigaciones ERP.

La Marina es la agencia líder para el ERP y por lo tanto, autor del Plan Maestro QAPP. Este documento ayudará a asegurar que los datos ambientales colectados o recopilados para investigaciones ambientales sean científicamente adecuadas, de calidad reconocida y documentada, y convenientes para los usos previstos.

Este Plan Maestro QAPP consiste de los siguientes planes:

Note: This summary is presented in English and Spanish for the convenience of the reader. Every effort has been made for the translations to be as accurate as reasonably possible. However, readers should be aware that the English version of the text is the official version.

Nota: Este resumen se presenta en inglés y en español para la conveniencia del lector. Se han hecho todos los esfuerzos para que la traducción sea precisa en lo más razonablemente posible. Sin embargo, los lectores deben estar al tanto que el texto en inglés es la versión oficial.

- Las hojas de Trabajo QAPP principales, documentan los procedimientos para asegurar que la información, datos y decisiones resultantes sean técnicamente apropiados, estadísticamente válidos y documentados correctamente. La información contenida en las hojas de trabajo es genérica a la mayoría o a todas las investigaciones de ERP. Si se requiere alguna adicional o cambios a esta información por los sitios específicos, proyectos o tareas, éstos serán provistos en los QAPP's específicos del proyecto.
- SOPs de Campo (Anejo 1), documentan los procedimientos de recolección de campo para asegurar que las muestras y los datos colectados en el campo se realicen de una manera técnica y consistente.
- HSP (Anejo 2), describe los requisitos de salud y seguridad necesarios para realizar el trabajo de campo en los sitios.
- IDWMP (Anejo 3), proveen los procedimientos sobre el manejo y disposición de desperdicios derivados de la investigación.
- DMP (Anejo 4), documentan y monitorean los datos y resultados de la investigación
- HHRA (Anejo 5), documentan los procesos estándares a través de los cuales se conducen las evaluaciones de riesgo a la salud humana bajo ERP. Este proceso cumple con las guías y procedimientos de la Marina y la USEPA
- ERAs (Anejo 6), documentan los procesos estándares a través de los cuales se conducen las evaluaciones de riesgo ecológicos cuantitativos bajo ERP. Este proceso cumple con los procedimientos de la Marina para Conducción de Evaluación de Riesgos Ecológicos (CNO, 1999) y las guías de la Marina para implementar este procedimiento ERA (NAVFAC, 2001).

Los SOPs de laboratorio, que documentan los procedimientos para asegurar que la información y los datos de los laboratorios sean colectados de una manera adecuada, no se incluyen en este Plan Maestro QAPP porque los laboratorios se seleccionan en base a un proyecto específico y por lo tanto, están sujetos a cambios. De ahí que, los SOPs de laboratorio se proveerán en cada proyecto específico de QAPP.

Note: This summary is presented in English and Spanish for the convenience of the reader. Every effort has been made for the translations to be as accurate as reasonably possible. However, readers should be aware that the English version of the text is the official version.

Nota: Este resumen se presenta en inglés y en español para la conveniencia del lector. Se han hecho todos los esfuerzos para que la traducción sea precisa en lo más razonablemente posible. Sin embargo, los lectores deben estar al tanto que el texto en inglés es la versión oficial.

QAPP Worksheet #1

Title and Approval Page

Master Quality Assurance Project Plan (QAPP) for the Environmental Restoration Program, Vieques, Puerto Rico

Document Title

U.S. Navy

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Regulatory Agency Stakeholder/Organization	Approval Signature/Date	

Document Control Number: Vieques–01

QAPP Worksheet #2
QAPP Identifying Information

1. Identify guidance used to prepare QAPP:

Uniform Federal Policy for Quality Assurance Project Plans (Parts 1 and 2A), Data Quality Objectives Process (EPA QA/G-4), Guidance for Quality Assurance Project Plans (EPA QA/G-5), Guidance for Data Quality Assessment (EPA QA/G-9)

2. Identify regulatory program:

USEPA Region 2, CERCLA

3. Identify approval entity:

USEPA Region 2

4. Indicate whether the QAPP is a generic or a project-specific QAPP. (underline one)

5. List dates of scoping sessions that were held:

December 29, 2005; January 10, 2006; January 24, 2006; January 31, 2006

6. List dates and titles of QAPP documents written for previous site work, if applicable:

Title	Approval Date
Master Work Plan, U.S. NASD	January 2001
Master Work Plan, AFWTF	June 12, 2003

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

U.S. Navy (NAVFAC, Atlantic), Lead Agency; USEPA Region 2, Lead Regulatory Agency; DOI, Land Owner; Municipality of Vieques; Land Owner, USFWS, Land Manager; PREQB, Support Regulatory Agency; NOAA, Technical Support Agency

8. List data users:

Same as above, and their contractors

9. If any required QAPP elements and required information are not applicable to the project, then circle the omitted QAPP elements and required information on the attached table. Provide an explanation for their exclusion below:

N/A

10. Document control is addressed in the header information in the upper-right corner of each page. Later versions will have the version number and date on revised pages, and copies of all revised pages will be provided to the distribution list in Worksheet#3.

QAPP Worksheet #2
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QAPP Worksheet #2
QAPP Identifying Information

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QAPP Worksheet #3
Distribution List

Below is a potential distribution list for environmental documents. Project specific distribution lists may vary.

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Katarina Rutkowski	Tech.Supp.Consultant for EQB	TRC	860-298-6202		rutkowski@trcsolutions.com	Vieques-01
Andrew Smyth	Tech.Supp.Consultant for EQB	TRC	978-656-3568		asmyth@trcsolutions.com	Vieques-01
Diane Wehner	Natural Resource Mgr	NOAA	240-338-3411		Diane.wehner@noaa.gov	Vieques-01
Brett Doerr	Environmental Manager	CH2M HILL	757-671-8311	757-497-6885	Brett.Doerr@ch2m.com	Vieques-01

QAPP Worksheet #4
Project Personnel Sign-Off Sheet

Organization: Subcontractors

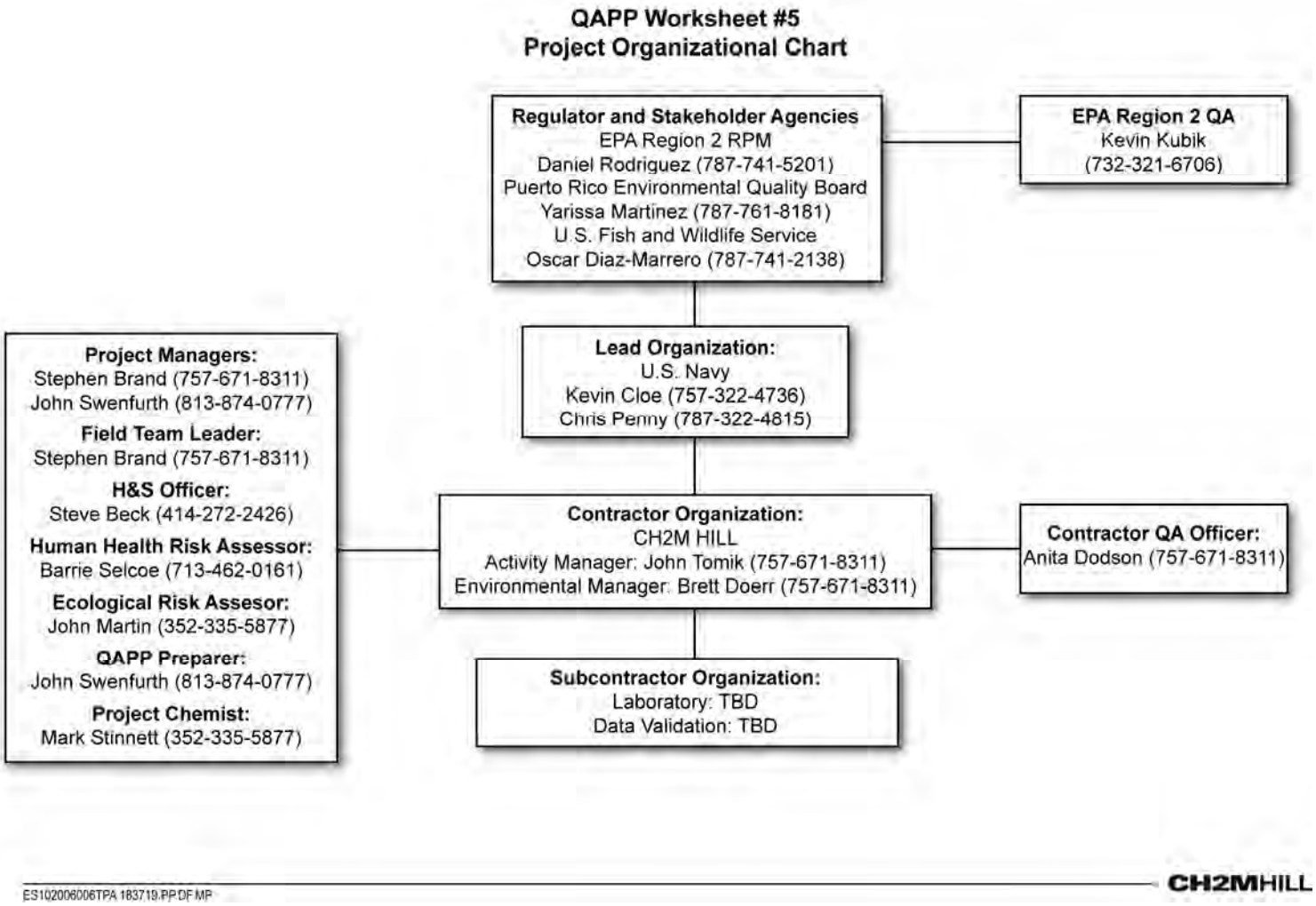
Project Personnel	Title	Telephone Number	Signature	Date QAPP Read
Project Specific	Laboratory Project Manager			
Project Specific	Data Validation Project Manager			

QAPP Worksheet #4
Project Personnel Sign-Off Sheet

Organization: CH2M HILL

Project Personnel	Title	Telephone Number	Signature	Date QAPP Read
John Tomik	Activity Manager	757-671-8311		
Brett Doerr	Environmental Manager	757-671-8311		
Anita Dodson	Project QA Officer	757-671-8311		
Stephen Brand	Field Team Leader/Project Manager	757-671-8311		
Mark Stinnett	Project Chemist	352-335-5877		
Steve Beck	Health and Safety Officer	414-272-2426		
Barrie Selcoe	Lead Human Health Risk Assessor	713-462-0161		
John Martin	Lead Ecological Risk Assessor	352-335-5877		
John Swenfurth	Project Manager	813-874-6522		
Others Project Specific	TBD			

QAPP Worksheet #5
Project Organizational chart



QAPP Worksheet #6
Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc)
Communication with Navy (lead agency)	Navy Project Coordinator for former NASD	Kevin Cloe	757-322-4736	Primary point of contact for Navy; can delegate communication to other internal or external points of contact
Communication with Navy (lead agency)	Navy Project Coordinator for former VNTR	Chris Penny	757-322-4815	Primary point of contact for Navy; can delegate communication to other internal or external points of contact
Communication with EPA (lead regulatory agency)	EPA Project Manager	Daniel Rodriguez	787-741-5201	Primary point of contact for EPA; can delegate communication to other internal or external points of contact
Communication with PREQB (support regulatory agency)	PREQB Project Manager	Yarissa Martinez	787-767-8181	Primary point of contact for PREQB; can delegate communication to other internal or external points of contact
Communication with USFWS (land management agency)	Refuge Manager	Oscar A. Diaz-Marrero	787-741-2138	Primary point of contact for USFWS; can delegate communication to other internal or external points of contact.
Communication with Municipality of Vieques (land ownership and site access)	Municipality of Vieques Manager	Michael Pablo Connelly Pagan	787-741-4442	Primary point of contact for MOV; can delegate communication to other internal or external points of contact.
Oversee ERP implementation	Contractor Environmental Manager	Brett Doerr	757-671-8311	Primary point of contact for stakeholder agency managers; can delegate agency communication to other contract staff, as appropriate
Manage all Project Phases	Contractor Project Managers	John Swenfurth Stephen Brand	813-874-0777 757-671-8311	Primary modes of communication are phone, e-mail, letter, document submittal; timing dependent on nature of communication and pre-defined schedules, as applicable and as requested by stakeholder agencies

QAPP Worksheet #6
Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc)
QAPP changes in the field	Field Team Leader	Stephen Brand	757-671-8311	Documentation of deviations from work plan made in field logbooks; deviations made only with approval from contractor project manager and/or environmental manager
Daily Field Progress Reports	Field Team Leader	Stephen Brand	757-671-8311	Field Team Leader will e-mail or fax daily field progress reports to contractor project managers weekly; telephone communication with project managers on as-needed basis
Data tracking from collection through upload to database	Environmental Information Specialist (EIS)	Chelsea Bennet	757-671-8311	EIS will track data from sample collection through upload to database, ensuring QAPP requirements are met by laboratory and field staff
Maintaining the database to ensure data is stored properly and can be retrieved by the EIS.	Database Manager	Bhavana Reddy	703-471-1441	Database Manager is responsible for maintaining the data in a useable database.
Reporting Lab Data Quality Issues	Laboratory Project Manager	Cathy Dover	919-379-4089	All QA/QC issues with project field samples will be reported by the lab the EIS, Project Chemist, and Contractor Quality Assurance Officer within 2 business days.
Field and Analytical Corrective Actions	Contractor Quality Assurance Officer	Anita Dodson	757-671-8311	The need for corrective action for field and analytical issues will be determined by the Field Team Leader and/or Contractor Quality Assurance Officer.
Release of Analytical Data	Project Chemist	Mark Stinnett	352-335-5877	No analytical data can be released until validation is completed and Project Chemist has approved the release.

QAPP Worksheet #7
Personnel Responsibilities and Qualifications Table

Name	Title	Organizational Affiliation	Responsibilities	Education and Experience Qualifications[1]
Kevin Cloe	West Vieques (Former NASD) Project Coordinator	U.S. Navy	Coordinates all Environmental activities on West Vieques	M.E. Environmental Engineering B.S. Civil Engineering, 15 yrs. Exp.
Chris Penny	East Vieques (Former VNTR) Project Coordinator	U.S. Navy	Coordinates all Environmental activities on East Vieques	B.S. Civil Engineering, MS in Environmental Engineering, PhD Candidate in Engineering Management , UXO Technician I Certificate 20 yrs Environmental Remediation Work in CERCLA and RCRA
Madeline Rivera	East and West Vieques Environmental Site Manager	U.S. Navy	Supports all environmental activities on east and west Vieques	M.S. Engineering Administration B.S. Chemical Engineering, REM, UXO Technician I, 12 yrs. Exp.
John Tomik	Activity Manager	CH2M HILL	Responsible for ERP & MRP at Vieques	M.S. Geology, 27 yrs. Exp.
Brett Doerr	Environmental Manager	CH2M HILL	Responsible for ERP at Vieques	M.S. Hydrogeology, 14 yrs. Exp.
Anita Dodson	QA Officer	CH2M HILL	Responsible for audits, corrective action, checks of QA performance	B.S. Chemistry, 12 yrs. Exp.
Mark Stinnett	Project Chemist	CH2M HILL	Performs oversight of laboratory	B.S. Chemistry, 18 yrs. Exp.
Stephen Brand	Field Team Leader	CH2M HILL	Supervises field sampling and coordinates all field activities	M.S. Geology, 15 yrs. Exp.
Steve Beck	H&S Officer	CH2M HILL	Oversees H&S for field activities	M.S. Occupational Safety and Health, 13 yrs. Exp.
John Swenfurth	Project Manager	CH2M HILL	Manages ERP projects; directs and oversees project staff	M.S. Hydrogeology, 9 yrs. Exp.
Stephen Brand	Project Manager	CH2M HILL	Manages ERP projects; directs and oversees project staff	M.S. Geology, 15 yrs. Exp.
Chelsea Bennet	EIS	CH2M HILL	Manages sample tracking; coordinates laboratory, data validator, and data management.	B.S. Biology, 6 years Exp.
Bhavana Reddy	Database Manager	CH2M HILL	Database Management	B.A. Business Administration and Accounting, 10 years Exp.

[1] Resumes are maintained by the individuals' organizations and are available upon request; other staff with similar qualifications may be removed, added, or substituted as necessary

QAPP Worksheet #8
Special Personnel Training Requirements Table

Project Function	Specialized Training—Title or Description of Course	Training Provider	Training Date	Personnel/Groups Receiving Training	Personnel Titles/ Organizational Affiliation	Location of Training Records/Certificates1
Environmental Field Work on Vieques	Hazwoper 40-hour Training	Registered Training Organization	Project-specific	Individuals in the field	Project-specific	Contractor Human Resources Department
Others, project specific						

[1]If training records and/or certificates are on file elsewhere, document their location in this column. If training records and/or certificates do not exist or are not available, then this should be noted.

QAPP Worksheet #9
Project Scoping Session Participants Sheet

Project Name: Environmental Restoration Program, Vieques, Puerto Rico

Projected Date(s) of Sampling: Project-specific | Site Name: Former NASD and Former VNTR

Environmental Manager: Brett Doerr | Site Location: Vieques, Puerto Rico

Dates of Sessions: 12/29/05, 01/10/06, 01/24/06, and 01/31/06

Scoping Session Purpose: Discuss Master QAPP

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Brett Doerr	Environmental Manager	CH2M HILL	757-671-8311	Brett.Doerr@CH2M.com	Environmental Manager
John Swenfurth	Project Manager	CH2M HILL	813-874-0777	John.Swenfurth@CH2M.com	Project Manager
Stephen Brand	Project Manager	CH2M HILL	757-671-8311	Stephen.Brand@CH2M.com	Project Manager
Anita Dodson	QAPP Reviewer	CH2M HILL	757-671-8311	Anita.Dodson@CH2M.com	Senior Chemist
Others, project-specific					

Comments/Decisions:

Action Items:

Consensus Decisions:

QAPP Worksheet #9
Personnel Responsibilities and Qualifications Table

Dates of Sessions: 1/06/06, 1/30/06

Scoping Session Purpose: Discuss Master QAPP

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Sergio Lopez	Investigation QC Specialist	EPA	732-321-67778	Lopez.sergio@epa.gov	QC Specialist
Jeff Harlow	NAVFAC RPM	Navy	757-322-4736	Jeffrey.harlow@navy.mil	Project RPM
Daniel Rodriguez	EPA Region 2 RPM	EPA	787-741-5201	Rodriguez.daniel@epamail.gov	EPA Region 2 RPM
Brett Doerr	Environmental Manager	CH2M HILL	757-671-8311	Brett.doerr@ch2m.com	Environmental Mgr.

Comments/Decisions: The UFP-QAPP would be required for the Master QAPP, but it was understood by EPA that much of the required information in the UFP-QAPP is project specific and not applicable to a Master QAPP. The information would be shown as “to be determined” or “site-specific” in the Master QAPP.

Action Items:

Consensus Decisions:

QAPP Worksheet #10
Problem Definition

The problem to be addressed by the project: Vieques Island has a land area of approximately 33,000 acres, and is located in the Caribbean Sea approximately 7 miles southeast of the eastern coast of the main island of Puerto Rico. The former Naval facilities are located on the eastern one-third (i.e., former VNTR) and western one-third (i.e., former NASD) of the island, with the communities of Isabel Segunda and Esperanza located in the center of the island. The former VNTR, which comprised approximately 14,573 acres, provided ground warfare and amphibious training for marines, Naval gunfire support training, and air to ground training. The former VNTR has also been referred to as the former Atlantic Fleet Weapons Training Facility (AFWTF) and the Eastern Maneuver Area (EMA). The former NASD, comprising 8,200 acres, provided munitions storage and other support facilities for the Atlantic Fleet training.

The ERP is intended to evaluate the nature and extent of contamination at former Navy sites, assess potential human health and ecological risks, and implement remedial actions, as appropriate, in a manner consistent with the CERCLA response processes to ensure that former site conditions are adequately protective of human health and the environment.

The environmental questions being asked: Are environmental media at former Navy sites contaminated by past releases and, if so, what is the nature and extent of contamination and what are the potential risks posed to human and ecological receptors under conservative exposure scenarios.

Observations from any site reconnaissance reports: Historical information is reviewed during the investigative process. Information includes historical aerial photographs, interviews with past operators, and site investigations.

A synopsis of secondary data or information from site reports: Past reports from the ERP studies on Vieques are found at web site: http://public.lantops-ir.org/sites/public/vieques/Public%20Files/library.aspx

The possible classes of contaminants and the affected matrices: Several different sites are being investigated and, therefore, classes of potential contaminants are site- and project-specific. The historical site usage, industrial processes, and waste disposal practices are investigated on a site by site basis.

The rationale for inclusion of chemical and nonchemical analyses: Potential contaminants of concern are evaluated on a site by site basis.

Information concerning various environmental indicators: Information regarding various aspects of environmental conditions is site-specific. Vieques has a land area of approximately 33,000 acres, and is located in the Caribbean Sea approximately 7 miles southeast of the eastern coast of the main island of Puerto Rico (Figure 1-1). Figure 1-2 identifies the areas to be assessed as part of the NPL. Figure 1-3 identifies the west Vieques NPL sites. Figure 1-4 shows an aerial photograph from 1938 which shows east Vieques prior to Navy operations. Figure 1-5 shows an aerial photograph of east Vieques in 2005. Figure 1-6 shows an aerial photograph of west Vieques in 1967, this is the oldest aerial

QAPP Worksheet #10
Problem Definition

found for west Vieques. Figure 1-7 shows an aerial photograph of west Vieques in 2005, which is the most current aerial of the area.

Project decision conditions ("If..., then..." statements): Decision conditions are project-specific. They may include one or more of the following conditions. If PA/SI data suggest no releases have occurred, then recommend no further action; otherwise, recommend additional data collection as part of expanded PA/SI or RI to adequately assess nature and extent of contamination and potential risks. If RI data adequately delineate nature and extent of contamination, then conduct quantitative human health and ecological risk assessments; otherwise, recommend additional data collection as part of supplemental RI. If risk assessments indicate potential risks are at acceptable levels, based on quantitative estimates, and/or comparison to background concentrations, or other acceptable procedures, then recommend no further action; otherwise, recommend process to evaluate means of eliminating, mitigating, and/or controlling the risks.

Anegada

British Virgin Islands

U.S. Virgin Islands

Virgin Gorda

Tortola

San Juan

Culebra

St. Thomas

St. John

U.S. Naval Activity Puerto Rico

VIEQUES

PUERTO RICO

WEST VIEQUES (Former NASD)

EAST VIEQUES (Former VNTR)

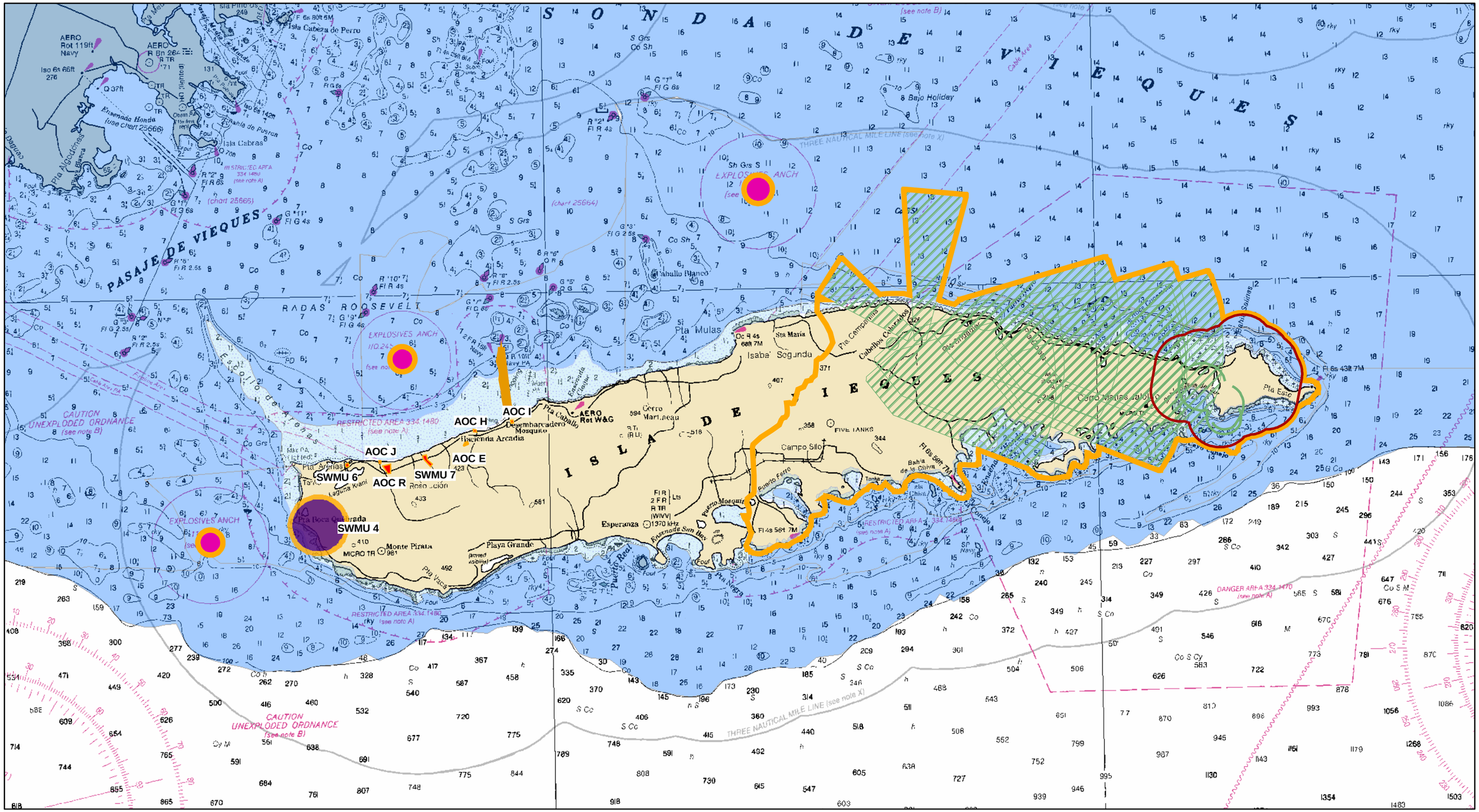
St. Croix

N

Scale in Miles

0 15

Figure 1-1
Regional Location Map
Master Quality Assurance Project Plan, Vieques Island, Puerto Rico



Legend

- Explosive Saftey Quantity Distance
- Agreed Areas of NPL Site
- Anchorage Location Boundary
- Artillery Safety Fan
- Western Vieques Environmental Sites
- SWMU 4 (Former OB/OD Site)
- Greater Than 0.5 Naval Gunfire Rounds/Acre/Year

Water Depth

- 0-10 Feet
- 10 - 150 Feet
- Greater Than 150 Feet

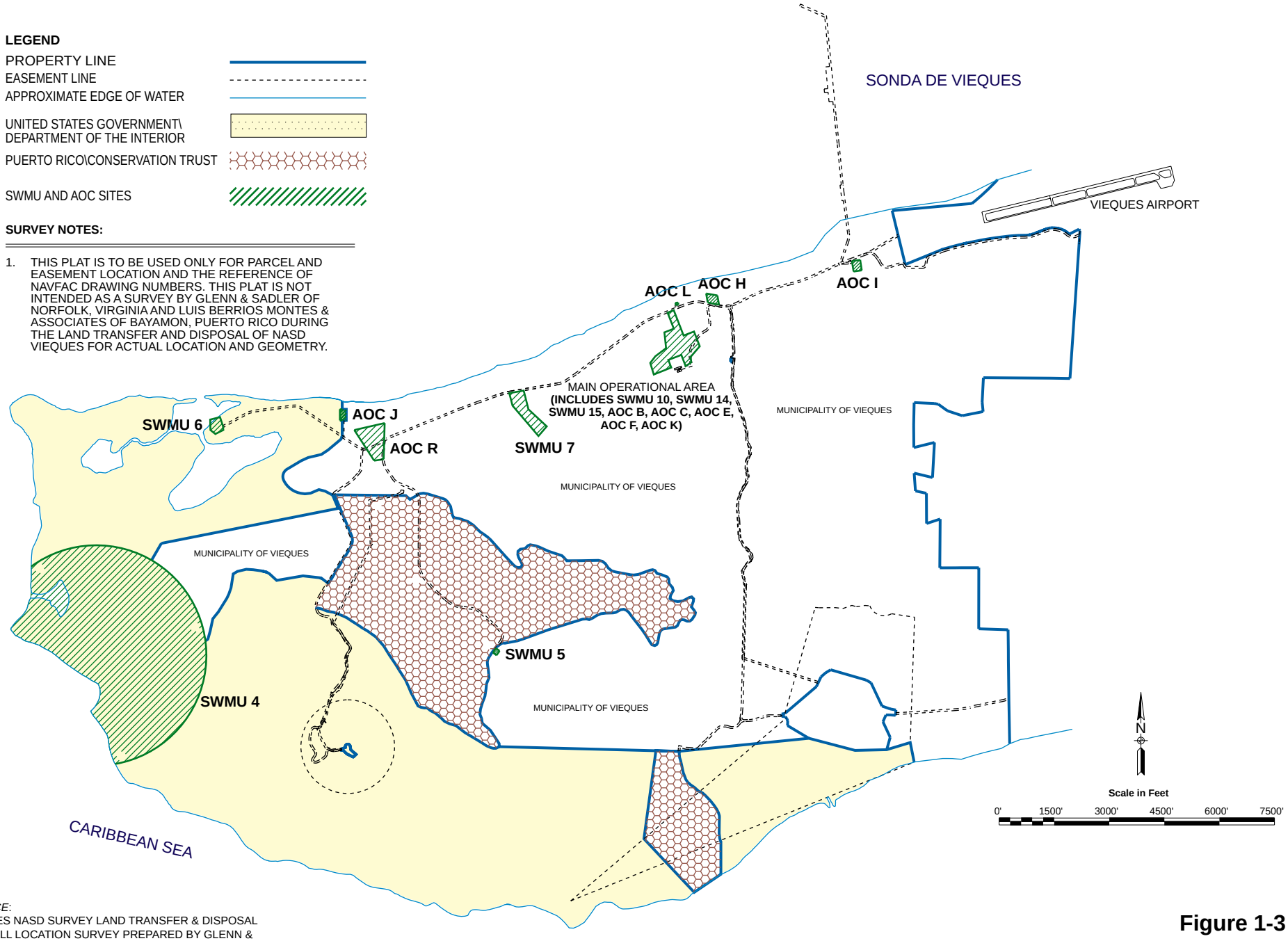
N W E S

0 Miles

File Path: \\tampa\projects\Environmental\Navy CLEAN II_Vieques_ PR\AFWTF\GIS\NOAA.mxd, Date: 06 28, 2004, User: gperdew

Figure 1-2
Vieques National Priority List Sites
Site Management Plan
Vieques, Puerto Rico

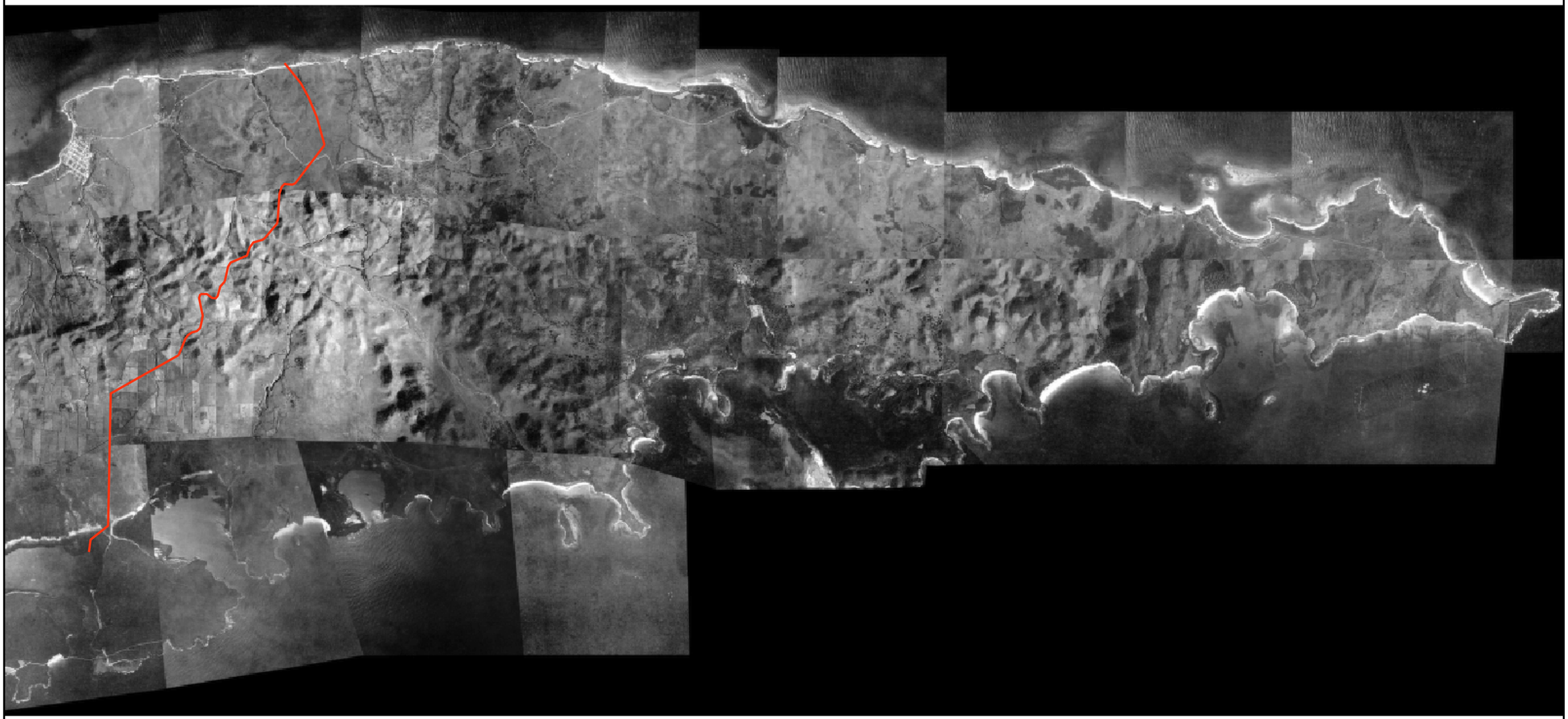
Master Quality Assurance Project Plan, Vieques Island, Puerto Rico



SOURCE:
VIEQUES NASD SURVEY LAND TRANSFER & DISPOSAL OVERALL LOCATION SURVEY PREPARED BY GLENN & SADLER AND LUIS BERRIOS MONTES & ASSOCIATES

Figure 1-3
NASD Sites
Master Quality Assurance Project Plan, Vieques Island, Puerto Rico

V:\\ariadne\proj\18gis\Vieques2\Figures\Master_QAPP\Figure 1-4 - East 1937 Aerial Photograph of Vieques.mxd



East Vieques Boundary Line

N

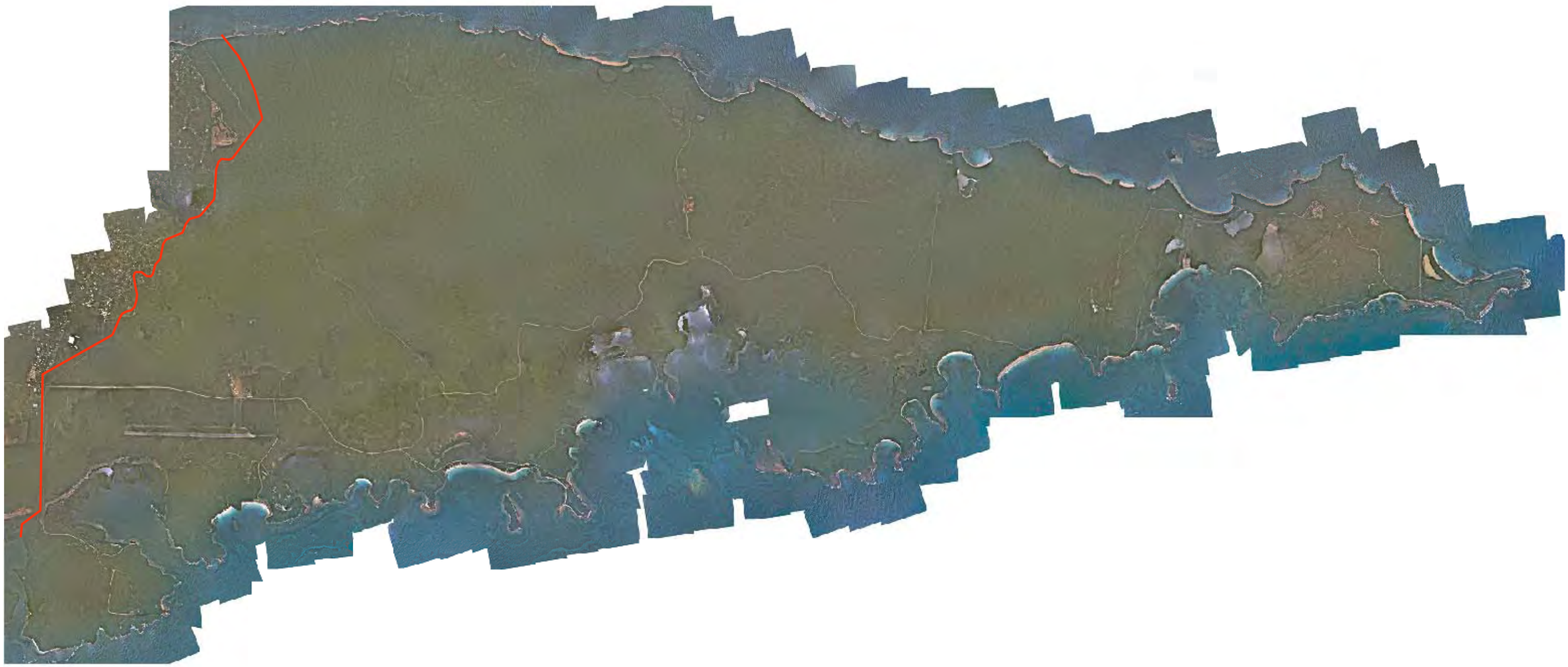
0 2,000 4,000 8,000 Feet

Figure 1-4
1937 Aerial Photograph of East Vieques
Vieques Island, Puerto Rico

Master Quality Assurance Project Plan, Vieques Island, Puerto Rico

CH2MHILL

V:\ariadne\proj\18gis\Vieques2\Figures\Master_QAPP\Figure 1-5 - East 2005 Aerial Photograph of Vieques.mxd



East Vieques Boundary Line

N

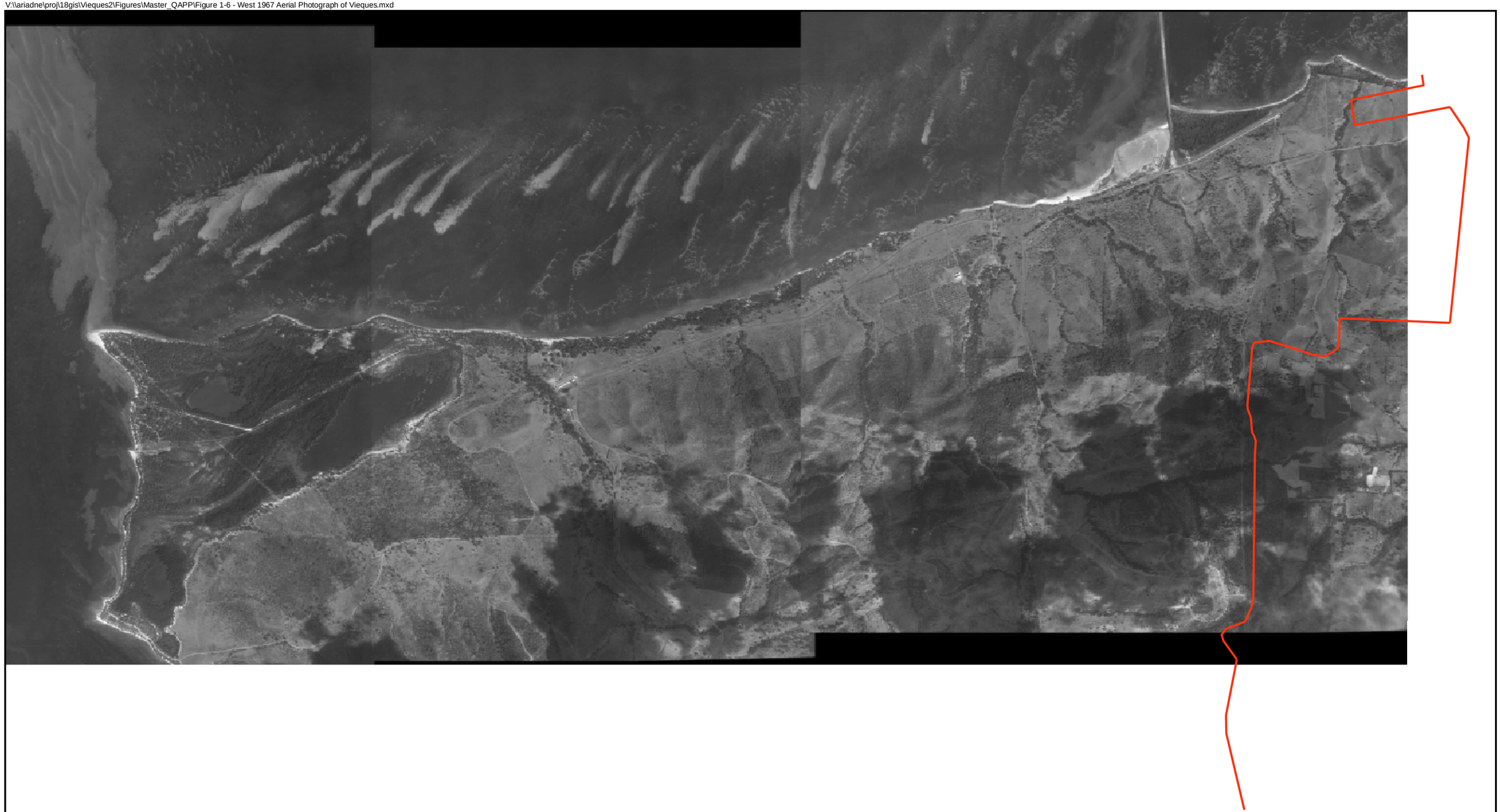
0 2,000 4,000 8,000 Feet

Figure 1-5
2005 Aerial Photograph of East Vieques
Vieques Island, Puerto Rico

Master Quality Assurance Project Plan, Vieques Island, Puerto Rico

CH2MHILL

V:\\ariadne\proj\18gis\Vieques2\Figures\Master_QAPP\Figure 1-6 - West 1967 Aerial Photograph of Vieques.mxd



Former Navy Area Boundary Line

N

0 1,000 2,000 4,000 Feet

Figure 1-6
1967 Aerial Photograph of West Vieques
Vieques Island, Puerto Rico
Master Quality Assurance Project Plan, Vieques Island, Puerto Rico

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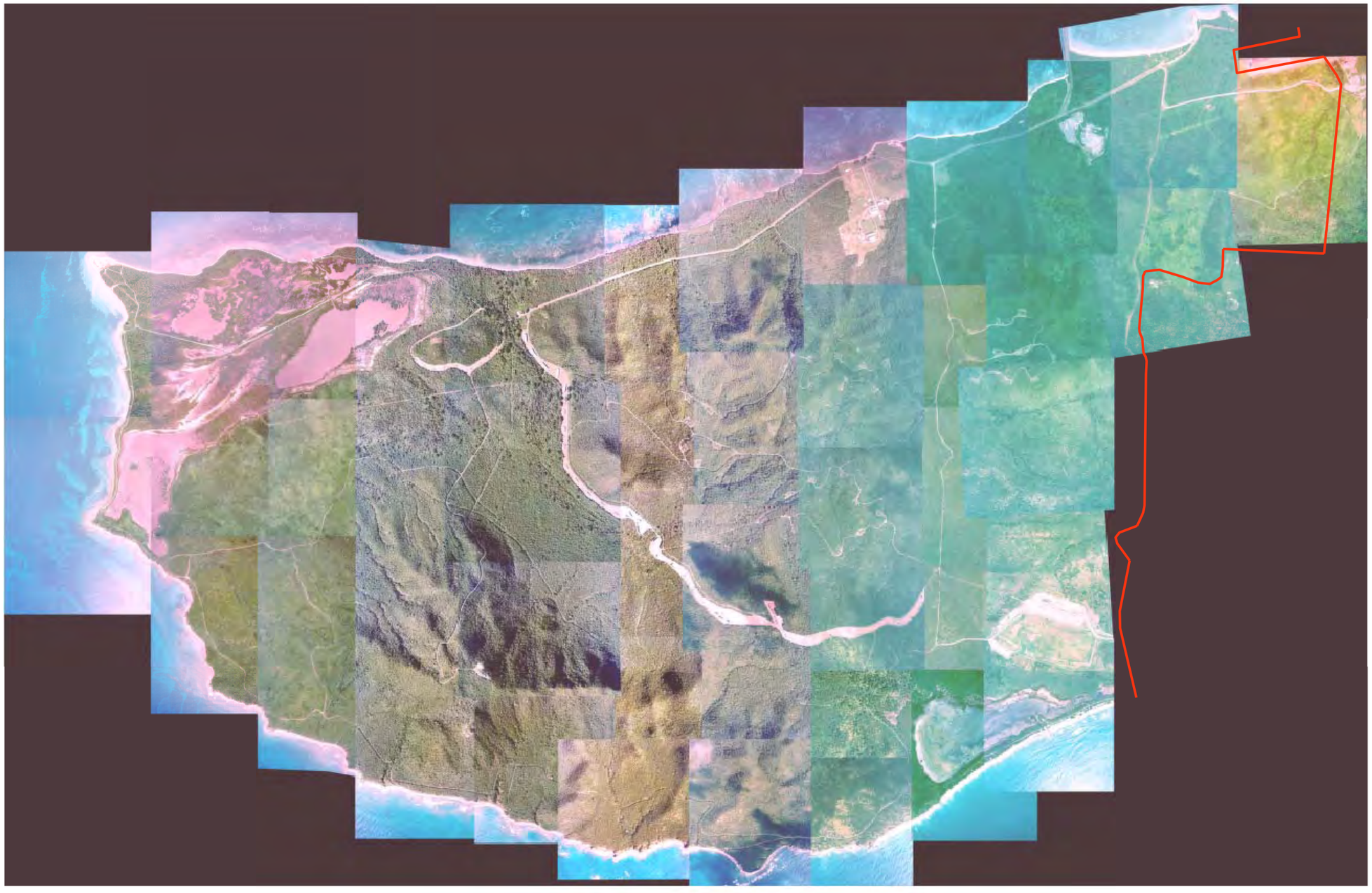
V:\ariadne\proj\18gis\Vieques2\Figures\Master_QAPP\Figure 1-7- West 2005 Aerial Photograph of Vieques.mxd



Former Navy Area Boundary Line

N

0 1,250 2,500 5,000 Feet

Figure 1-7
2005 Aerial Photograph of West Vieques
Vieques Island, Puerto Rico
Master Quality Assurance Project Plan, Vieques Island, Puerto Rico

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QAPP Worksheet #11
Project Quality Objectives/Systematic Planning Process Statements

Who will use the data? Data will be used by the Navy (and its contractors) and the other stakeholder agencies to ensure the sites are adequately assessed and, if necessary, appropriate measures are taken to provide adequate protection of human health and the environment at sites within the former NASD and former VNTR.

What will the data be used for? The data will be used to determine whether there have been releases of hazardous waste or hazardous constituents to environmental media from past Navy operations. If the data suggest the presence of a release, adequate data will be collected to determine the nature and extent of contamination and the potential risks the contamination poses to human and ecological receptors**.**

What type of data are needed? (target analytes, analytical groups, field screening, on-site analytical or off-site laboratory techniques, sampling techniques. The type of data to be collected will be determined on a site by site basis. The data collected will be representative of the site. Standard protocols for sample collection, handling, sample preparation, and analytical methods will be used. In general, data related to the nature and extent of contamination in applicable media and its fate and transport will be collected. More detail is provided in the field SOPs, Attachment 1.

How "good" do the data need to be in order to support the environmental decision? The quality of the data will depend on their intended use. Screening data need not be of the same quality as data used to support human health and ecological risk assessments. In general, the data will be of the quantity and quality necessary to provide technically sound and defensible assessments of potential risks to human and ecological receptors posed by the contaminants identified. For risk assessment and high-level decisions laboratory methods will meet CERCLA, EPA Region II, and Navy guidance, as appropriate, and the data will be validated by a third-party validator using Region II and national functional guidance.

How much data are needed? (number of samples for each analytical group, matrix, and concentration) The quantity of data will be determined on a site by site basis and will depend on their intended use. As noted above, the data will be of the quantity and quality necessary to provide technically sound and defensible assessments of potential risks to human and ecological receptors posed by the contaminants identified.

What is the completeness goal? Completeness is defined as the percentage of measurements that are judged to be valid compared to the total number of measurements made. The objective of the overall completeness goal for each individual project is set at 95% usable data. This goal is inclusive of both field and laboratory analytical data.

Where, when, and how should the data be collected/generated? The data will be collected following regulatory approved site specific work plans, which will cite this Master QAPP for standard procedures.

Who will collect and generate the data? Field staff will collect the samples. In general, a laboratory will analyze samples and produce sample data. In some cases, data will be field-

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

generated, such as field screening (e.g., vapor monitoring, immunoassays, etc.) and testing (e.g., water levels, aquifer characteristics, etc.) data.

How will the data be reported? Reports will be prepared describing and evaluating the data collected. In general, CERCLA guidance will be followed. More detail is provided in the Data Management Plan, Attachment 4.

How will the data be archived? The data will be archived in accordance with federal law. At the end of the project, archived data will be returned to the Navy.

QAPP Worksheet #12-1

Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Volatile Organic Compounds
Concentration Level	Low/Medium (SOM01.1)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
A-6, G-5	EPA CLP SOM01.1	contamination	must meet all internal standard and DMC criteria; all target compounds < CRQL except methylene chloride, acetone, and 2-butanone which must be < 2 times the CRQL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank, Trip Blank)	S
		precision	should meet RPD criteria of 35% for soil/sediment	Field Duplicate	S&A
		contamination/bias	must meet all internal standard and DMC criteria; all target compounds < CRQL except methylene chloride, acetone, and 2-butanone which must be < 2 times the CRQL	Method Blank	A
		contamination	must meet all internal standard and DMC criteria; all target compounds < CRQL	Instrument Blank	A
		accuracy	surrogate recovery must meet % recovery criteria in SOM01.1 SOW	Deuterated Monitoring Compounds (DMC)	A
		precision/accuracy	must meet relative RT criteria; should meet advisory % recovery and RPD criteria in SOM01.1 SOW	Matrix spike/Matrix spike duplicate	S&A
		contamination/bias	same as method blank	Storage Blank	A

[1]Reference number from QAPP Worksheet #21.
[2]TBD when laboratory is selected for specific events.
EPA = U.S. Environmental Protection Agency
CLP = Contract laboratory program
CRQL = Contract Required Quantitation Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-2
Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Semivolatile Organic Compounds
Concentration Level	Low/Medium (SOM01.1)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
A-1, A-2, A-5, G-5	EPA CLP SOM01.1	contamination	must meet all internal standard and DMC criteria in SOM01.1 SOW; all target compounds < CRQL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 35% for soil/sediment	Field Duplicate	S&A
		contamination/bias	must meet all internal standard and DMC criteria in SOM01.1 SOW; all target compounds < CRQL except bis-(2-ethylhexyl)phalate which must be < 5 times CRQL	Method Blank Low-Level	A
		contamination/bias	must meet all internal standard and DMC criteria in SOM01.1 SOW; all target compounds < CRQL	Method Blank Medium-Level	A
		accuracy	surrogate recovery must meet % recovery criteria in SOM01.1 SOW	Deuterated Monitoring Compounds (DMC)	A
		precision/accuracy	must meet relative RT criteria; should meet advisory spike recovery and RPD criteria in the SOM01.1 SOW	Matrix spike/Matrix spike duplicate	S&A

[1]Reference number from QAPP Worksheet #21.

[2]TBD when laboratory is selected for specific events.

EPA = U.S. Environmental Protection Agency
CLP = Contract laboratory program
CRQL = Contract Required Quantitation Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-3
Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Semivolatile Organic Compounds
Concentration Level	Selected Ion Monitoring (SIM) (SOM01.1)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
A-1, A-2, A-5, G-5	EPA CLP SOM01.1	contamination	must meet all internal standard and DMC criteria in SOM01.1 SOW; all target compounds < CRQL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 35% for soil/sediment	Field Duplicate	S&A
		contamination	must meet all internal standard and DMC criteria in SOM01.1 SOW; all target compounds < CRQL	Method Blank	A
		accuracy	surrogate recovery must meet internal standard relative RT criteria; must meet % recovery criteria in SOM01.1 SOW	Deuterated Monitoring Compounds (DMC)	A
		precision/accuracy	must meet relative RT criteria; should meet advisory spike recovery and RPD criteria in the SOM01.1 SOW	MS/MSD	S&A

[1]Reference number from QAPP Worksheet #21.
[2]TBD when laboratory is selected for specific events.
EPA = U.S. Environmental Protection Agency
CLP = Contract laboratory program
CRQL = Contract Required Quantitation Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-4
Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Organochlorine Pesticides
Concentration Level	Low (SOM01.1)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
A-1, A-2, A-5, G-5	EPA CLP SOM01.1	contamination	all target compounds < CRQL; surrogates must be within RT windows; surrogate recoveries must be within 30-150%	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 35% for soil/sediment	Field Duplicate	S&A
		contamination/bias	all target compounds < CRQL; surrogates must be within RT windows; surrogate recoveries must be within 30-150%	Method Blank	A
		contamination/bias	same as method blank	Sulfur Blank	A
		contamination/bias	all target compounds < CRQL; surrogates must be within RT windows	Instrument Blank	A
		accuracy	must be within the RT windows; must meet % recovery criteria in SOM01.1 SOW	Surrogate Spikes	A
		accuracy	surrogates must be within RT windows; surrogate recoveries must be with 30-150%;spike recoveries must meet criteria in SOM01.1 SOW	Laboratory Control Sample	A
		precision/accuracy	surrogates must be within RT windows; should meet advisory spike recovery and RPD criteria in SOM01.1 SOW	Matrix spike/Matrix spike duplicate	S&A

[1]Reference number from QAPP Worksheet #21.

[2]TBD when laboratory is selected for specific events.
EPA = U.S. Environmental Protection Agency
CLP = Contract laboratory program
CRQL = Contract Required Quantitation Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-5
Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Polychlorinated Biphenyls
Concentration Level	Low (SOM01.1)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
A-1, A-2, A-5, G-5	EPA CLP SOM01.1	contamination	all target compounds < CRQL; surrogates must be within RT windows; surrogate recoveries must be within 30-150%	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 35% for soil/sediment	Field Duplicate	S&A
		contamination/bias	all target compounds < CRQL; surrogates must be within RT windows; surrogate recoveries must be within 30-150%	Method Blank	A
		contamination/bias	same as method blank	Sulfur Blank	A
		contamination/bias	all target compounds < CRQL; surrogates must be within RT windows	Instrument Blank	A
		accuracy	surrogates must be within RT windows; surrogate recoveries must be with 30-150%;spike recoveries must meet criteria in SOM01.1 SOW	Laboratory Control Sample	A
		accuracy	must be within RT windows; must meet % recovery criteria in SOM01.1 SOW	Surrogate Spikes	A
		precision/accuracy	surrogates must be within RT windows; should meet advisory spike recovery and RPD criteria in SOM01.1 SOW	Matrix spike/Matrix spike duplicate	S&A

[1]Reference number from QAPP Worksheet #21.
[2]TBD when laboratory is selected for specific events.
EPA = U.S. Environmental Protection Agency
CLP = Contract laboratory program
CRQL = Contract Required Quantitation Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-6
Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Explosives
Concentration Level	Medium (8330)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
A-1, A-2, A-5, G-5	SW-846 8330	contamination	no target compounds > the reporting limit; surrogate recovery must be within the limits of 38-155%	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 35% for soil/sediment	Field Duplicate	S&A
		contamination/bias	no target compounds > the reporting limit; surrogate recovery must be within the limits of 38-155%	Method Blank	A
		accuracy/bias	surrogate recovery must be within the limits of 38-155%; spike recovery limits must be within the range of 50-150%	LCS	A
		precision/accuracy	spike recovery limits are 50-150%; RPD limts are 30%	MS/MSD	S&A

[1]Reference number from QAPP Worksheet #21.
[2]TBD when laboratory is selected for specific events.
RL = Reporting Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-7
Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Perchlorate
Concentration Level	Medium (DoD Perchlorate Handbook)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
A-1, A-2, A-5, G-5	Methodology listed in DoD Perchlorate Handbook, March 2006	contamination	no target compounds > 1/2 the reporting limit	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 20% for soil/sediment	Field Duplicate	S&A
		contamination/bias	no target compounds > 1/2 the reporting limit	Method Blank	A
		accuracy/bias	spike recovery limits must be within the range of 85-115%	LCS	A
		precision/accuracy	spike recovery limits are 75-125%; RPD limts are 20%	MS/MSD	S&A

[1]Reference number from QAPP Worksheet #21.

[2]TBD when laboratory is selected for specific events.

RL = Reporting Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-8
Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Total Petroleum Hydrocarbons
Concentration Level	Normal (8015M)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
A-1, A-2, A-5, G-5	SW-846 8015M	contamination	all target compound < RL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank, Trip Blank)	S
		precision	should meet RPD criteria of 35% for soil/sediment	Field Duplicate	S&A
		contimination/bias	all target compound < RL	Method Blank	A
		accuracy	must meet the recovery limits of 50-150 for DRO; must meet recovery limits of 75-110 for GRO	LCS	A
		accuracy/precision	should meet the spike recovery limits of 50-142 and RPD of 20 for GRO; should meet the spike recovery limits fo 50-150 fand RPD of 25 for DRO	MS/MSD	S&A

[1]Reference number from QAPP Worksheet #21.

[2]TBD when laboratory is selected for specific events.

RL = Reporting Limit

RPD = Relative Percent Difference

QAPP Worksheet #12-9
Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Metals
Concentration Level	Low/Medium (ILM05.3)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
A-1, A-2, A-5, G-5	EPA CLP ILM05.3	contamination	absolute values of all analyte concentrations must be < the CRQL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 35% for soil/sediment	Field Duplicate	S&A
		accuracy	analyte recovery must fall within the limits of 70-130% (50-150 for antimony, lead, and thallium)	CRQL Check Standard (CRI)	A
		contamination/bias	All analytes must be < the CRQL	Calibration Blank	A
		contamination/bias	absolute values of all analyte concentrations must be < the CRQL	Preparation blank	A
		accuracy/bias	must be within ± 2x the CRQL of the analyte's true value or ± 20% of the analyte's true value, whichever is greater	Interference Check Sample (ICS)	A
		accuracy/bias	spike recovery limits are 75-125%	Matrix Spike	S&A
		accuracy	purchased reference material;must meet the recovery limits established by the vendor	LCS	A
		precision/accuracy	RPD of 20%, if concentration is > 5x CRQL; or ± the CRQL if the concentration is < 5x CRQL	Laboratory Duplicate	A
		precision/accuracy	should agree within 10% of the undiluted sample	Serial Dilution	A

[1]Reference number from QAPP Worksheet #21.
[2]TBD when laboratory is selected for specific events.
EPA = U.S. Environmental Protection Agency
CLP = Contract laboratory program
CRQL = Contract Required Quantitation Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-10
Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Wet Chemistry
Concentration Level	Medium (various)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
A-1, A-2, A-5, G-5	SW-846 9045C	contamination	NA	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should be ± 0.1pH units	Field Duplicate	S&A
		contamination/bias	calibration check must be within 0.05pH units of calibration buffer solution, and samle temperature must be within 2°C of buffer solution	Electrode Check	A
		contamination/bias	NA	Method Blank	A

[1]Reference number from QAPP Worksheet #21.
[2]TBD when laboratory is selected for specific events.
NA = Not Applicable
RL = Reporting Limit
RPD = Relative Percent Difference

QAPP Worksheet #12-11
Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Wet Chemistry
Concentration Level	Medium (various)

Sampling Procedure[1]	**Analytical Method/SOP**[2]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
A-1, A-2, A-5, G-5	SM2580B	contamination	NA	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	within ± 22mV	Field Duplicate	S&A
		contamination/bias	within ± 10mV	Calibration Check	A
		contamination/bias	NA	Method Blank	A

[1]Reference number from QAPP Worksheet #21.

[2]TBD when laboratory is selected for specific events.

SM = Standard Methods
NA = Not Applicable
RL = Reporting Limit
RPD = Relative Percent Difference

QAPP Worksheet #12-12
Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Wet Chemistry
Concentration Level	Medium (various)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
A-1, A-2, A-5, G-5	SW-846 9081	contamination	all target compound < RL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 35% for soil/sediment	Field Duplicate	S&A
		contamination/bias	all target compound < RL	Calibration Blank	A
		contamination/bias	all target compound < RL	Method Blank	A
		precision/accuracy	RPD or 20%	Laboratory Duplicate	A

[1]Reference number from QAPP Worksheet #21.
[2]TBD when laboratory is selected for specific events.
EPA = U.S. Environmental Protection Agency
RL = Reporting Limit
RPD = Relative Percent Difference

QAPP Worksheet #12-13
Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Wet Chemistry
Concentration Level	Medium (various)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
A-1, A-2, A-5, G-5	Lloyd Kahn/SW-846 9060	contamination	all target compound < RL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 35% for soil/sediment	Field Duplicate	S&A
		contamination/bias	all target compound < RL	Calibration Blank	A
		contamination/bias	all target compound < RL	Method Blank	A
		accuracy	spike recovery ± 25%; RPD of ≤ 35	MS/MSD	S&A
		accuracy	spike recovery ± 10%	LCS	A
		precision/accuracy	RPD or 35%	Laboratory Duplicate	A

[1]Reference number from QAPP Worksheet #21.

[2]TBD when laboratory is selected for specific events.
EPA = U.S. Environmental Protection Agency
RL = Reporting Limit
RPD = Relative Percent Difference

QAPP Worksheet #12-14
Measurement Performance Criteria Table

Matrix	Water/Groundwater
Analytical Group	Volatile Organic Compounds
Concentration Level	Low/Medium (SOM01.1)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
B-1, B-2, B-3, G-2	EPA CLP SOM01.1	contamination	must meet all internal standard and DMC criteria; all target compounds < CRQL except methylene chloride, acetone, and 2-butanone which must be < 2 times the CRQL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank, Trip Blank)	S
		precision	should meet RPD criteria of 25% for water/groundwater	Field Duplicate	S&A
		contamination/bias	must meet all internal standard and DMC criteria; all target compounds < CRQL except methylene chloride, acetone, and 2-butanone which must be < 2 times the CRQL	Method Blank	A
		contamination	must meet all internal standard and DMC criteria; all target compounds < CRQL	Instrument Blank	A
		accuracy	surrogate recovery must meet % recovery criteria in SOM01.1 SOW	Deuterated Monitoring Compounds (DMC)	A
		precision/accuracy	must meet relative RT criteria; should meet advisory % recovery and RPD criteria in SOM01.1 SOW	Matrix spike/Matrix spike duplicate	S&A
		contamination/bias	same as method blank	Storage Blank	A

[1]Reference number from QAPP Worksheet #21.

[2]TBD when laboratory is selected for specific events.

EPA = U.S. Environmental Protection Agency
CLP = Contract laboratory program
CRQL = Contract Required Quantitation Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-15
Measurement Performance Criteria Table

Matrix	Water/Groundwater
Analytical Group	Volatile Organic Compounds
Concentration Level	Trace (SOM01.1)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
B-1, B-2, B-3, G-2	EPA CLP SOM01.1	contamination	must meet all internal standard and DMC criteria; all target compounds < CRQL except methylene chloride, acetone, and 2-butanone which must be < 2 times the CRQL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank, Trip Blank)	S
		precision	should meet RPD criteria of 25% for water/groundwater	Field Duplicate	S&A
		contamination/bias	must meet all internal standard and DMC criteria; all target compounds < CRQL except methylene chloride, acetone, and 2-butanone which must be < 2 times the CRQL	Method Blank	A
		contamination	must meet all internal standard and DMC criteria; all target compounds < CRQL	Instrument blank	A
		accuracy	surrogate recovery must meet % recovery criteria in SOM01.1 SOW	Deuterated Monitoring Compounds (DMC)	A
		precision/accuracy	must meet relative RT criteria; should meet advisory % recovery and RPD criteria in SOM01.1 SOW	MS/MSD	S&A
		contamination/bias	same as method blank	Storage Blank	A

[1]Reference number from QAPP Worksheet #21.

[2]TBD when laboratory is selected for specific events.

EPA = U.S. Environmental Protection Agency

CLP = Contract laboratory program

CRQL = Contract Required Quantitation Limit

RPD = Relative Percent Difference

SOW = Statement of Work

QAPP Worksheet #12-16
Measurement Performance Criteria Table

Matrix	Water /Groundwater
Analytical Group	Semivolatile Organic Compounds
Concentration Level	Low/Medium (SOM01.1)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
B-1, B-2, G-2	EPA CLP SOM01.1	contamination	must meet all internal standard and DMC criteria in SOM01.1 SOW; all target compounds < CRQL except bis-(2-ethylhexyl)phalate which must be < 5 times CRQL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 25% for water/groundwater	Field Duplicate	S&A
		contamination/bias	must meet all internal standard and DMC criteria in SOM01.1 SOW; all target compounds < CRQL except bis-(2-ethylhexyl)phalate which must be < 5 times CRQL	Method Blank	A
		accuracy	surrogate recovery must meet % recovery criteria in SOM01.1 SOW	Deuterated Monitoring Compounds (DMC)	A
		precision/accuracy	must meet relative RT criteria; should meet advisory spike recovery and RPD criteria in the SOM01.1 SOW	Matrix spike/Matrix spike duplicate	S&A

[1]Reference number from QAPP Worksheet #21.

[2]TBD when laboratory is selected for specific events.

EPA = U.S. Environmental Protection Agency
CLP = Contract laboratory program
CRQL = Contract Required Quantitation Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-17
Measurement Performance Criteria Table

Matrix	Water/Groundwater
Analytical Group	Semivolatile Organic Compounds
Concentration Level	Selected Ion Monitoring (SIM) (SOM01.1)

Sampling Procedure[1]	**Analytical Method/SOP**[2]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
B-1, B-2. G-2	EPA CLP SOM01.1	contamination	must meet all internal standard and DMC criteria in SOM01.1 SOW; all target compounds < CRQL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 25% for water/groundwater	Field Duplicate	S&A
		contamination	must meet all internal standard and DMC criteria in SOM01.1 SOW; all target compounds < CRQL	Method Blank	A
		accuracy	surrogate recovery must meet internal standard relative RT criteria; must meet % recovery criteria in SOM01.1 SOW	Deuterated Monitoring Compounds (DMC)	A
		precision/accuracy	must meet relative RT criteria; should meet advisory spike recovery and RPD criteria in the SOM01.1 SOW	MS/MSD	S&A

[1]Reference number from QAPP Worksheet #21.
[2]TBD when laboratory is selected for specific events.
EPA = U.S. Environmental Protection Agency
CLP = Contract laboratory program
CRQL = Contract Required Quantitation Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-18
Measurement Performance Criteria Table

Matrix	Water/Groundwater
Analytical Group	Organochlorine Pesticides
Concentration Level	Low (SOM01.1)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
B-1, B-2, G-2	EPA CLP SOM01.1	contamination	all target compounds < CRQL; surrogates must be within RT windows; surrogate recoveries must be within 30-150%	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 25% for water/groundwater	Field Duplicate	S&A
		contamination/bias	all target compounds < CRQL; surrogates must be within RT windows; surrogate recoveries must be within 30-150%	Method Blank	A
		contamination/bias	same as method blank	Sulfur Blank	A
		contamination/bias	all target compounds < CRQL; surrogates must be within RT windows	Instrument Blank	A
		accuracy	surrogates must be within RT windows; surrogate recoveries must be with 30-150%;spike recoveries must meet criteria in SOM01.1 SOW	Laboratory Control Sample	A
		accuracy	must be within RT windows; must meet % recovery criteria in SOM01.1 SOW	Surrogate Spikes	A
		precision/accuracy	surrogates must be within RT windows; should meet advisory spike recovery and RPD criteria in SOM01.1 SOW	Matrix spike/Matrix spike duplicate	S&A

[1]Reference number from QAPP Worksheet #21.
[2]TBD when laboratory is selected for specific events.
EPA = U.S. Environmental Protection Agency
CLP = Contract laboratory program
CRQL = Contract Required Quantitation Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-19
Measurement Performance Criteria Table

Matrix	Water/Groundwater
Analytical Group	Polychlorinated Biphenyls
Concentration Level	Low (SOM01.1)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
B-1, B-2, G-2	EPA CLP SOM01.1	contamination	target compounds must be < CRQL; surrogates must be within the RT window and within the recovery range of 30-150%	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 25% for water/groundwater	Field Duplicate	S&A
		contamination/bias	target compounds must be < CRQL; surrogates must be within the RT window and within the recovery range of 30-150%	Method Blank	A
		contamination/bias	same as method blank	Sulfur Cleanup Blank	A
		contamination/bias	target compounds must be < CRQL; surrogates must be within the RT window	Instrument Blank	A
		accuracy	surrogates must be within the RT window and within the recovery range of 30-150%; spike recoveries must be within the range specified in the SOM01.1 SOW	LCS	A
		accuracy	meet be within the RT window; must meet % recovery criteria in SOM01.1 SOW	Surrogate Spikes	A
		precision/accuracy	surrogates must be within RT windows; spike recoveries should be within advisory recovery and RPD limits stated in the SOM01.1 SOW	MS/MSD	S&A

[1]Reference number from QAPP Worksheet #21.
[2]TBD when laboratory is selected for specific events.
EPA = U.S. Environmental Protection Agency
CLP = Contract laboratory program
CRQL = Contract Required Quantitation Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-20
Measurement Performance Criteria Table

Matrix	Water/Groundwater
Analytical Group	Explosives
Concentration Level	Normal (8330)

Sampling Procedure[1]	**Analytical Method/SOP**[2]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
B-1, B-2, G-2	SW-846 8330	contamination	no target compounds > the reporting limit; surrogate recovery must be within the limits of 39-132%	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 25% for water/groundwater	Field Duplicate	S&A
		contamination/bias	no target compounds > the reporting limit; surrogate recovery must be within the limits of 39-132%	Method Blank	A
		accuracy/bias	surrogate recovery must be within the limits of 39-132%; spike recovery limits must be within the range of 50-150%	LCS	A
		precision/accuracy	spike recovery limits are 50-150%; RPD limts are 30%	MS/MSD	S&A

[1]Reference number from QAPP Worksheet #21.

[2]TBD when laboratory is selected for specific events.

RL = Reporting Limit

RPD = Relative Percent Difference

SOW = Statement of Work

QAPP Worksheet #12-21
Measurement Performance Criteria Table

Matrix	Soil/Sediment
Analytical Group	Perchlorate
Concentration Level	Medium (DoD Perchlorate Handbook)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
B-1, B-2, G-2	Methodology listed in DoD Perchlorate Handbook, March 2006	contamination	no target compounds > 1/2 the reporting limit	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 20% for water/groundwater	Field Duplicate	S&A
		contamination/bias	no target compounds > 1/2 the reporting limit	Method Blank	A
		accuracy/bias	spike recovery limits must be within the range of 85-115%	LCS	A
		precision/accuracy	spike recovery limits are 75-125%; RPD limts are 20%	MS/MSD	S&A

[1]Reference number from QAPP Worksheet #21.

[2]TBD when laboratory is selected for specific events.

RL = Reporting Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-22
Measurement Performance Criteria Table

Matrix	Water/Groundwater
Analytical Group	Metals
Concentration Level	Low/Medium (ILM05.3)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
B-1, B-2, B-4, B-5, G-2, G-3	EPA CLP ILM05.3	contamination	absolute values of all analyte concentrations must be < the CRQL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 25% for water/groundwater	Field Duplicate	S&A
		accuracy	analyte recovery must fall within the limits of 70-130% (50-150 for antimony, lead, and thallium)	CRQL Check Standard (CRI)	A
		contamination/bias	All analytes must be < the CRQL	Calibration Blank	A
		contamination/bias	absolute values of all analyte concentrations must be < the CRQL	Preparation blank	A
		accuracy/bias	must be within ± 2x the CRQL of the analyte's true value or ± 20% of the analyte's true value, whichever is greater	Interference Check Sample (ICS)	A
		accuracy/bias	spike recovery limits are 75-125%	Matrix Spike	S&A
		accuracy	must meet the recovery limits of 20% of the true value	LCS	A
		precision/accuracy	RPD of 20%, if concentration is > 5x CRQL; or ± the CRQL if the concentration is < 5x CRQL	Laboratory Duplicate	A
		precision/accuracy	should agree within 10% of the undiluted sample	Serial Dilution	A

[1]Reference number from QAPP Worksheet #21.

[2]TBD when laboratory is selected for specific events.

EPA = U.S. Environmental Protection Agency
CLP = Contract laboratory program
CRQL = Contract Required Quantitation Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-23
Measurement Performance Criteria Table

Matrix	Water/Groundwater
Analytical Group	Total Petroleum Hydrocarbons
Concentration Level	Normal (8015M)

Sampling Procedure[1]	**Analytical Method/SOP**[2]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
B-1, B-2, G-2	SW-846 8015M	contamination	all target compound < RL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank, Trip Blank)	S
		precision	should meet RPD criteria of 25% for water/groundwater	Field Duplicate	S&A
		contimination/bias	all target compound < RL	Method Blank	A
		accuracy	must meet the recovery limits of 50-150 for DRO; must meet recovery limits of 75-110 for GRO	LCS	A
		accuracy/precision	should meet the spike recovery limits of 50-142 and RPD of 20 for GRO; should meet the spike recovery limits fo 50-150 fand RPD of 25 for DRO	MS/MSD	S&A

[1]Reference number from QAPP Worksheet #21.

[2]TBD when laboratory is selected for specific events.

SOP = Standard Operating Procedure
RL = Reporting Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-24
Measurement Performance Criteria Table

Matrix	Water/Groundwater
Analytical Group	Wet Chemistry
Concentration Level	Normal (various)

Sampling Procedure[1]	Analytical Method/SOP[2]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
B-1, B-2, G-2	MCAWW 160.2	contamination	all target compound < RL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 25% for water/groundwater	Field Duplicate	S&A
		contamination/bias	all target compound < RL	Calibration Blank	A
		contamination/bias	all target compound < RL	Method Blank	A
		accuracy	spike recovery limits ± 10%	LCS	A
		precision/accuracy	spike recovery limits ± 20%; RPD of 20%	MS/MSD	S&A
		contamination/bias	< reporting limit	Method Blank	A
		accuracy	spike revcovery limits ± 10%	LCS	A
		precision	RPD limits 20%	Laboratory Duplicate	A

[1]Reference number from QAPP Worksheet #21.

[2]TBD when laboratory is selected for specific events.

MCAWW = Meth MCAWW = Methods for c MCAWW = Methods for chen MCAWW = Methods for chemical Ana MCAWW = Methods for chemica MCAWW = Methods for chemical Analysis of Water and
SOP = Standard Operating Procedures
RL = Contract Required Quantitation Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-25
Measurement Performance Criteria Table

Matrix	Water/Groundwater
Analytical Group	Wet Chemistry
Concentration Level	Normal (various)

Sampling Procedure[1]	**Analytical Method/SOP**[2]	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
B-1, B-2, G-2	MCAWW 130.2	contamination	all target compound < RL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 25% for water/groundwater	Field Duplicate	S&A
		contamination/bias	all target compound < RL	Calibration Blank	A
		contamination/bias	all target compound < RL	Method Blank	A
		accuracy	spike recovery limits ± 10%	LCS	A
		precision/accuracy	spike recovery limits ± 20%; RPD of 20%	MS/MSD	S&A
		contamination/bias	< reporting limit	Method Blank	A
		accuracy	spike revcovery limits ± 10%	LCS	A
		precision	RPD limits 20%	Laboratory Duplicate	A

[1]Reference number from QAPP Worksheet #21.

[2]TBD when laboratory is selected for specific events.
MCAWW = Methods for chemical Analysis of Water and Wastes
SOP = Standard Operating Procedures
RL = Contract Required Quantitation Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #12-26
Measurement Performance Criteria Table

Matrix	Water/Groundwater
Analytical Group	Wet Chemistry
Concentration Level	Normal (various)

Sampling Procedure[1]	**Analytical Method/SOP[2]**	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)**
B-1, B-2, G-2	EPA 300.0	contamination	all target compound < RL	Field Blanks (Equipment Rinsate Blank, Ambient Field Blank)	S
		precision	should meet RPD criteria of 25% for water/groundwater	Field Duplicate	S&A
		contamination/bias	all target compound < RL	Calibration Blank	A
		contamination/bias	all target compound < RL	Method Blank	A
		accuracy	spike recovery limits ± 10%	LCS	A
		precision/accuracy	spike recovery limits ± 20%; RPD of 20%	MS/MSD	S&A
		contamination/bias	< reporting limit	Method Blank	A
		accuracy	spike revcovery limits ± 10%	LCS	A
		precision	RPD limits 20%	Laboratory Duplicate	A

[1]Reference number from QAPP Worksheet #21.
[2]TBD when laboratory is selected for specific events.
EPA = U.S. Environmental Protection Agency
SOP = Standard Operating Procedures
RL = Contract Required Quantitation Limit
RPD = Relative Percent Difference
SOW = Statement of Work

QAPP Worksheet #13
Secondary Data Criteria and Limitations Table

Secondary Data	Data Source (Originating Organization, Report Title, and Date)	Data Generator(s) (Originating Org., Data Types, Data Generation/ Collection Dates)	How Data Will Be Used	Limitations on Data Use
Site specific	Site specific	Site specific	Site specific	Site specific

QAPP Worksheet #14
Summary of Project Tasks

Sampling Tasks:

1. Monitor groundwater and surface water quality parameters of temperature, pH, dissolved oxygen (DO), turbidity, oxidation reduction potential (ORP), and specific conductance.
2. Organic vapor monitoring.
3. Conduct geophysical surveys including electromagnetic induction (EM), ground penetrating radar (GPR), magnetometry, and downhole geophysics.
4. Collect surface water, sediment, surface and subsurface soil, and groundwater samples.
5. Install, develop, and abandon monitoring wells.
6. Advance and then backfill subsurface soil borings.
7. Characterize lithology during subsurface drilling.
8. Conduct aquifer testing through slug tests, step-drawdown pumping tests, and constant-rate pumping tests.
9. Collect surface water and groundwater level measurements.
10. Excavate test pits/trenches.
11. Survey sample locations, elevations, and grids.
12. Dispose of investigation derived wastes (IDW).
13. Decontaminate reusable equipment that comes in contact with environmental samples.
14. Monitor ambient air determine the presence of organic and/or explosive vapors that may pose a health risk.

Analysis Tasks:

1. The laboratory will process, prepare, and analyze environmental samples such as groundwater, surface water, sediment, soil, and aquatic biota.
2. The laboratory will perform routine analysis of environmental samples for such analyte groups as target compound list (TCL) volatile organic compounds (VOCs), TCL semivolatile organic compounds (SVOCs), target analyte list (TAL) metals, TCL pesticides/polychlorinated biphenyls (PCBs). Additionally, on a case specific basis, total petroleum hydrocarbons (TPH), explosives, and perchlorates may be analyzed.

Quality Control Tasks:

1. Implement SOPs for field and laboratory activities being performed.
2. QC samples are described on Worksheet #28.

QAPP Worksheet #14
Summary of Project Tasks

Secondary Data:

1. See Worksheet #13.

Data Management Tasks:

1. Analytical data will be placed in a database after validation. See Data Management Plan, Attachment 4.

Documentation and Records:

1. See Worksheet #29.

Assessment/Audit Tasks:

1. See Worksheets #31 and #32.

Data Review Tasks:

1. See Worksheets #35 and #36 for data validation tasks.
2. See Worksheet #37 for data usability assessment tasks.

QAPP Worksheet #15-1
Reference Limits and Evaluation Table

Matrix: Soil
Analytical Group: Volatile Organic Compounds
Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
					MDLs	Method QLs	MDLs	QLs
Dichlorodifluoromethane	75-71-8	9400 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Chloromethane	74-87-3	4700 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Vinyl Chloride	75-01-4	79 µg/kg	10 µg/kg [3]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Bromomethane	74-83-9	390 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Chloroethane	75-00-3	3000 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Trichlorofluoromethane	75-69-4	39000 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,1-Dichloroethene	75-35-4	12000 µg/kg	100 µg/kg [3]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	2100000 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Acetone	67-64-1	1400000 µg/kg	NA	10 µg/kg	N/A	10 µg/kg	TBD	10 µg/kg
Carbon Disulfide	75-15-0	36000 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Methyl Acetate	79-20-9	2200000 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Methylene Chloride	75-09-2	9100 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
trans-1,2-Dichloroethene	156-60-5	6900 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Methyl tert-Butyl Ether	1634-04-4	32000 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,1-Dichloroethane	75-34-3	51000 µg/kg	20 µg/kg [3]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
cis-1,2-Dichloroethene	156-59-2	4300 µg/kg	200 µg/kg [3]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
2-Butanone	78-93-3	2200000 µg/kg	NA	10 µg/kg	N/A	10 µg/kg	TBD	10 µg/kg
Bromochloromethane	74-97-5	820 µg/kg*	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Chloroform	67-66-3	220 µg/kg	20 µg/kg [3]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,1,1-Trichloroethane	71-55-6	200000 µg/kg	70 µg/kg [3]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Cyclohexane	110-82-7	140000 µg/kg	100 µg/kg [5]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Carbon Tetrachloride	56-23-5	220 µg/kg	1000000 µg/kg [4]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Benzene	71-43-2	640 µg/kg	10 µg/kg [3]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,2-Dichloroethane	107-06-2	280 µg/kg	20 µg/kg [3]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,4-Dioxane	123-91-1	44000 µg/kg	NA	100 µg/kg	N/A	100 µg/kg	TBD	100 µg/kg
Trichloroethene	79-01-6	53 µg/kg	100 µg/kg [3]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Methylcyclohexane	108-87-2	260000 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,2-Dichloropropane	78-87-5	340 µg/kg	700000 µg/kg [4]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Bromodichloromethane	75-27-4	820 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
cis-1,3-Dichloropropene	10061-01-5	780 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
4-Methyl-2-pentanone	108-10-1	530000 µg/kg	NA	10 µg/kg	N/A	10 µg/kg	TBD	10 µg/kg
Toluene	108-88-3	66000 µg/kg	200000 µg/kg [6]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
trans-1,3-Dichloropropene	10061-02-6	780 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,1,2-Trichloroethane	79-00-5	730 µg/kg	400 µg/kg [3]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Tetrachloroethene	127-18-4	480 µg/kg	2 µg/kg [3]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
2-Hexanone	591-78-6	310000 µg/kg	NA	10 µg/kg	N/A	10 µg/kg	TBD	10 µg/kg
Dibromochloromethane	124-48-1	1100 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,2-Dibromoethane	106-93-4	32 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Chlorobenzene	108-90-7	15000 µg/kg	40000 µg/kg [4]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Ethylbenzene	100-41-4	190000 µg/kg	30 µg/kg [3]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
m,p-Xylene	NA	2700 µg/kg**	100 µg/kg [3]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
o-Xylene	95-47-6	2700 µg/kg**	100 µg/kg [3]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Styrene	100-42-5	440000 µg/kg	300000 µg/kg [6]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Bromoform	75-25-2	62000 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Isopropylbenzene	98-82-8	57000 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,1,2,2-Tetrachloroethane	79-34-5	410 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,3-Dichlorobenzene	541-73-1	53000 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,4-Dichlorobenzene	106-46-7	3400 µg/kg	20000 µg/kg [4]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,2-Dichlorobenzene	95-50-1	110000 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,2-Dibromo-3-chloropropane	96-12-8	210 µg/kg	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,2,4-Trichlorobenzene	120-82-1	6200 µg/kg	20000 µg/kg [4]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,2,3-Trichlorobenzene	87-61-6	6200 µg/kg***	20000 µg/kg [4]	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

* = Bromodichloromethane PRG value used as surrogate.

** = Total xylene PRG value used as surrogate.

*** = 1,2,4-Trichlorobenzene PRG value used as surrogate.

NA = Not Available

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

[3] Ministry of Housing, Spatial Planning and Environment, 2000

[4] Efroymson, 1997a

[5] Beyer, 1990

[6] Efroymson, 1997b

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

Shading represents Screening Values which are below Project Quantitation Limits.

QAPP Worksheet #15-2
Reference Limits and Evaluation Table

Matrix: Sediment

Analytical Group: Volatile Organic Compounds

Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater	Marine [3]		MDLs	Method QLs	MDLs	QLs
Dichlorodifluoromethane	75-71-8	9400 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Chloromethane	74-87-3	4700 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Vinyl Chloride	75-01-4	79 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Bromomethane	74-83-9	390 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Chloroethane	75-00-3	3000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Trichlorofluoromethane	75-69-4	39000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,1-Dichloroethene	75-35-4	12000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	2100000	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Acetone	67-64-1	1400000 µg/kg	NA	NA	10 µg/kg	N/A	10 µg/kg	TBD	10 µg/kg
Carbon Disulfide	75-15-0	36000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Methyl Acetate	79-20-9	2200000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Methylene Chloride	75-09-2	9100 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
trans-1,2-Dichloroethene	156-60-5	6900 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Methyl tert-Butyl Ether	1634-04-4	32000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,1-Dichloroethane	75-34-3	51000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
cis-1,2-Dichloroethene	156-59-2	4300 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
2-Butanone	78-93-3	2200000 µg/kg	NA	NA	10 µg/kg	N/A	10 µg/kg	TBD	10 µg/kg
Bromochloromethane	74-97-5	820 µg/kg*	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Chloroform	67-66-3	220 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,1,1-Trichloroethane	71-55-6	200000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Cyclohexane	110-82-7	140000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Carbon Tetrachloride	56-23-5	220 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Benzene	71-43-2	640 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,2-Dichloroethane	107-06-2	280 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,4-Dioxane	123-91-1	44000 µg/kg	NA	NA	100 µg/kg	N/A	100 µg/kg	TBD	100 µg/kg
Trichloroethene	79-01-6	53 µg/kg4	NA	41 µg/kg	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Methylcyclohexane	108-87-2	260000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,2-Dichloropropane	78-87-5	340 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Bromodichloromethane	75-27-4	820 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
cis-1,3-Dichloropropene	10061-01-5	780 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
4-Methyl-2-pentanone	108-10-1	530000 µg/kg	NA	NA	10 µg/kg	N/A	10 µg/kg	TBD	10 µg/kg
Toluene	108-88-3	66000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
trans-1,3-Dichloropropene	10061-02-6	780 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,1,2-Trichloroethane	79-00-5	730 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Tetrachloroethene	127-18-4	480 µg/kg	NA	57 µg/kg	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
2-Hexanone	591-78-6	310000 µg/kg	NA	NA	10 µg/kg	N/A	10 µg/kg	TBD	10 µg/kg
Dibromochloromethane	124-48-1	1100 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,2-Dibromoethane	106-93-4	32 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Chlorobenzene	108-90-7	15000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Ethylbenzene	100-41-4	190000 µg/kg	NA	4 µg/kg	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
m,p-Xylene	NA	2700 µg/kg**	NA	4 µg/kg	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
o-Xylene	95-47-6	2700 µg/kg**	NA	4 µg/kg	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Styrene	100-42-5	440000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Bromoform	75-25-2	62000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
Isopropylbenzene	98-82-8	57000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,1,2,2-Tetrachloroethane	79-34-5	410 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,3-Dichlorobenzene	541-73-1	53000 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,4-Dichlorobenzene	106-46-7	3400 µg/kg	NA	110 µg/kg	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,2-Dichlorobenzene	95-50-1	110000 µg/kg	NA	13 µg/kg	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,2-Dibromo-3-chloropropane	96-12-8	210 µg/kg	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,2,4-Trichlorobenzene	120-82-1	6200 µg/kg	NA	4.8 µg/kg	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg
1,2,3-Trichlorobenzene	87-61-6	6200 µg/kg***	NA	NA	5 µg/kg	N/A	5 µg/kg	TBD	5 µg/kg

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] National Oceanic and Atmospheric Association, Buchman,1999

[4] Based on Cal/EPA toxicity values.

* = Bromodichloromethane PRG value used as surrogate.

** = Total xylene PRG value used as surrogate.

*** = 1,2,4-Trichlorobenzene PRG value used as surrogate.

NA = Not Available

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

Shading represents Screening Values which are below Project Quantitation Limits.

QAPP Worksheet #15-3
Reference Limits and Evaluation Table

Matrix: Soil
Analytical Group: Semi Volatile Organic Compounds
Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
					MDLs	Method QLs	MDLs	QLs
Benzaldehyde	100-52-7	610000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Phenol	108-95-2	1800000 µg/kg	30000 µg/kg [3]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
bis-(2-Chloroethyl) ether	111-44-4	220 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2-Chlorophenol	95-57-8	6300 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2-Methylphenol	95-48-7	310000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,2'-oxybis(1-Chloropropane)	108-60-1	2900 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Acetophenone	98-86-2	780000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
4-Methylphenol	106-44-5	31000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
N-Nitroso-di-n propylamine	621-64-7	69 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Hexachloroethane	67-72-1	6100 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Nitrobenzene	98-95-3	2000 µg/kg	40000 µg/kg [3]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Isophorone	78-59-1	510000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2-Nitrophenol	88-75-5	6300 µg/kg*	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,4-Dimethylphenol	105-67-9	120000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
bis(2-Chloroethoxy) methane	111-91-1	2900 µg/kg**	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,4-Dichlorophenol	120-83-2	18000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Naphthalene	91-20-3	5600 µg/kg	100 µg/kg [4]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
4-Chloroaniline	106-47-8	24000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Hexachlorobutadiene	87-68-3	1800 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Caprolactam	105-60-2	31000000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
4-Chloro-3-methylphenol	59-50-7	6300 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2-Methylnaphthalene	91-57-6	160000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
1,2,4,5-Tetrachlorobenzene	95-94-3	1800 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Hexachlorocyclo-pentadiene	77-47-4	37000 µg/kg	10000 µg/kg [5]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,4,6-Trichlorophenol	88-06-2	610 µg/kg	10000 µg/kg [3]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,4,5-Trichlorophenol	95-95-4	610000 µg/kg	4000 µg/kg [5]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
1,1'-Biphenyl	92-52-4	300000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2-Chloronaphthalene	91-58-7	490000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2-Nitroaniline	88-74-4	180000 µg/kg	NA	330 µg/kg	N/A	330 µg/kg	TBD	330 µg/kg
Dimethylphthalate	131-11-3	61000000 µg/kg	200000 µg/kg [3]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,6-Dinitrotoluene	606-20-2	6100 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Acenaphthylene	208-96-8	370000 µg/kg [6]	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
3-Nitroaniline	99-09-2	1800 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Acenaphthene	83-32-9	370000 µg/kg	20000 µg/kg [5]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,4-Dinitrophenol	51-28-5	12000 µg/kg	20000 µg/kg [5]	330 µg/kg	N/A	330 µg/kg	TBD	330 µg/kg
4-Nitrophenol	100-02-7	2000 µg/kg [7]	7000 µg/kg [3]	330 µg/kg	N/A	330 µg/kg	TBD	330 µg/kg
Dibenzofuran	132-64-9	15000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,3,4,6-Tetrachlorophenol	58-90-2	180000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,4-Dinitrotoluene	121-14-2	12000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Diethylphthalate	84-66-2	4900000 µg/kg	100000 µg/kg [5]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Fluorene	86-73-7	270000 µg/kg	30000 µg/kg [3]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
4-Chlorophenyl-phenyl ether	7005-72-3	2900 µg/kg**	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
4-Nitroaniline	100-01-6	18000 µg/kg	NA	330 µg/kg	N/A	330 µg/kg	TBD	330 µg/kg
4,6-Dinitro-2-methylphenol	534-52-1	610 µg/kg	NA	330 µg/kg	N/A	330 µg/kg	TBD	330 µg/kg
N-Nitroso diphenylamine	86-30-6	99000 µg/kg	20000 µg/kg [3]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
4-Bromophenyl-phenylether	101-55-3	2900 µg/kg**	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Hexachlorobenzene	118-74-1	300 µg/kg	1000000 µg/kg [3]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Atrazine	1912-24-9	2200 µg/kg	0.2 µg/kg [8]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Pentachlorophenol	87-86-5	3000 µg/kg	3000 µg/kg [5]	330 µg/kg	N/A	330 µg/kg	TBD	330 µg/kg
Phenanthrene	85-01-8	230000 µg/kg****	100 µg/kg [4]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Anthracene	120-12-7	2200000 µg/kg	100 µg/kg [4]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Carbazole	86-74-8	24000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Di-n-butylphthalate	84-74-2	610000 µg/kg	200000 µg/kg [5]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Fluoranthene	206-44-0	230000 µg/kg	100 µg/kg [4]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Pyrene	129-00-0	230000 µg/kg	100 µg/kg [4]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Butylbenzylphthalate	85-68-7	1200000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
3,3'-Dichlorobenzidine	91-94-1	1100 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Benzo(a)anthracene	56-55-3	620 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Chrysene	218-01-9	62000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
bis(2-Ethylhexyl) phthalate	117-81-7	35000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Di-n-octylphthalate	117-84-0	240000 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Benzo(b)fluoranthene	205-99-2	620 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Benzo(k)fluoranthene	207-08-9	6200 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Benzo(a)pyrene	50-32-8	62 µg/kg	100 µg/kg [4]	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Indeno(1,2,3-cd)-pyrene	193-39-5	620 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Dibenzo(a,h)-anthracene	53-70-3	62 µg/kg	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Benzo(g,h,i)perylene	191-24-2	2300000 µg/kg	\A	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.
[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.
[3] Efroymson, 1997a
[4] Beyer, 1990
[5] Efroymson, 1997b
[6] Acenaphthene PRG value used as surrogate.
[7] Nitrobenzene PRG value used as a surrogate.
[8] Ministry of Housing, Spatial Planning and Environment, 2000
* = 2-Chlorophenol PRG value used as surrogate PRG value for 2-Nitrophenol.
** = Bis(2-Chloro)isopropyl ether PRG value used as surrogate.
*** = 2-chlorophenol PRG value used as surrogate PRG value for 4-methyl-3-methylphenol.
**** = Pyrene PRG value used as surrogate PRG value for phenanthrene.
Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
Shading represents Screening Values which are below Project Quantitation Limits.
NA = Not Available
Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-4
Reference Limits and Evaluation Table

Matrix: Soil

Analytical Group: Semi Volatile Organic Compounds
Concentration Level: Low (SOM01.1 SIM)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
					MDLs	Method QLs	MDLs	QLs
Naphthalene	91-20-3	5600 µg/kg	100 µg/kg [4]	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
2-Methylnaphthalene	91-57-6	160000 µg/kg	NA	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Acenaphthylene	208-96-8	370000 µg/kg**	NA	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Acenaphthene	83-32-9	370000 µg/kg	20000 µg/kg [5]	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Fluorene	86-73-7	270000 µg/kg	30000 µg/kg [3]	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Pentachlorophenol	87-86-5	3000 µg/kg	3000 µg/kg [5]	6.7 µg/kg	N/A	6.7 µg/kg	TBD	6.7 µg/kg
Phenanthrene	85-01-8	230000 µg/kg*	100 µg/kg [4]	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Anthracene	120-12-7	2200000 µg/kg	100 µg/kg [4]	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Fluoranthene	206-44-0	230000 µg/kg	100 µg/kg [4]	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Pyrene	129-00-0	230000 µg/kg	100 µg/kg [4]	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Benzo(a)anthracene	56-55-3	620 µg/kg	NA	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Chrysene	218-01-9	62000 µg/kg	NA	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Benzo(b)fluoranthene	205-99-2	620 µg/kg	NA	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Benzo(k)fluoranthene	207-08-9	6200 µg/kg	NA	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Benzo(a)pyrene	50-32-8	62 µg/kg	100 µg/kg [4]	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Indeno(1,2,3-cd)-pyrene	193-39-5	620 µg/kg	NA	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Dibenzo(a,h)-anthracene	53-70-3	62 µg/kg	NA	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Benzo(g,h,i)perylene	191-24-2	2300000 µg/kg	NA	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] Efroymson, 1997a

[4] Beyer, 1990

[5] Efroymson, 1997b

* = Pyrene PRG value used as surrogate PRG value for phenanthrene.

** Acenaphthene PRG value used as surrogate.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-5
Reference Limits and Evaluation Table

Matrix: Sediment
Analytical Group: Semi Volatile Organic Compounds
Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater [3]	Marine [3]		MDLs	Method QLs	MDLs	QLs
Benzaldehyde	100-52-7	610000 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Phenol	108-95-2	1800000 µg/kg	NA	130 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
bis-(2-Chloroethyl) ether	111-44-4	220 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2-Chlorophenol	95-57-8	6300 µg/kg	NA	8 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2-Methylphenol	95-48-7	310000 µg/kg	NA	8 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,2'-oxybis(1-Chloropropane)	108-60-1	2900 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Acetophenone	98-86-2	780000 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
4-Methylphenol	106-44-5	31000 µg/kg	NA	100 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
N-Nitroso-di-n propylamine	621-64-7	69 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Hexachloroethane	67-72-1	6100 µg/kg	NA	73 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Nitrobenzene	98-95-3	2000 µg/kg	NA	21 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Isophorone	78-59-1	510000 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2-Nitrophenol	88-75-5	6300 µg/kg*	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,4-Dimethylphenol	105-67-9	120000 µg/kg	NA	18 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
bis(2-Chloroethoxy) methane	111-91-1	2900 µg/kg**	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,4-Dichlorophenol	120-83-2	18000 µg/kg	NA	5 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Naphthalene	91-20-3	5600 µg/kg	14.65 µg/kg	160 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
4-Chloroaniline	106-47-8	24000 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Hexachlorobutadiene	87-68-3	1800 µg/kg	NA	1.3 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Caprolactam	105-60-2	3100000 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
4-Chloro-3-methylphenol	59-50-7	6300 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2-Methylnaphthalene	91-57-6	160000 µg/kg	NA	70 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
1,2,4,5-Tetrachlorobenzene	95-94-3	1800 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Hexachlorocyclo-pentadiene	77-47-4	37000 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,4,6-Trichlorophenol	88-06-2	610 µg/kg	NA	6 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,4,5-Trichlorophenol	95-95-4	610000 µg/kg	NA	3 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
1,1'-Biphenyl	92-52-4	300000 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2-Chloronaphthalene	91-58-7	490000 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2-Nitroaniline	88-74-4	180000 µg/kg	NA	NA	330 µg/kg	N/A	330 µg/kg	TBD	330 µg/kg
Dimethylphthalate	131-11-3	61000000 µg/kg	NA	6 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,6-Dinitrotoluene	606-20-2	6100 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Acenaphthylene	208-96-8	370000 µg/kg4	NA	44 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
3-Nitroaniline	99-09-2	1800 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Acenaphthene	83-32-9	370000 µg/kg	NA	16 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,4-Dinitrophenol	51-28-5	12000 µg/kg	NA	NA	330 µg/kg	N/A	330 µg/kg	TBD	330 µg/kg
4-Nitrophenol	100-02-7	2000 µg/kg5	NA	NA	330 µg/kg	N/A	330 µg/kg	TBD	330 µg/kg
Dibenzofuran	132-64-9	15000 µg/kg	NA	110 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,3,4,6-Tetrachlorophenol	58-90-2	180000 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
2,4-Dinitrotoluene	121-14-2	12000 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Diethylphthalate	84-66-2	4900000 µg/kg	NA	6 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Fluorene	86-73-7	270000 µg/kg	10 µg/kg	19 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
4-Chlorophenyl-phenyl ether	7005-72-3	2900 µg/kg**	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
4-Nitroaniline	100-01-6	18000 µg/kg	NA	NA	330 µg/kg	N/A	330 µg/kg	TBD	330 µg/kg
4,6-Dinitro-2-methylphenol	534-52-1	610 µg/kg	NA	NA	330 µg/kg	N/A	330 µg/kg	TBD	330 µg/kg
N-Nitroso diphenylamine	86-30-6	99000 µg/kg	NA	28 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
4-Bromophenyl-phenylether	101-55-3	2900 µg/kg**	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Hexachlorobenzene	118-74-1	300 µg/kg	NA	6 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Atrazine	1912-24-9	2200 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Pentachlorophenol	87-86-5	3000 µg/kg	NA	17 µg/kg	330 µg/kg	N/A	330 µg/kg	TBD	330 µg/kg
Phenanthrene	85-01-8	230000 µg/kg****	41.9 µg/kg	240 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Anthracene	120-12-7	2200000 µg/kg	10 µg/kg	85.3 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Carbazole	86-74-8	24000 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Di-n-butylphthalate	84-74-2	610000 µg/kg	NA	58 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Fluoranthene	206-44-0	230000 µg/kg	111 µg/kg	600 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Pyrene	129-00-0	230000 µg/kg	53 µg/kg	665 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Butylbenzylphthalate	85-68-7	1200000 µg/kg	NA	63 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
3,3'-Dichlorobenzidine	91-94-1	1100 µg/kg	NA	NA	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Benzo(a)anthracene	56-55-3	620 µg/kg	31.7 µg/kg	261 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Chrysene	218-01-9	62000 µg/kg	57.1 µg/kg	384 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
bis(2-Ethylhexyl) phthalate	117-81-7	35000 µg/kg	NA	182.16 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Di-n-octylphthalate	117-84-0	240000 µg/kg	NA	61 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Benzo(b)fluoranthene	205-99-2	620 µg/kg	NA	1800 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Benzo(k)fluoranthene	207-08-9	6200 µg/kg	27.2 µg/kg	1800 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Benzo(a)pyrene	50-32-8	62 µg/kg	31.9 µg/kg	430 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Indeno(1,2,3-cd)-pyrene	193-39-5	620 µg/kg	17.32 µg/kg	600 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Dibenzo(a,h)-anthracene	53-70-3	62 µg/kg	10 µg/kg	63.4 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg
Benzo(g,h,i)perylene	191-24-2	2300000 µg/kg	NA	670 µg/kg	170 µg/kg	N/A	170 µg/kg	TBD	170 µg/kg

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] National Oceanic and Atmospheric Association, Buchman,1999

[4] Acenaphthene PRG value used as surrogate.

[5] Nitrobenzene PRG value used as a surrogate.

* = 2-Chlorophenol PRG value used as surrogate PRG value for 2-Nitrophenol.

** = Bis(2-Chloro)isopropyl ether PRG value used as surrogate.

*** = 2-chlorophenol PRG value used as surrogate PRG value for 4-methyl-3-methylphenol.

**** = Pyrene PRG value used as surrogate PRG value for phenanthrene.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Shading represents Screening Values which are below Project Quantitation Limits.

NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-6
Reference Limits and Evaluation Table

Matrix: Sediment
Analytical Group: Semi Volatile Organic Compounds
Concentration Level: Low (SOM01.1 SIM)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater [3]	Marine [3]		MDLs	Method QLs	MDLs	QLs
Naphthalene	91-20-3	5600 µg/kg	14.65 µg/kg	160 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
2-Methylnaphthalene	91-57-6	160000 µg/kg	NA	70 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Acenaphthylene	208-96-8	370000 µg/kg**	NA	44 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Acenaphthene	83-32-9	370000 µg/kg	NA	16 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Fluorene	86-73-7	270000 µg/kg	10 µg/kg	19 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Pentachlorophenol	87-86-5	3000 µg/kg	NA	17 µg/kg	6.7 µg/kg	N/A	6.7 µg/kg	TBD	6.7 µg/kg
Phenanthrene	85-01-8	230000 µg/kg*	41.9 µg/kg	240 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Anthracene	120-12-7	2200000 µg/kg	10 µg/kg	85.3 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Fluoranthene	206-44-0	230000 µg/kg	111 µg/kg	600 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Pyrene	129-00-0	230000 µg/kg	53 µg/kg	665 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Benzo(a)anthracene	56-55-3	620 µg/kg	31.7 µg/kg	261 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Chrysene	218-01-9	62000 µg/kg	57.1 µg/kg	384 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Benzo(b)fluoranthene	205-99-2	620 µg/kg	NA	1800 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Benzo(k)fluoranthene	207-08-9	6200 µg/kg	27.2 µg/kg	1800 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Benzo(a)pyrene	50-32-8	62 µg/kg	31.9 µg/kg	430 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Indeno(1,2,3-cd)-pyrene	193-39-5	620 µg/kg	17.32 µg/kg	600 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Dibenzo(a,h)-anthracene	53-70-3	62 µg/kg	10 µg/kg	63.4 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg
Benzo(g,h,i)perylene	191-24-2	2300000 µg/kg	NA	670 µg/kg	3.3 µg/kg	N/A	3.3 µg/kg	TBD	3.3 µg/kg

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.
[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.
[3] National Oceanic and Atmospheric Association, Buchman,1999
* = Pyrene PRG value used as surrogate PRG value for phenanthrene.
** Acenaphthene PRG value used as surrogate.
Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
NA = Not Available
Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-7
Reference Limits and Evaluation Table

Matrix: Soil
Analytical Group: Organochlorine Pesticides
Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
					MDLs	Method QLs	MDLs	QLs
alpha-BHC	319-84-6	90 µg/kg	3 µg/kg [3]	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
beta-BHC	319-85-7	320 µg/kg	9 µg/kg [3]	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
delta-BHC	319-86-8	440 µg/kg	NA	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
gamma-BHC (Lindane)	58-89-9	440 µg/kg	0.05 µg/kg [3]	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
Heptachlor	76-44-8	110 µg/kg	0.7 µg/kg [3]	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
Aldrin	309-00-2	29 µg/kg	0.06 µg/kg [3]	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
Heptachlor epoxide	1024-57-3	53 µg/kg	0.0002 µg/kg [3]	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
Endosulfan I	959-98-8	37000 µg/kg	0.01 µg/kg [3]	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
Dieldrin	60-57-1	30 µg/kg	0.5 µg/kg [3]	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
4,4'-DDE	72-55-9	1700 µg/kg	10 µg/kg [3]	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
Endrin	72-20-8	1800 µg/kg	0.04 µg/kg [3]	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
Endosulfan II	33213-65-9	37000 µg/kg	0.01 µg/kg [3]	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
4,4'-DDD	72-54-8	2400 µg/kg	10 µg/kg [3]	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
Endosulfan sulfate	1031-07-8	37000 µg/kg	NA	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
4,4'-DDT	50-29-3	1700 µg/kg	10 µg/kg [3]	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
Methoxychlor	72-43-5	31000 µg/kg	NA	17 µg/Kg	N/A	17 µg/Kg	TBD	17 µg/Kg
Endrin ketone	53494-70-5	1800 µg/kg	100 µg/kg [4]	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
Endrin aldehyde	7421-93-4	1800 µg/kg	100 µg/kg [4]	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
alpha-Chlordane	5103-71-9	1600 µg/kg	NA	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
gamma-Chlordane	5103-74-2	1600 µg/kg	NA	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
Toxaphene	8001-35-2	440 µg/kg	NA	170 µg/Kg	N/A	170 µg/Kg	TBD	170 µg/Kg

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.
[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.
[3] Ministry of Housing, Spatial Planning and Environment, 2000
[4] Beyer, 1990
Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
NA = Not Available
Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.
Shading represents Screening Values which are below Project Quantitation Limits.

QAPP Worksheet #15-8
Reference Limits and Evaluation Table

Matrix: Sediment
Analytical Group: Organochlorine Pesticides
Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater [3]	Marine [3]		MDLs	Method QLs	MDLs	QLs
alpha-BHC	319-84-6	90 µg/kg	NA	NA	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
beta-BHC	319-85-7	320 µg/kg	NA	NA	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
delta-BHC	319-86-8	440 µg/kg	NA	NA	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
gamma-BHC (Lindane)	58-89-9	440 µg/kg	0.94 µg/kg	0.32 µg/kg	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
Heptachlor	76-44-8	110 µg/kg	NA	0.3 µg/kg	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
Aldrin	309-00-2	29 µg/kg	NA	9.5 µg/kg	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
Heptachlor epoxide	1024-57-3	53 µg/kg	0.6 µg/kg	NA	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
Endosulfan I	959-98-8	37000 µg/kg	NA	NA	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
Dieldrin	60-57-1	30 µg/kg	2.85 µg/kg	0.02 µg/kg	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
4,4'-DDE	72-55-9	1700 µg/kg	1.42 µg/kg	2.2 µg/kg	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
Endrin	72-20-8	1800 µg/kg	2.67 µg/kg	NA	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
Endosulfan II	33213-65-9	37000 µg/kg	NA	NA	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
4,4'-DDD	72-54-8	2400 µg/kg	3.54 µg/kg	2 µg/kg	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
Endosulfan sulfate	1031-07-8	37000 µg/kg	NA	NA	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
4,4'-DDT	50-29-3	1700 µg/kg	NA	1 µg/kg	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
Methoxychlor	72-43-5	31000 µg/kg	NA	NA	17 µg/Kg	N/A	17 µg/Kg	TBD	17 µg/Kg
Endrin ketone	53494-70-5	1800 µg/kg	NA	NA	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
Endrin aldehyde	7421-93-4	1800 µg/kg	NA	NA	3.3 µg/Kg	N/A	3.3 µg/Kg	TBD	3.3 µg/Kg
alpha-Chlordane	5103-71-9	1600 µg/kg	4.5 µg/kg	0.5 µg/kg	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
gamma-Chlordane	5103-74-2	1600 µg/kg	4.5 µg/kg	0.5 µg/kg	1.7 µg/Kg	N/A	1.7 µg/Kg	TBD	1.7 µg/Kg
Toxaphene	8001-35-2	440 µg/kg	NA	NA	170 µg/Kg	N/A	170 µg/Kg	TBD	170 µg/Kg

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] National Oceanic and Atmospheric Association, Buchman,1999

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

Shading represents Screening Values which are below Project Quantitation Limits.

QAPP Worksheet #15-9
Reference Limits and Evaluation Table

Matrix: Soil
Analytical Group: Polychlorinated Biphenyls
Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values [3]	Project Quantitation Limit Goal	Analytical Method [1]		Achievable Laboratory Limits [2]	
					MDLs	Method QLs	MDLs	QLs
Aroclor-1016	12674-11-2	390 µg/Kg	40000 µg/kg	33 µg/Kg	N/A	33 µg/Kg	TBD	33 µg/Kg
Aroclor-1221	11104-28-2	110 µg/Kg	40000 µg/kg	33 µg/Kg	N/A	33 µg/Kg	TBD	33 µg/Kg
Aroclor-1232	11141-16-5	110 µg/Kg	40000 µg/kg	33 µg/Kg	N/A	33 µg/Kg	TBD	33 µg/Kg
Aroclor-1242	53469-21-9	110 µg/Kg	40000 µg/kg	33 µg/Kg	N/A	33 µg/Kg	TBD	33 µg/Kg
Aroclor-1248	12672-29-6	110 µg/Kg	40000 µg/kg	33 µg/Kg	N/A	33 µg/Kg	TBD	33 µg/Kg
Aroclor-1254	11097-69-1	110 µg/Kg	40000 µg/kg	33 µg/Kg	N/A	33 µg/Kg	TBD	33 µg/Kg
Aroclor-1260	11096-82-5	110 µg/Kg	40000 µg/kg	33 µg/Kg	N/A	33 µg/Kg	TBD	33 µg/Kg

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] Efroymson, 1997b

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
NA = Not Available
Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-10
Reference Limits and Evaluation Table

Matrix: Sediment
Analytical Group: Polychlorinated Biphenyls
Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater [3]	Marine [3]		MDLs	Method QLs	MDLs	QLs
Aroclor-1016	12674-11-2	390 µg/Kg	34.1 µg/Kg [4]	22.7 µg/Kg [4]	33 µg/Kg	N/A	33 µg/Kg	TBD	33 µg/Kg
Aroclor-1221	11104-28-2	110 µg/Kg	34.1 µg/Kg [4]	22.7 µg/Kg [4]	33 µg/Kg	N/A	33 µg/Kg	TBD	33 µg/Kg
Aroclor-1232	11141-16-5	110 µg/Kg	34.1 µg/Kg [4]	22.7 µg/Kg [4]	33 µg/Kg	N/A	33 µg/Kg	TBD	33 µg/Kg
Aroclor-1242	53469-21-9	110 µg/Kg	34.1 µg/Kg [4]	22.7 µg/Kg [4]	33 µg/Kg	N/A	33 µg/Kg	TBD	33 µg/Kg
Aroclor-1248	12672-29-6	110 µg/Kg	34.1 µg/Kg [4]	22.7 µg/Kg [4]	33 µg/Kg	N/A	33 µg/Kg	TBD	33 µg/Kg
Aroclor-1254	11097-69-1	110 µg/Kg	34.1 µg/Kg [4]	22.7 µg/Kg [4]	33 µg/Kg	N/A	33 µg/Kg	TBD	33 µg/Kg
Aroclor-1260	11096-82-5	110 µg/Kg	34.1 µg/Kg [4]	22.7 µg/Kg [4]	33 µg/Kg	N/A	33 µg/Kg	TBD	33 µg/Kg

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] National Oceanic and Atmospheric Association, Buchman,1999

[4] Value represents total PCBs

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
NA = Not Available
Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.
Shading represents Screening Values which are below Project Quantitation Limits.

QAPP Worksheet #15-11
Reference Limits and Evaluation Table

Matrix: Soil
Analytical Group: Explosives
Concentration Level: Low/Medium (SW-846 8330)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
					MDLs	Method QLs	MDLs	QLs
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	310 mg/kg	NA	TBD	N/A	2.2 mg/kg	TBD	TBD
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	4.4 mg/kg	NA	TBD	N/A	1.0 mg/kg	TBD	TBD
1,3,5-Trinitrobenzene (1,3,5-TNB)	99-35-4	180 mg/kg	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
1,3-Dinitrobenzene (1,3-DNB)	99-65-0	0.610 mg/kg	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	61 mg/kg	NA	TBD	N/A	0.65 mg/kg	TBD	TBD
Nitrobenzene (NB)	98-95-3	2 mg/kg	40 mg/kg	TBD	N/A	0.26 mg/kg	TBD	TBD
2,4,6-Trinitrotoluene (2,4,6-TNT)	118-96-7	16 mg/kg	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	1946-51-0	1.2 mg/kg	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	35572-78-2	1.2 mg/kg	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
2,4-Dinitrotoluene (2,4-DNT)	121-14-2	12 mg/kg	NA	TBD	N/A	0.26 mg/kg	TBD	TBD
2,6-Dinitrotoluene (2,6-DNT)	606-20-2	6.1 mg/kg	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
2-Nitrotoluene (2-NT)	88-72-2	0.880 mg/kg	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
3-Nitrotoluene (3-NT)	99-08-1	73 mg/kg	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
4-Nitrotoluene (4-NT)	99-99-0	12 mg/kg	NA	TBD	N/A	0.25 mg/kg	TBD	TBD

[1] Analytical QLs are those documented in the analytical method. MDLs are rarely specified in the analytical method.

[2] Achievable MDLs and QLs are laboratory-specific and to be determined when a laboratory is selected.

[3] Efroymson, 1997a

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
NA = Not Available
Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-12
Reference Limits and Evaluation Table

Matrix: Sediment
Analytical Group: Explosives
Concentration Level: Low/Medium (SW-846 8330)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater	Marine[3]		MDLs	Method QLs	MDLs	QLs
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	310 mg/kg	NA	NA	TBD	N/A	2.2 mg/kg	TBD	TBD
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	4.4 mg/kg	NA	NA	TBD	N/A	1.0 mg/kg	TBD	TBD
1,3,5-Trinitrobenzene (1,3,5-TNB)	99-35-4	180 mg/kg	NA	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
1,3-Dinitrobenzene (1,3-DNB)	99-65-0	0.610 mg/kg	NA	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	61 mg/kg	NA	NA	TBD	N/A	0.65 mg/kg	TBD	TBD
Nitrobenzene (NB)	98-95-3	2 mg/kg	NA	21 mg/kg	TBD	N/A	0.26 mg/kg	TBD	TBD
2,4,6-Trinitrotoluene (2,4,6-TNT)	118-96-7	16 mg/kg	NA	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	1946-51-0	1.2 mg/kg	NA	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	35572-78-2	1.2 mg/kg	NA	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
2,4-Dinitrotoluene (2,4-DNT)	121-14-2	12 mg/kg	NA	NA	TBD	N/A	0.26 mg/kg	TBD	TBD
2,6-Dinitrotoluene (2,6-DNT)	606-20-2	6.1 mg/kg	NA	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
2-Nitrotoluene (2-NT)	88-72-2	0.880 mg/kg	NA	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
3-Nitrotoluene (3-NT)	99-08-1	73 mg/kg	NA	NA	TBD	N/A	0.25 mg/kg	TBD	TBD
4-Nitrotoluene (4-NT)	99-99-0	12 mg/kg	NA	NA	TBD	N/A	0.25 mg/kg	TBD	TBD

[1] Analytical QLs are those documented in the analytical method. MDLs are rarely specified in the analytical method.

[2] Achievable MDLs and QLs are laboratory-specific and to be determined when a laboratory is selected.

[3] National Oceanic and Atmospheric Association, Buchman,1999

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-13
Reference Limits and Evaluation Table

Matrix: Soil
Analytical Group: Perchlorate
Concentration Level: Low/Medium (Per DOD Perchlorate Handbook)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
					MDLs	Method QLs	MDLs	QLs
Perchlorate	7601-90-3	780 µg/Kg	NA	TBD	N/A	N/A	TBD	TBD

[1] Analytical QLs are those documented in the analytical method. MDLs are rarely specified in the analytical method.

[2] Achievable MDLs and QLs are laboratory-specific and to be determined when a laboratory is selected.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-14
Reference Limits and Evaluation Table

Matrix: Sediment
Analytical Group: Perchlorate
Concentration Level: Low/Medium (Per DOD Perchlorate Handbook)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater	Marine		MDLs	Method QLs	MDLs	QLs
Perchlorate	7601-90-3	780 µg/Kg	NA	NA	TBD	N/A	N/A	TBD	TBD

[1] Analytical QLs are those documented in the analytical method. MDLs are rarely specified in the analytical method.
[2] Achievable MDLs and QLs are laboratory-specific and to be determined when a laboratory is selected.
Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
NA = Not Available
Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-15
Reference Limits and Evaluation Table

Matrix: Soil
Analytical Group: TAL Metals
Concentration Level: Low/Medium (ILM05.3)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values	Proiect Ouantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
					MDLs	Method QLs	MDLs	QLs
Aluminum	7429-90-5	7600000 µg/kg	NA	20000 µg/kg	N/A	20000 µg/kg	TBD	20000 µg/kg
Antimony	7440-36-0	3100 µg/kg	78000 µg/kg [3]	6000 µg/kg	N/A	6000 µg/kg	TBD	6000 µg/kg
Arsenic	7440-38-2	390 µg/kg	18000 µg/kg [3]	1000 µg/kg	N/A	1000 µg/kg	TBD	1000 µg/kg
Barium	7440-39-3	540000 µg/kg	330000 µg/kg [3]	20000 µg/kg	N/A	20000 µg/kg	TBD	20000 µg/kg
Beryllium	7440-41-7	15000 µg/kg	40000 µg/kg [3]	500 µg/kg	N/A	500 µg/kg	TBD	500 µg/kg
Cadmium	7440-43-9	3700 µg/kg	32000 µg/kg [3]	5000 µg/kg	N/A	5000 µg/kg	TBD	5000 µg/kg
Calcium	7440-70-2		NA	500 µg/kg	N/A	500 µg/kg	TBD	500 µg/kg
Chromium	7440-47-3	210000 µg/kg	400 µg/kg [4]	1000 µg/kg	N/A	1000 µg/kg	TBD	1000 µg/kg
Cobalt	7440-48-4	140000 µg/kg	13000 µg/kg [3]	5000 µg/kg	N/A	5000 µg/kg	TBD	5000 µg/kg
Copper	7440-50-8	310000 µg/kg	50000 µg/kg [4]	2500 µg/kg	N/A	2500 µg/kg	TBD	2500 µg/kg
Iron	7439-89-6	2400000 µg/kg	NA	10000 µg/kg	N/A	10000 µg/kg	TBD	10000 µg/kg
Lead	7439-92-1	400000 µg/kg	120000 µg/kg [3]	1000 µg/kg	N/A	1000 µg/kg	TBD	1000 µg/kg
Magnesium	7439-95-4		NA	500000 µg/kg	N/A	500000 µg/kg	TBD	500000 µg/kg
Manganese	7439-96-5	180000 µg/kg	100000 µg/kg [4]	1500 µg/kg	N/A	1500 µg/kg	TBD	1500 µg/kg
Mercury	7439-97-6	2300 µg/kg	100 µg/kg [4]	100 µg/kg	N/A	100 µg/kg	TBD	100 µg/kg
Nickel	7440-02-0	160000 µg/kg	30000 µg/kg [6]	4000 µg/kg	N/A	4000 µg/kg	TBD	4000 µg/kg
Potassium	7440-09-7		NA	500000 µg/kg	N/A	500000 µg/kg	TBD	500000 µg/kg
Selenium	7782-49-2	39000 µg/kg	1000 µg/kg [6]	3500µg/kg	N/A	3500µg/kg	TBD	3500µg/kg
Silver	7440-22-4	39000 µg/kg	2000 µg/kg [6]	1000 µg/kg	N/A	1000 µg/kg	TBD	1000 µg/kg
Sodium	7440-23-5		NA	500000 µg/kg	N/A	500000 µg/kg	TBD	500000 µg/kg
Thallium	7440-28-0	520 µg/kg	1000 µg/kg [6]	2500 µg/kg	N/A	2500 µg/kg	TBD	2500 µg/kg
Vanadium	7440-62-2	7800 µg/kg	2000 µg/kg [5]	5000 µg/kg	N/A	5000 µg/kg	TBD	5000 µg/kg
Zinc	7440-66-6	2400000 µg/kg	50000 µg/kg [6]	6000 µg/kg	N/A	6000 µg/kg	TBD	6000 µg/kg
Cyanide	57-12-5	120000 µg/kg [7]	1000 µg/kg [5]	2500 µg/kg	N/A	2500 µg/kg	TBD	2500 µg/kg

[1] Analytical QLs are those documented in EPA CLP ILM05.3 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] EPA 2005

[4] Efroymson, 1997a

[5] Ministry of Housing, Spatial Planning and Environment, 2000

[6] Efroymson, 1997b

[7] Based on free cyanide.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Shading represents Screening Values which are below Project Quantitation Limits.

NA = Not Available

Note: Ecological Project Action Limit values in this table are only intended for evaluating laboratory limits. Values used in ecological risk assessments may differ for some chemicals based on site specific conditions.

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-16
Reference Limits and Evaluation Table

Matrix: Sediment
Analytical Group: TAL Metals
Concentration Level: Low/Medium (ILM05.3)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater [3]	Marine [3]		MDLs	Method QLs	MDLs	QLs
Aluminum	7429-90-5	7600000 µg/kg	25500000 µg/kg	18000000 µg/kg	20000 µg/kg	N/A	20000 µg/kg	TBD	20000 µg/kg
Antimony	7440-36-0	3100 µg/kg	NA	9300 µg/kg	6000 µg/kg	N/A	6000 µg/kg	TBD	6000 µg/kg
Arsenic	7440-38-2	390 µg/kg	5900 µg/kg	8200 µg/kg	1000 µg/kg	N/A	1000 µg/kg	TBD	1000 µg/kg
Barium	7440-39-3	540000 µg/kg	NA	NA	20000 µg/kg	N/A	20000 µg/kg	TBD	20000 µg/kg
Beryllium	7440-41-7	15000 µg/kg	NA	NA	500 µg/kg	N/A	500 µg/kg	TBD	500 µg/kg
Cadmium	7440-43-9	3700 µg/kg	596 µg/kg	1200 µg/kg	5000 µg/kg	N/A	5000 µg/kg	TBD	5000 µg/kg
Calcium	7440-70-2		NA	NA	500 µg/kg	N/A	500 µg/kg	TBD	500 µg/kg
Chromium	7440-47-3	210000 µg/kg	37300 µg/kg	81000 µg/kg	1000 µg/kg	N/A	1000 µg/kg	TBD	1000 µg/kg
Cobalt	7440-48-4	140000 µg/kg	NA	10000 µg/kg	5000 µg/kg	N/A	5000 µg/kg	TBD	5000 µg/kg
Copper	7440-50-8	310000 µg/kg	35700 µg/kg	34000 µg/kg	2500 µg/kg	N/A	2500 µg/kg	TBD	2500 µg/kg
Iron	7439-89-6	2400000 µg/kg	188400000 µg/kg	220000000 µg/kg	10000 µg/kg	N/A	10000 µg/kg	TBD	10000 µg/kg
Lead	7439-92-1	400000 µg/kg	35000 µg/kg	46700 µg/kg	1000 µg/kg	N/A	1000 µg/kg	TBD	1000 µg/kg
Magnesium	7439-95-4		NA	NA	500000 µg/kg	N/A	500000 µg/kg	TBD	500000 µg/kg
Manganese	7439-96-5	180000 µg/kg	630000 µg/kg	260000 µg/kg	1500 µg/kg	N/A	1500 µg/kg	TBD	1500 µg/kg
Mercury	7439-97-6	2300 µg/kg	174 µg/kg	150 µg/kg	100 µg/kg	N/A	100 µg/kg	TBD	100 µg/kg
Nickel	7440-02-0	160000 µg/kg	18000 µg/kg	20900 µg/kg	4000 µg/kg	N/A	4000 µg/kg	TBD	4000 µg/kg
Potassium	7440-09-7		NA	NA	500000 µg/kg	N/A	500000 µg/kg	TBD	500000 µg/kg
Selenium	7782-49-2	39000 µg/kg	NA	1000 µg/kg	3500µg/kg	N/A	3500µg/kg	TBD	3500µg/kg
Silver	7440-22-4	39000 µg/kg	NA	1000 µg/kg	1000 µg/kg	N/A	1000 µg/kg	TBD	1000 µg/kg
Sodium	7440-23-5		NA	NA	500000 µg/kg	N/A	500000 µg/kg	TBD	500000 µg/kg
Thallium	7440-28-0	520 µg/kg	NA	NA	2500 µg/kg	N/A	2500 µg/kg	TBD	2500 µg/kg
Vanadium	7440-62-2	7800 µg/kg	NA	57000 µg/kg	5000 µg/kg	N/A	5000 µg/kg	TBD	5000 µg/kg
Zinc	7440-66-6	2400000 µg/kg	123100 µg/kg	150000 µg/kg	6000 µg/kg	N/A	6000 µg/kg	TBD	6000 µg/kg
Cyanide	57-12-5	120000 µg/kg[4]	NA	NA	2500 µg/kg	N/A	2500 µg/kg	TBD	2500 µg/kg

[1] Analytical QLs are those documented in EPA CLP ILM05.3 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] National Oceanic and Atmospheric Association, Buchman,1999

[4] Based on free cyanide.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Shading represents Screening Values which are below Project Quantitation Limits.

NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-17
Reference Limits and Evaluation Table

Matrix: Soil
Analytical Group: Total Petroleum Hydrocarbons
Concentration Level: Low/Medium (SW-846 8015M)

Analyte	CAS Number	Human Health Project Screening Values[3]	Ecological Project Screening Values[3]	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
					MDLs	Method QLs	MDLs	QLs
Gasoline Range Organics (GRO)	TPH-GRO	100000 µg/Kg	NA	TBD	N/A	N/A	TBD	TBD
Diesel Range Organics (DRO)	TPH-DRO	100000 µg/Kg	NA	TBD	N/A	N/A	TBD	TBD
Oil Range Organics (ORO)	TPH-ORO	100000 µg/Kg	NA	TBD	N/A	N/A	TBD	TBD

[1] Analytical QLs are those documented in the analytical method. MDLs are rarely specified in the analytical method.

[2] Achievable MDLs and QLs are laboratory-specific and to be determined when a laboratory is selected.

NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-18
Reference Limits and Evaluation Table

Matrix: Sediment
Analytical Group: Total Petroleum Hydrocarbons
Concentration Level: Low/Medium (SW-846 8015M)

Analyte	CAS Number	Human Health Project Screening Values[3]	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater	Marine		MDLs	Method QLs	MDLs	QLs
Gasoline Range Organics (GRO)	TPH-GRO	100000 µg/Kg	NA	NA	TBD	N/A	N/A	TBD	TBD
Diesel Range Organics (DRO)	TPH-DRO	100000 µg/Kg	NA	NA	TBD	N/A	N/A	TBD	TBD
Oil Range Organics (ORO)	TPH-ORO	100000 µg/Kg	NA	NA	TBD	N/A	N/A	TBD	TBD

[1] Analytical QLs are those documented in the analytical method. MDLs are rarely specified in the analytical method.
[2] Achievable MDLs and QLs are laboratory-specific and to be determined when a laboratory is selected.
NA = Not Available
Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-19
Reference Limits and Evaluation Table

Matrix: Soil/Sediment
Analytical Group: Wet Chemistry
Concentration Level: Medium (SW-846 9045C, SM2580B, SW-846 9081, Lloyd Kahn/SW-846 9060)

Analyte	CAS Number	Human Health Project Screening Values[3]	Ecological Project Screening Values[3]	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
					MDLs	Method QLs	MDLs	QLs
pH	PH	NA	NA	TBD	N/A	N/A	TBD	TBD
Redox Potential	ORP	NA	NA	TBD	N/A	N/A	TBD	TBD
Cation exchange capacity	CEC	NA	NA	TBD	N/A	N/A	TBD	TBD
Total Organic Carbon	TOC	NA	NA	TBD	N/A	N/A	TBD	TBD

[1] Analytical QLs are those documented in the analytical method. MDLs are rarely specified in the analytical method.

[2] Achievable MDLs and QLs are laboratory-specific and to be determined when a laboratory is selected.

NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-20
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Volatile Organic Compounds
Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs	MDLs	QLs
Dichlorodifluoromethane	75-71-8	39 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Chloromethane	74-87-3	16 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Vinyl Chloride	75-01-4	0.02 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Bromomethane	74-83-9	0.87 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Chloroethane	75-00-3	4.6 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Trichlorofluoromethane	75-69-4	130 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,1-Dichloroethene	75-35-4	34 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	5900 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Acetone	67-64-1	550 µg/L	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Carbon Disulfide	75-15-0	100 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Methyl Acetate	79-20-9	610 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Methylene Chloride	75-09-2	4.3 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
trans-1,2-Dichloroethene	156-60-5	12 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Methyl tert-Butyl Ether	1634-04-4	11 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,1-Dichloroethane	75-34-3	81 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
cis-1,2-Dichloroethene	156-59-2	6.1 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Butanone	78-93-3	700 µg/L	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Bromochloromethane	74-97-5	0.18 µg/L*	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Chloroform	67-66-3	0.17 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,1,1-Trichloroethane	71-55-6	320 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Cyclohexane	110-82-7	1000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Carbon Tetrachloride	56-23-5	0.17 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Benzene	71-43-2	0.35 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2-Dichloroethane	107-06-2	0.12 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,4-Dioxane	123-91-1	6.1 µg/L	100 µg/L	N/A	100 µg/L	TBD	100 µg/L
Trichloroethene	79-01-6	1.4 µg/L[3]	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Methylcyclohexane	108-87-2	520 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2-Dichloropropane	78-87-5	0.16 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Bromodichloromethane	75-27-4	0.18 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
cis-1,3-Dichloropropene	10061-01-5	0.4 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Methyl-2-pentanone	108-10-1	200 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Toluene	108-88-3	72 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
trans-1,3-Dichloropropene	10061-02-6	0.4 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,1,2-Trichloroethane	79-00-5	0.2 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Tetrachloroethene	127-18-4	0.1 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Hexanone	591-78-6	150 µg/L	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Dibromochloromethane	124-48-1	0.13 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2-Dibromoethane	106-93-4	0.0056 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Chlorobenzene	108-90-7	11 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Ethylbenzene	100-41-4	130 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
m,p-Xylene	NA	21 µg/L**	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
o-Xylene	95-47-6	21 µg/L**	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Styrene	100-42-5	160 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Bromoform	75-25-2	8.5 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Isopropylbenzene	98-82-8	66 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,1,2,2-Tetrachloroethane	79-34-5	0.055 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,3-Dichlorobenzene	541-73-1	18 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,4-Dichlorobenzene	106-46-7	0.5 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2-Dichlorobenzene	95-50-1	37 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2-Dibromo-3-chloropropane	96-12-8	0.035 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2,4-Trichlorobenzene	120-82-1	0.72 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2,3-Trichlorobenzene	87-61-6	0.72 µg/L***	5 µg/L	N/A	5 µg/L	TBD	5 µg/L

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] Based on Cal/EPA toxicity values.

* = Bromodichloromethane PRG value used as surrogate PRG value for bromochloromethane

** = Total xylene PRG value used as surrogate PRG value for o-xylene and m,p-xylene

*** = 1,2,4-Trichlorobbenzene PRG value used as surrogate PRG value for 1,2,3-Trichlorobenzene.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Shading represents Screening Values which are below Project Quantitation Limits.

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health risk assessments may differ for some chemicals based on site specific conditions.

NA = Not Available

QAPP Worksheet #15-21
Reference Limits and Evaluation Table

Matrix: Surface Water
Analytical Group: Volatile Organic Compounds
Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater [3]	Marine [3]		MDLs	Method QLs	MDLs	QLs
Dichlorodifluoromethane	75-71-8	39 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Chloromethane	74-87-3	16 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Vinyl Chloride	75-01-4	0.02 µg/L	2 µg/L	5250 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Bromomethane	74-83-9	0.87 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Chloroethane	75-00-3	4.6 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Trichlorofluoromethane	75-69-4	130 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,1-Dichloroethene	75-35-4	34 µg/L	0.57 µg/L	32 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	5900 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Acetone	67-64-1	550 µg/L	NA	NA	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Carbon Disulfide	75-15-0	100 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Methyl Acetate	79-20-9	610 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Methylene Chloride	75-09-2	4.3 µg/L	470 µg/L	16000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
trans-1,2-Dichloroethene	156-60-5	12 µg/L	700 µg/L	140000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Methyl tert-Butyl Ether	1634-04-4	11 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,1-Dichloroethane	75-34-3	81 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
cis-1,2-Dichloroethene	156-59-2	6.1 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Butanone	78-93-3	700 µg/L	NA	NA	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Bromochloromethane	74-97-5	0.18 µg/L*	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Chloroform	67-66-3	0.17 µg/L	57 µg/L	4700 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,1,1-Trichloroethane	71-55-6	320 µg/L	200 µg/L	1030 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Cyclohexane	110-82-7	1000 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Carbon Tetrachloride	56-23-5	0.17 µg/L	2.5 µg/L	44 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Benzene	71-43-2	0.35 µg/L	12 µg/L	710 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2-Dichloroethane	107-06-2	0.12 µg/L	3.8 µg/L	990 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,4-Dioxane	123-91-1	6.1 µg/L	NA	NA	100 µg/L	N/A	100 µg/L	TBD	100 µg/L
Trichloroethene	79-01-6	1.4 µg/L [4]	27 µg/L	810 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Methylcyclohexane	108-87-2	520 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2-Dichloropropane	78-87-5	0.16 µg/L	5.2 µg/L	390 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Bromodichloromethane	75-27-4	0.18 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
cis-1,3-Dichloropropene	10061-01-5	0.4 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Methyl-2-pentanone	108-10-1	200 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Toluene	108-88-3	72 µg/L	6800 µg/L	200000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
trans-1,3-Dichloropropene	10061-02-6	0.4 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,1,2-Trichloroethane	79-00-5	0.2 µg/L	6 µg/L	420 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Tetrachloroethene	127-18-4	0.1 µg/L	8 µg/L	88.5 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Hexanone	591-78-6	150 µg/L	NA	NA	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Dibromochloromethane	124-48-1	0.13 µg/L	5.6 µg/L	460 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2-Dibromoethane	106-93-4	0.0056 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Chlorobenzene	108-90-7	11 µg/L	680 µg/L	21000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Ethylbenzene	100-41-4	130 µg/L	3100 µg/L	29000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
m,p-Xylene	NA	21 µg/L**	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
o-Xylene	95-47-6	21 µg/L**	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Styrene	100-42-5	160 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Bromoform	75-25-2	8.5 µg/L	43 µg/L	3600 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Isopropylbenzene	98-82-8	66 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,1,2,2-Tetrachloroethane	79-34-5	0.055 µg/L	1.7 µg/L	110 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,3-Dichlorobenzene	541-73-1	18 µg/L	400 µg/L	2600 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,4-Dichlorobenzene	106-46-7	0.5 µg/L	400 µg/L	2600 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2-Dichlorobenzene	95-50-1	37 µg/L	2700 µg/L	17000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2-Dibromo-3-chloropropane	96-12-8	0.035 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2,4-Trichlorobenzene	120-82-1	0.72 µg/L	260 µg/L	940 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2,3-Trichlorobenzene	87-61-6	0.72 µg/L***	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] Puerto Rico Water Quality Standards (2003)

[4] Based on Cal/EPA toxicity values.

* = Bromodichloromethane PRG value used as surrogate PRG value for bromochloromethane

** = Total xylene PRG value used as surrogate PRG value for o-xylene and m,p-xylene

*** = 1,2,4-Trichlorobbenzene PRG value used as surrogate PRG value for 1,2,3-Trichlorobenzene.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Shading represents Screening Values which are below Project Quantitation Limits.

NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-22
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Volatile Organic Compounds
Concentration Level: Low/Trace (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs	MDLs	QLs
Dichlorodifluoromethane	75-71-8	39 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Chloromethane	74-87-3	16 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Vinyl Chloride	75-01-4	0.02 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Bromomethane	74-83-9	0.87 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Chloroethane	75-00-3	4.6 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Trichlorofluoromethane	75-69-4	130 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,1-Dichloroethene	75-35-4	34 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	5900 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Acetone	67-64-1	550 µg/L	5.0 µg/L	N/A	5.0 µg/L	TBD	5.0 µg/L
Carbon Disulfide	75-15-0	100 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Methyl Acetate	79-20-9	610 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Bromochloromethane	74-97-5	0.18 µg/L*	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Methylene Chloride	75-09-2	4.3 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
trans-1,2-Dichloroethene	156-60-5	12 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Methyl tert-Butyl Ether	1634-04-4	11 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,1-Dichloroethane	75-34-3	81 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
cis-1,2-Dichloroethene	156-59-2	6.1 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
2-Butanone	78-93-3	700 µg/L	5.0 µg/L	N/A	5.0 µg/L	TBD	5.0 µg/L
Chloroform	67-66-3	0.17 µg/L	5.0 µg/L	N/A	5.0 µg/L	TBD	5.0 µg/L
1,1,1-Trichloroethane	71-55-6	320 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Cyclohexane	110-82-7	1000 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Carbon Tetrachloride	56-23-5	0.17 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Benzene	71-43-2	0.35 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,2-Dichloroethane	107-06-2	0.12 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,4-Dioxane	123-91-1	6.1 µg/L	20 µg/L	N/A	20 µg/L	TBD	20 µg/L
Trichloroethene	79-01-6	1.4 µg/L[3]	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Methylcyclohexane	108-87-2	520 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,2-Dichloropropane	78-87-5	0.16 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Bromodichloromethane	75-27-4	0.18 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
cis-1,3-Dichloropropene	10061-01-5	0.4 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
4-Methyl-2-pentanone	108-10-1	200 µg/L	5.0 µg/L	N/A	5.0 µg/L	TBD	5.0 µg/L
Toluene	108-88-3	72 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
trans-1,3-Dichloropropene	10061-02-6	0.4 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,1,2-Trichloroethane	79-00-5	0.2 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Tetrachloroethene	127-18-4	0.1 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
2-Hexanone	591-78-6	150 µg/L	5.0 µg/L	N/A	5.0 µg/L	TBD	5.0 µg/L
Dibromochloromethane	124-48-1	0.13 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,2-Dibromoethane	106-93-4	0.0056 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Chlorobenzene	108-90-7	11 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Ethylbenzene	100-41-4	130 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
m,p-Xylene	NA	21 µg/L**	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
o-Xylene	95-47-6	21 µg/L**	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Styrene	100-42-5	160 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Bromoform	75-25-2	8.5 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Isopropylbenzene	98-82-8	66 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,1,2,2-Tetrachloroethane	79-34-5	0.055 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,3-Dichlorobenzene	541-73-1	18 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,4-Dichlorobenzene	106-46-7	0.5 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,2-Dichlorobenzene	95-50-1	37 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,2-Dibromo-3-chloropropane	96-12-8	0.035 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,2,4-Trichlorobenzene	120-82-1	0.72 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,2,3-Trichlorobenzene	87-61-6	0.72 µg/L***	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] Based on Cal/EPA toxicity values.

* = Bromodichloromethane PRG value used as surrogate PRG value for bromochloromethane

** = Total xylene PRG value used as surrogate PRG value for o-xylene and m,p-xylene

*** = 1,2,4-Trichlorobbenzene PRG value used as surrogate PRG value for 1,2,3-Trichlorobenzene.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Shading represents Screening Values which are below Project Quantitation Limits.

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health risk assessments may differ for some chemicals based on site specific conditions.

NA = Not Available

QAPP Worksheet #15-23
Reference Limits and Evaluation Table

Matrix: Surface Water
Analytical Group: Volatile Organic Compounds
Concentration Level: Low/Trace (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater [3]	Marine [3]		MDLs	Method QLs	MDLs	QLs
Dichlorodifluoromethane	75-71-8	39 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Chloromethane	74-87-3	1.6 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Vinyl Chloride	75-01-4	0.02 µg/L	2 µg/L	5250 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Bromomethane	74-83-9	0.87 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Chloroethane	75-00-3	4.6 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Trichlorofluoromethane	75-69-4	130 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,1-Dichloroethene	75-35-4	34 µg/L	0.57 µg/L	32 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	5900 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Acetone	67-64-1	550 µg/L	NA	NA	5.0 µg/L	N/A	5.0 µg/L	TBD	5.0 µg/L
Carbon Disulfide	75-15-0	100 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Methyl Acetate	79-20-9	610 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Bromochloromethane	74-97-5	0.18 µg/L*	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Methylene Chloride	75-09-2	4.3 µg/L	470 µg/L	16000 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
trans-1,2-Dichloroethene	156-60-5	12 µg/L	700 µg/L	140000 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Methyl tert-Butyl Ether	1634-04-4	11 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,1-Dichloroethane	75-34-3	81 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
cis-1,2-Dichloroethene	156-59-2	6.1 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
2-Butanone	78-93-3	700 µg/L	NA	NA	5.0 µg/L	N/A	5.0 µg/L	TBD	5.0 µg/L
Chloroform	67-66-3	0.17 µg/L	57 µg/L	4700 µg/L	5.0 µg/L	N/A	5.0 µg/L	TBD	5.0 µg/L
1,1,1-Trichloroethane	71-55-6	320 µg/L	200 µg/L	1030 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Cyclohexane	110-82-7	1000 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Carbon Tetrachloride	56-23-5	0.17 µg/L	2.5 µg/L	44 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Benzene	71-43-2	0.35 µg/L	12 µg/L	710 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,2-Dichloroethane	107-06-2	0.12 µg/L	3.8 µg/L	990 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,4-Dioxane	123-91-1	6.1 µg/L	NA	NA	20 µg/L	N/A	20 µg/L	TBD	20 µg/L
Trichloroethene	79-01-6	1.4 µg/L[4]	27 µg/L	810 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Methylcyclohexane	108-87-2	520 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,2-Dichloropropane	78-87-5	0.16 µg/L	5.2 µg/L	390 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Bromodichloromethane	75-27-4	0.18 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
cis-1,3-Dichloropropene	10061-01-5	0.4 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
4-Methyl-2-pentanone	108-10-1	200 µg/L	NA	NA	5.0 µg/L	N/A	5.0 µg/L	TBD	5.0 µg/L
Toluene	108-88-3	72 µg/L	6800 µg/L	200000 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
trans-1,3-Dichloropropene	10061-02-6	0.4 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,1,2-Trichloroethane	79-00-5	0.2 µg/L	6 µg/L	420 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Tetrachloroethene	127-18-4	0.1 µg/L	8 µg/L	88.5 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
2-Hexanone	591-78-6	150 µg/L	NA	NA	5.0 µg/L	N/A	5.0 µg/L	TBD	5.0 µg/L
Dibromochloromethane	124-48-1	0.13 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,2-Dibromoethane	106-93-4	0.0056 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Chlorobenzene	108-90-7	11 µg/L	680 µg/L	21000 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Ethylbenzene	100-41-4	130 µg/L	3100 µg/L	29000 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
m,p-Xylene	NA	21 µg/L**	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
o-Xylene	95-47-6	21 µg/L**	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Styrene	100-42-5	160 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Bromoform	75-25-2	8.5 µg/L	43 µg/L	3600 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Isopropylbenzene	98-82-8	66 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,1,2,2-Tetrachloroethane	79-34-5	0.055 µg/L	1.7 µg/L	110 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,3-Dichlorobenzene	541-73-1	18 µg/L	400 µg/L	2600 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,4-Dichlorobenzene	106-46-7	0.5 µg/L	400 µg/L	2600 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,2-Dichlorobenzene	95-50-1	37 µg/L	2700 µg/L	17000 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,2-Dibromo-3-chloropropane	96-12-8	0.035 µg/L	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,2,4-Trichlorobenzene	120-82-1	0.72 µg/L	260 µg/L	940 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,2,3-Trichlorobenzene	87-61-6	0.72 µg/L***	NA	NA	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] Puerto Rico Water Quality Standards (2003)

[4] Based on Cal/EPA toxicity values.

* = Bromodichloromethane PRG value used as surrogate PRG value for bromochloromethane

** = Total xylene PRG value used as surrogate PRG value for o-xylene and m,p-xylene

*** = 1,2,4-Trichlorobbenzene PRG value used as surrogate PRG value for 1,2,3-Trichlorobenzene.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Shading represents Screening Values which are below Project Quantitation Limits.

NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-24
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Volatile Organic Compounds
Concentration Level: Low/TraceSIM (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs	MDLs	QLs
1,4-Dioxane	123-91-1	6.1 µg/L	2.0 µg/L	N/A	2.0 µg/L	TBD	2.0 µg/L
1,2-Dibromoethane	106-93-4	0.0056 µg/L	0.05 µg/L	N/A	0.50 µg/L	TBD	0.05 µg/L
1,2-Dibromo-3-chloropropane	96-12-8	0.035 µg/L	0.05 µg/L	N/A	0.50 µg/L	TBD	0.05 µg/L

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

NA = Not Available

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
Analyte list is subject to minor change depending upon individual laboratory.

Shading represents Screening Values which are below Project Quantitation Limits.

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-25
Reference Limits and Evaluation Table

Matrix: Surface Water
Analytical Group: Volatile Organic Compounds
Concentration Level: Low/TraceSIM (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater	Marine		MDLs	Method QLs	MDLs	QLs
1,4-Dioxane	123-91-1	6.1 µg/L	NA	NA	2.0 µg/L	N/A	2.0 µg/L	TBD	2.0 µg/L
1,2-Dibromoethane	106-93-4	0.0056 µg/L	NA	NA	0.05 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
1,2-Dibromo-3-chloropropane	96-12-8	0.035 µg/L	NA	NA	0.05 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Analyte list is subject to minor change depending upon individual laboratory.

Shading represents Screening Values which are below Project Quantitation Limits.

NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-26
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Semi Volatile Organic Compounds
Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs	MDLs	QLs
Benzaldehyde	100-52-7	360 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Phenol	108-95-2	1100 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
bis-(2-Chloroethyl) ether	111-44-4	0.01 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Chlorophenol	95-57-8	3 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Methylphenol	95-48-7	180 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,2'-oxybis(1-Chloropropane)	108-60-1	0.27 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Acetophenone	98-86-2	42 µg/L[3]	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Methylphenol	106-44-5	18 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
N-Nitroso-di-n propylamine	621-64-7	0.0096 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Hexachloroethane	67-72-1	3.6 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Nitrobenzene	98-95-3	0.34 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Isophorone	78-59-1	71 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Nitrophenol	88-75-5	3 µg/L*	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,4-Dimethylphenol	105-67-9	73 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
bis(2-Chloroethoxy) methane	111-91-1	0.27 µg/L**	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,4-Dichlorophenol	120-83-2	11 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Naphthalene	91-20-3	0.62 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Chloroaniline	106-47-8	15 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Hexachlorobutadiene	87-68-3	0.86 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Caprolactam	105-60-2	1800 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Chloro-3-methylphenol	59-50-7	3 µg/L***	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Methylnaphthalene	91-57-6	12 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2,4,5-Tetrachlorobenzene	95-94-3	1.1 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Hexachlorocyclo-pentadiene	77-47-4	22 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,4,6-Trichlorophenol	88-06-2	0.36 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,4,5-Trichlorophenol	95-95-4	360 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,1'-Biphenyl	92-52-4	30 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Chloronaphtalene	91-58-7	49 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Nitroaniline	88-74-4	11 µg/L	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Dimethylphthalate	131-11-3	36000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,6-Dinitrotoluene	606-20-2	3.6 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Acenaphthylene	208-96-8	37 µg/L[4]	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
3-Nitroaniline	99-09-2	1.1 µg/L	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Acenaphthene	83-32-9	37 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,4-Dinitrophenol	51-28-5	7.3 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Nitrophenol	100-02-7	0.34 µg/L[5]	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Dibenzofuran	132-64-9	1.2 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,3,4,6-Tetrachlorophenol	58-90-2	110 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,4-Dinitrotoluene	121-14-2	7.3 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Diethylphthalate	84-66-2	2900 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Fluorene	86-73-7	24 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Chlorophenyl-phenyl ether	7005-72-3	0.27 µg/L**	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Nitroaniline	100-01-6	3.2 µg/L	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
4,6-Dinitro-2-methylphenol	534-52-1	0.36 µg/L	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
N-Nitroso diphenylamine	86-30-6	14 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Bromophenyl-phenylether	101-55-3	0.27 µg/L**	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Hexachlorobenzene	118-74-1	0.042 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Atrazine	1912-24-9	0.3 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Pentachlorophenol	87-86-5	0.56 µg/L	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Phenanthrene	85-01-8	18 µg/L*****	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Anthracene	120-12-7	180 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Carbazole	86-74-8	3.4 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Di-n-butylphthalate	84-74-2	360 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Fluoranthene	206-44-0	150 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Pyrene	129-00-0	18 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Butylbenzylphthalate	85-68-7	730 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
3,3'-Dichlorobenzidine	91-94-1	0.15 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
bis(2-Ethylhexyl) phthalate	117-81-7	4.8 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Benzo(a)anthracene	56-55-3	0.092 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Chrysene	218-01-9	9.2 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Di-n-octylphthalate	117-84-0	150 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Benzo(b)fluoranthene	205-99-2	0.092 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Benzo(k)fluoranthene	207-08-9	0.92 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Benzo(a)pyrene	50-32-8	0.0092 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Indeno(1,2,3-cd)-pyrene	193-39-5	0.092 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Dibenzo(a,h)-anthracene	53-70-3	0.0092 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Benzo(g,h,i)perylene	191-24-2	18 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.
[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.
[3] Calculated value.
[4] Acenaphthene PRGs value used surrogate.
[5] Nitrobenzene PRG value used for surrogate.
* = 2-Chlorophenol PRG value used as surrogate PRG value for 2-Nitrophenol.
** = Bis(2-Chloro)isopropyl ether PRG value used as surrogate,
*** = 2-chlorophenol PRG value used as surrogate PRG value for 4-methyl-3-methylphenol.
**** = Methoxychlor PRG value used as surrogate PRG value for 4-chlorophenyl-phenyl ether.
***** = Pyrene PRG value used as surrogate PRG value for phenanthrene.
Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
Shading represents Screening Values which are below Project Quantitation Limits.
Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-27
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Semi Volatile Organic Compounds
Concentration Level: Low/SIM (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs	MDLs	QLs
Naphthalene	91-20-3	0.62 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
2-Methylnaphthalene	91-57-6	12 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Acenaphthylene	208-96-8	37 µg/L[3]	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Acenaphthene	83-32-9	37 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Fluorene	86-73-7	24 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Pentachlorophenol	87-86-5	0.56 µg/L	0.2 µg/L	N/A	0.2 µg/L	TBD	0.2 µg/L
Phenanthrene	85-01-8	18 µg/L**	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Anthracene	120-12-7	180 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Fluoranthene	206-44-0	150 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Pyrene	129-00-0	18 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Benzo(a)anthracene	56-55-3	0.092 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Chrysene	218-01-9	9.2 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Benzo(b)fluoranthene	205-99-2	0.092 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Benzo(k)fluoranthene	207-08-9	0.92 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Benzo(a)pyrene	50-32-8	0.0092 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Indeno(1,2,3-cd)-pyrene	193-39-5	0.092 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Dibenzo(a,h)-anthracene	53-70-3	0.0092 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Benzo(g,h,i)perylene	191-24-2	18 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] Acenaphthene PRGs value used surrogate.

* = Pyrene PRG value used as surrogate PRG value for phenanthrene.

** = Pyrene PRG value used as surrogate PRG value for phenanthrene.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Shading represents Screening Values which are below Project Quantitation Limits.

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-28
Reference Limits and Evaluation Table

Matrix: Surface Water
Analytical Group: Semi Volatile Organic Compounds
Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater [3]	Marine [3]		MDLs	Method QLs	MDLs	QLs
Benzaldehyde	100-52-7	360 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Phenol	108-95-2	1100 µg/L	21000 µg/L	4600000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
bis-(2-Chloroethyl) ether	111-44-4	0.01 µg/L	0.31 µg/L	0.31 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Chlorophenol	95-57-8	3 µg/L	120 µg/L	400 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Methylphenol	95-48-7	180 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,2'-oxybis(1-Chloropropane)	108-60-1	0.27 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Acetophenone	98-86-2	42 µg/L[3]	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Methylphenol	106-44-5	18 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
N-Nitroso-di-n propylamine	621-64-7	0.0096 µg/L	0.05 µg/L	14 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Hexachloroethane	67-72-1	3.6 µg/L	19 µg/L	89 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Nitrobenzene	98-95-3	0.34 µg/L	17 µg/L	1900 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Isophorone	78-59-1	71 µg/L	360 µg/L	26000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Nitrophenol	88-75-5	3 µg/L*	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,4-Dimethylphenol	105-67-9	73 µg/L	540 µg/L	2300 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
bis(2-Chloroethoxy) methane	111-91-1	0.01 µg/L**	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,4-Dichlorophenol	120-83-2	11 µg/L	93 µg/L	790 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Naphthalene	91-20-3	0.62 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Chloroaniline	106-47-8	15 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Hexachlorobutadiene	87-68-3	0.86 µg/L	4.4 µg/L	500 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Caprolactam	105-60-2	1800 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Chloro-3-methylphenol	59-50-7	3 µg/L***	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Methylnaphthalene	91-57-6	12 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,2,4,5-Tetrachlorobenzene	95-94-3	1.1 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Hexachlorocyclo-pentadiene	77-47-4	22 µg/L	240 µg/L	17000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,4,6-Trichlorophenol	88-06-2	0.36 µg/L	21 µg/L	65 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,4,5-Trichlorophenol	95-95-4	360 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
1,1'-Biphenyl	92-52-4	30 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Chloronaphthalene	91-58-7	49 µg/L	1700 µg/L	4300 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2-Nitroaniline	88-74-4	11 µg/L	NA	NA	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Dimethylphthalate	131-11-3	36000 µg/L	313000 µg/L	2900000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,6-Dinitrotoluene	606-20-2	3.6 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Acenaphthylene	208-96-8	37 µg/L[3]	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
3-Nitroaniline	99-09-2	1.1 µg/L	NA	NA	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Acenaphthene	83-32-9	37 µg/L	1200 µg/L [4]	2700 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,4-Dinitrophenol	51-28-5	7.3 µg/L	70 µg/L	14000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Nitrophenol	100-02-7	0.34 µg/L[7]	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Dibenzofuran	132-64-9	1.2 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,3,4,6-Tetrachlorophenol	58-90-2	110 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
2,4-Dinitrotoluene	121-14-2	7.3 µg/L	0.11 µg/L	9.1 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Diethylphthalate	84-66-2	2900 µg/L	23000 µg/L	120000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Fluorene	86-73-7	24 µg/L	1300 µg/L	1400 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Chlorophenyl-phenyl ether	7005-72-3	0.27 µg/L**	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Nitroaniline	100-01-6	3.2 µg/L	NA	NA	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
4,6-Dinitro-2-methylphenol	534-52-1	0.36 µg/L	NA	NA	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
N-Nitroso diphenylamine	86-30-6	14 µg/L	50 µg/L	160 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
4-Bromophenyl-phenylether	101-55-3	0.27 µg/L**	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Hexachlorobenzene	118-74-1	0.042 µg/L	0.0075 µg/L	0.0077 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Atrazine	1912-24-9	0.3 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Pentachlorophenol	87-86-5	0.56 µg/L	2.8 µg/L	7.9 µg/L	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Phenanthrene	85-01-8	18 µg/L*****	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Anthracene	120-12-7	180 µg/L	9600 µg/L	110000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Carbazole	86-74-8	3.4 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Di-n-butylphthalate	84-74-2	360 µg/L	2700 µg/L	12000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Fluoranthene	206-44-0	150 µg/L	300 µg/L	370 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Pyrene	129-00-0	18 µg/L	960 µg/L	11000 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Butylbenzylphthalate	85-68-7	730 µg/L	3000 µg/L	5200 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
3,3'-Dichlorobenzidine	91-94-1	0.15 µg/L	0.4 µg/L	0.77 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
bis(2-Ethylhexyl) phthalate	117-81-7	4.8 µg/L	18 µg/L	59 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Benzo(a)anthracene	56-55-3	0.092 µg/L	0.044 µg/L	0.49 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Chrysene	218-01-9	9.2 µg/L	0.044 µg/L	0.49 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Di-n-octylphthalate	117-84-0	150 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Benzo(b)fluoranthene	205-99-2	0.092 µg/L	0.044 µg/L	0.49 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Benzo(k)fluoranthene	207-08-9	0.92 µg/L	0.044 µg/L	0.49 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Benzo(a)pyrene	50-32-8	0.0092 µg/L	0.044 µg/L	0.49 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Indeno(1,2,3-cd)-pyrene	193-39-5	0.092 µg/L	0.044 µg/L	0.49 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Dibenzo(a,h)-anthracene	53-70-3	0.0092 µg/L	0.044 µg/L	0.49 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Benzo(g,h,i)perylene	191-24-2	18 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.
[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.
[3] Puerto Rico Water Quality Standards unless otherwise noted (2003)
[4] National Recommended Water Quality Criteria, EPA, 2002
[5] Calculated value.
[6] Acenaphthene PRGs value used surrogate.
[7] Nitrobenzene PRG value used for surrogate.
* = 2-Chlorophenol PRG value used as surrogate PRG value for 2-Nitrophenol.
** = Bis(2-Chloro)isopropyl ether PRG value used as surrogate,
*** = 2-chlorophenol PRG value used as surrogate PRG value for 4-methyl-3-methylphenol.
**** = Methoxychlor PRG value used as surrogate PRG value for 4-chlorophenyl-phenyl ether.
***** = Pyrene PRG value used as surrogate PRG value for phenanthrene.
Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
Shading represents Screening Values which are below Project Quantitation Limits.
NA = Not Available
Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-29
Reference Limits and Evaluation Table

Matrix: Surface Water
Analytical Group: Semi Volatile Organic Compounds
Concentration Level: Low/SIM (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater [3]	Marine [3]		MDLs	Method QLs	MDLs	QLs
Naphthalene	91-20-3	0.62 µg/L	NA	NA	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
2-Methylnaphthalene	91-57-6	12 µg/L	NA	NA	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Acenaphthylene	208-96-8	37 µg/L[5]	NA	NA	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Acenaphthene	83-32-9	37 µg/L	1200 µg/L [4]	2700 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Fluorene	86-73-7	24 µg/L	1300 µg/L	14000 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Pentachlorophenol	87-86-5	0.56 µg/L	2.8 µg/L	7.9 µg/L	0.2 µg/L	N/A	0.2 µg/L	TBD	0.2 µg/L
Phenanthrene	85-01-8	18 µg/L*	NA	NA	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Anthracene	120-12-7	180 µg/L	9600 µg/L	110000 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Fluoranthene	206-44-0	150 µg/L	300 µg/L	370 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Pyrene	129-00-0	18 µg/L	960 µg/L	11000 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Benzo(a)anthracene	56-55-3	0.092 µg/L	0.044 µg/L	0.49 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Chrysene	218-01-9	9.2 µg/L	0.044 µg/L	0.49 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Benzo(b)fluoranthene	205-99-2	0.092 µg/L	0.044 µg/L	0.49 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Benzo(k)fluoranthene	207-08-9	0.92 µg/L	0.044 µg/L	0.49 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Benzo(a)pyrene	50-32-8	0.0092 µg/L	0.044 µg/L	0.49 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Indeno(1,2,3-cd)-pyrene	193-39-5	0.092 µg/L	0.044 µg/L	0.49 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Dibenzo(a,h)-anthracene	53-70-3	0.0092 µg/L	0.044 µg/L	0.49 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Benzo(g,h,i)perylene	191-24-2	18 µg/L	NA	NA	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] Puerto Rico Water Quality Standards unless otherwise noted (2003)

[4] National Recommended Water Quality Criteria, EPA, 2002

[5] Acenaphthene PRGs value used surrogate.

* = Pyrene PRG value used as surrogate PRG value for phenanthrene.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Shading represents Screening Values which are below Project Quantitation Limits.

NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-30
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Explosives
Concentration Level: Low/Medium (SW-846 8330)

Analyte	CAS Number	Human Health Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs	MDLs	QLs
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	180 µg/L	TBD	N/A	13.0 µg/L	TBD	TBD
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	0.61 µg/L	TBD	N/A	0.84 µg/L	TBD	TBD
1,3,5-Trinitrobenzene (1,3,5-TNB)	99-35-4	110 µg/L	TBD	N/A	0.26 µg/L	TBD	TBD
1,3-Dinitrobenzene (1,3-DNB)	99-65-0	0.36 µg/L	TBD	N/A	0.11 µg/L	TBD	TBD
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	36 µg/L	TBD	N/A	4.0 µg/L	TBD	TBD
Nitrobenzene (NB)	98-95-3	0.34 µg/L	TBD	N/A	6.4 µg/L	TBD	TBD
2,4,6-Trinitrotoluene (2,4,6-TNT)	118-96-7	1.8 µg/L	TBD	N/A	0.11 µg/L	TBD	TBD
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	1946-51-0	0.73 µg/L	TBD	N/A	0.060 µg/L	TBD	TBD
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	35572-78-2	0.73 µg/L	TBD	N/A	0.035 µg/L	TBD	TBD
2,4-Dinitrotoluene (2,4-DNT)	121-14-2	7.3 µg/L	TBD	N/A	0.31 µg/L	TBD	TBD
2,6-Dinitrotoluene (2,6-DNT)	606-20-2	3.6 µg/L	TBD	N/A	0.020 µg/L	TBD	TBD
2-Nitrotoluene (2-NT)	88-72-2	0.049 µg/L	TBD	N/A	12.0 µg/L	TBD	TBD
3-Nitrotoluene (3-NT)	99-08-1	12 µg/L	TBD	N/A	8.5 µg/L	TBD	TBD
4-Nitrotoluene (4-NT)	99-99-0	0.66 µg/L	TBD	N/A	7.9 µg/L	TBD	TBD

[1] Analytical QLs are those documented in the analytical method. MDLs are rarely specified in the analytical method.

[2] Achievable MDLs and QLs are laboratory-specific and to be determined when a laboratory is selected.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-31
Reference Limits and Evaluation Table

Matrix: Surface Water
Analytical Group: Explosives
Concentration Level: Low/Medium (SW-846 8330)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater [3]	Marine [3]		MDLs	Method QLs	MDLs	QLs
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	180 µg/L	NA	NA	TBD	N/A	13.0 µg/L	TBD	TBD
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	0.61 µg/L	NA	NA	TBD	N/A	0.84 µg/L	TBD	TBD
1,3,5-Trinitrobenzene (1,3,5-TNB)	99-35-4	110 µg/L	NA	NA	TBD	N/A	0.26 µg/L	TBD	TBD
1,3-Dinitrobenzene (1,3-DNB)	99-65-0	0.36 µg/L	NA	NA	TBD	N/A	0.11 µg/L	TBD	TBD
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	36 µg/L	NA	NA	TBD	N/A	4.0 µg/L	TBD	TBD
Nitrobenzene (NB)	98-95-3	0.34 µg/L	17 µg/L	1900 µg/L	TBD	N/A	6.4 µg/L	TBD	TBD
2,4,6-Trinitrotoluene (2,4,6-TNT)	118-96-7	1.8 µg/L	NA	NA	TBD	N/A	0.11 µg/L	TBD	TBD
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	1946-51-0	0.73 µg/L	NA	NA	TBD	N/A	0.060 µg/L	TBD	TBD
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	35572-78-2	0.73 µg/L	NA	NA	TBD	N/A	0.035 µg/L	TBD	TBD
2,4-Dinitrotoluene (2,4-DNT)	121-14-2	7.3 µg/L	NA	NA	TBD	N/A	0.31 µg/L	TBD	TBD
2,6-Dinitrotoluene (2,6-DNT)	606-20-2	3.6 µg/L	NA	NA	TBD	N/A	0.020 µg/L	TBD	TBD
2-Nitrotoluene (2-NT)	88-72-2	0.049 µg/L	NA	NA	TBD	N/A	12.0 µg/L	TBD	TBD
3-Nitrotoluene (3-NT)	99-08-1	12 µg/L	NA	NA	TBD	N/A	8.5 µg/L	TBD	TBD
4-Nitrotoluene (4-NT)	99-99-0	0.66 µg/L	NA	NA	TBD	N/A	7.9 µg/L	TBD	TBD

[1] Analytical QLs are those documented in the analytical method. MDLs are rarely specified in the analytical method.

[2] Achievable MDLs and QLs are laboratory-specific and to be determined when a laboratory is selected.

[3] Puerto Rico Water Quality Standards, unless otherwise noted (2003)

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-32
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Perchlorate
Concentration Level: Low/Medium (Per DOD Perchlorate Handbook)

Analyte	CAS Number	Human Health Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs[3]	MDLs	QLs
Perchlorate	7601-90-3	24 µg/Kg[3]	TBD	N/A	N/A	TBD	TBD

[1] Analytical QLs are those documented in the analytical method. MDLs are rarely specified in the analytical method.

[2] Achievable MDLs and QLs are laboratory-specific and to be determined when a laboratory is selected.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-33
Reference Limits and Evaluation Table

Matrix: Surface Water
Analytical Group: Perchlorate
Concentration Level: Low/Medium (Per DOD Perchlorate Handbook)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater	Marine		MDLs	Method QLs[3]	MDLs	QLs
Perchlorate	7601-90-3	24 µg/Kg	NA	NA	TBD	N/A	N/A	TBD	TBD

[1] Analytical QLs are those documented in the analytical method. MDLs are rarely specified in the analytical method.

[2] Achievable MDLs and QLs are laboratory-specific and to be determined when a laboratory is selected.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-34
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Organochlorine Pesticides
Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs	MDLs	QLs
alpha-BHC	319-84-6	0.011 µg/L	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
beta-BHC	319-85-7	0.037 µg/L	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
delta-BHC	319-86-8	0.052 µg/L	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
gamma-BHC (Lindane)	58-89-9	0.052 µg/L	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
Heptachlor	76-44-8	0.015 µg/L	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
Aldrin	309-00-2	0.004 µg/L	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
Heptachlor epoxide	1024-57-3	0.0074 µg/L	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
Endosulfan I	959-98-8	22 µg/L	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
Dieldrin	60-57-1	0.0042 µg/L	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
4,4'-DDE	72-55-9	0.2 µg/L	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
Endrin	72-20-8	1.1 µg/L	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
Endosulfan II	33213-65-9	22 µg/L	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
4,4'-DDD	72-54-8	0.28 µg/L	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
Endosulfan sulfate	1031-07-8	22 µg/L	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
4,4'-DDT	50-29-3	0.2 µg/L	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
Methoxychlor	72-43-5	18 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Endrin ketone	53494-70-5	1.1 µg/L	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
Endrin aldehyde	7421-93-4	1.1 µg/L	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
alpha-Chlordane	5103-71-9	0.19 µg/L	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
gamma-Chlordane	5103-74-2	0.19 µg/L	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
Toxaphene	8001-35-2	0.061 µg/L	5.0 µg/L	N/A	5.0 µg/L	TBD	5.0 µg/L

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Shading represents Screening Values which are below Project Quantitation Limits.

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-35
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Organochlorine Pesticides
Concentration Level: Low (OLC03.2)

Analyte	CAS Number	Human Health Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs	MDLs	QLs
alpha-BHC	319-84-6	0.011 µg/L	0.01 µg/L	N/A	0.01 µg/L	TBD	0.01 µg/L
beta-BHC	319-85-7	0.037 µg/L	0.01 µg/L	N/A	0.01 µg/L	TBD	0.01 µg/L
delta-BHC	319-86-8	0.052 µg/L	0.01 µg/L	N/A	0.01 µg/L	TBD	0.01 µg/L
gamma-BHC (Lindane)	58-89-9	0.052 µg/L	0.01 µg/L	N/A	0.01 µg/L	TBD	0.01 µg/L
Heptachlor	76-44-8	0.015 µg/L	0.01 µg/L	N/A	0.01 µg/L	TBD	0.01 µg/L
Aldrin	309-00-2	0.004 µg/L	0.01 µg/L	N/A	0.01 µg/L	TBD	0.01 µg/L
Heptachlor epoxide	1024-57-3	0.0074 µg/L	0.01 µg/L	N/A	0.01 µg/L	TBD	0.01 µg/L
Endosulfan I	959-98-8	22 µg/L	0.01 µg/L	N/A	0.01 µg/L	TBD	0.01 µg/L
Dieldrin	60-57-1	0.0042 µg/L	0.02 µg/L	N/A	0.02 µg/L	TBD	0.02 µg/L
4,4'-DDE	72-55-9	0.2 µg/L	0.02 µg/L	N/A	0.02 µg/L	TBD	0.02 µg/L
Endrin	72-20-8	1.1 µg/L	0.02 µg/L	N/A	0.02 µg/L	TBD	0.02 µg/L
Endosulfan II	33213-65-9	22 µg/L	0.02 µg/L	N/A	0.02 µg/L	TBD	0.02 µg/L
4,4'-DDD	72-54-8	0.28 µg/L	0.02 µg/L	N/A	0.02 µg/L	TBD	0.02 µg/L
Endosulfan sulfate	1031-07-8	22 µg/L	0.02 µg/L	N/A	0.02 µg/L	TBD	0.02 µg/L
4,4'-DDT	50-29-3	0.2 µg/L	0.02 µg/L	N/A	0.02 µg/L	TBD	0.02 µg/L
Methoxychlor	72-43-5	18 µg/L	0.1 µg/L	N/A	0.1 µg/L	TBD	0.1 µg/L
Endrin ketone	53494-70-5	1.1 µg/L	0.02 µg/L	N/A	0.02 µg/L	TBD	0.02 µg/L
Endrin aldehyde	7421-93-4	1.1 µg/L	0.02 µg/L	N/A	0.02 µg/L	TBD	0.02 µg/L
alpha-Chlordane	5103-71-9	0.19 µg/L	0.01 µg/L	N/A	0.01 µg/L	TBD	0.01 µg/L
gamma-Chlordane	5103-74-2	0.19 µg/L	0.01 µg/L	N/A	0.01 µg/L	TBD	0.01 µg/L
Toxaphene	8001-35-2	0.061 µg/L	1 µg/L	N/A	1 µg/L	TBD	1 µg/L

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Shading represents Screening Values which are below Project Quantitation Limits.

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-36
Reference Limits and Evaluation Table

Matrix: Surface Water
Analytical Group: Organochlorine Pesticides
Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater [3]	Marine [3]		MDLs	Method QLs	MDLs	QLs
alpha-BHC	319-84-6	0.011 µg/L	NA	NA	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
beta-BHC	319-85-7	0.037 µg/L	NA	NA	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
delta-BHC	319-86-8	0.052 µg/L	NA	NA	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
gamma-BHC (Lindane)	58-89-9	0.052 µg/L	0.19 µg/L	0.16 µg/L	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
Heptachlor	76-44-8	0.015 µg/L	0.0021 µg/L	0.0021 µg/L	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
Aldrin	309-00-2	0.004 µg/L	0.0013 µg/L	0.0014 µg/L	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
Heptachlor epoxide	1024-57-3	0.0074 µg/L	0.0038 µg/L [4]	0.0036 µg/L [4]	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
Endosulfan I	959-98-8	22 µg/L	0.056 µg/L	0.0087 µg/L [4]	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
Dieldrin	60-57-1	0.0042 µg/L	0.0014 µg/L	0.0014 µg/L	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
4,4'-DDE	72-55-9	0.2 µg/L	0.001 µg/L	0.001 µg/L	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
Endrin	72-20-8	1.1 µg/L	0.036 µg/L	0.0023 µg/L [4]	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
Endosulfan II	33213-65-9	22 µg/L	0.056 µg/L [4]	0.0087 µg/L [4]	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
4,4'-DDD	72-54-8	0.28 µg/L	0.001 µg/L	0.001 µg/L	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
Endosulfan sulfate	1031-07-8	22 µg/L	NA	NA	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
4,4'-DDT	50-29-3	0.2 µg/L	0.001 µg/L	0.001 µg/L	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
Methoxychlor	72-43-5	18 µg/L	0.03 µg/L	0.03 µg/L	0.50 µg/L	N/A	0.50 µg/L	TBD	0.50 µg/L
Endrin ketone	53494-70-5	1.1 µg/L	NA	NA	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
Endrin aldehyde	7421-93-4	1.1 µg/L	NA	NA	0.10 µg/L	N/A	0.10 µg/L	TBD	0.10 µg/L
alpha-Chlordane	5103-71-9	0.19 µg/L	0.0043 µg/L	0.004 µg/L	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
gamma-Chlordane	5103-74-2	0.19 µg/L	0.0043 µg/L	0.004 µg/L	0.050 µg/L	N/A	0.050 µg/L	TBD	0.050 µg/L
Toxaphene	8001-35-2	0.061 µg/L	0.0002 µg/L	0.0002 µg/L	5.0 µg/L	N/A	5.0 µg/L	TBD	5.0 µg/L

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.
[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.
[3] Puerto Rico Water Quality Standards, unless otherwise noted (2003)
[4] National Recommended Water Quality Criteria, EPA, 2002
Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
Shading represents Screening Values which are below Project Quantitation Limits.
NA = Not Available
Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-37
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Polychlorinated Biphenyls
Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs	MDLs	QLs
Aroclor-1016	12674-11-2	0.26 µg/L	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1221	11104-28-2	0.034 µg/L	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1232	11141-16-5	0.034 µg/L	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1242	53469-21-9	0.034 µg/L	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1248	12672-29-6	0.034 µg/L	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1254	11097-69-1	0.034 µg/L	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1260	11096-82-5	0.034 µg/L	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1262	37324-23-5	0.034 µg/L	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1268	11100-14-4	0.034 µg/L	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
Shading represents Screening Values which are below Project Quantitation Limits.

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-38
Reference Limits and Evaluation Table

Matrix: Surface Water
Analytical Group: Polychlorinated Biphenyls
Concentration Level: Low/Medium (SOM01.1)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater [3]	Marine [3]		MDLs	Method QLs	MDLs	QLs
Aroclor-1016	12674-11-2	0.26 µg/L	0.014	0.03	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1221	11104-28-2	0.034 µg/L	0.014	0.03	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1232	11141-16-5	0.034 µg/L	0.014	0.03	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1242	53469-21-9	0.034 µg/L	0.014	0.03	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1248	12672-29-6	0.034 µg/L	0.014	0.03	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1254	11097-69-1	0.034 µg/L	0.014	0.03	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1260	11096-82-5	0.034 µg/L	0.014	0.03	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1262	37324-23-5	0.034 µg/L	0.014	0.03	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L
Aroclor-1268	11100-14-4	0.034 µg/L	0.014	0.03	1.0 µg/L	N/A	1.0 µg/L	TBD	1.0 µg/L

[1] Analytical QLs are those documented in EPA CLP SOM01.1 . MDLs are rarely specified in the analytical method.
[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.
[3] National Recommended Water Quality Criteria, EPA, 2002
Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
Shading represents Screening Values which are below Project Quantitation Limits.
Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-39
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: TAL Metals (Total and Dissolved)
Concentration Level: Low/Medium (ILM05.3)

Analyte	CAS Number	Human Health Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs[3]	MDLs	QLs
Aluminum	7429-90-5	3600 µg/L	200 µg/L	N/A	200 µg/L	TBD	200 µg/L
Antimony	7440-36-0	1.5 µg/L	60 µg/L	N/A	60 µg/L	TBD	60 µg/L
Arsenic	7440-38-2	0.045 µg/L	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Barium	7440-39-3	260 µg/L	200 µg/L	N/A	200 µg/L	TBD	200 µg/L
Beryllium	7440-41-7	7.3 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Cadmium	7440-43-9	1.8 µg/L	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Calcium	7440-70-2	NA	5000 µg/L	N/A	5000 µg/L	TBD	5000 µg/L
Chromium	7440-47-3	11 µg/L*	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Cobalt	7440-48-4	73 µg/L	50 µg/L	N/A	50 µg/L	TBD	50 µg/L
Copper	7440-50-8	150 µg/L	25 µg/L	N/A	25 µg/L	TBD	25 µg/L
Iron	7439-89-6	1100 µg/L	100 µg/L	N/A	100 µg/L	TBD	100 µg/L
Lead	7439-92-1	15 µg/L[3]	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Magnesium	7439-95-4	NA	5000 µg/L	N/A	5000 µg/L	TBD	5000 µg/L
Manganese	7439-96-5	88 µg/L	15 µg/L	N/A	15 µg/L	TBD	15 µg/L
Mercury	7439-97-6	1.1 µg/L	0.2 µg/L	N/A	0.2 µg/L	TBD	0.2 µg/L
Nickel	7440-02-0	73 µg/L	40 µg/L	N/A	40 µg/L	TBD	40 µg/L
Potassium	7440-09-7	NA	5000 µg/L	N/A	5000 µg/L	TBD	5000 µg/L
Selenium	7782-49-2	18 µg/L	35 µg/L	N/A	35 µg/L	TBD	35 µg/L
Silver	7440-22-4	18 µg/L	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Sodium	7440-23-5	NA	5000 µg/L	N/A	5000 µg/L	TBD	5000 µg/L
Thallium	7440-28-0	0.24 µg/L	2.4 µg/L	N/A	25 µg/L	TBD	25 µg/L
Vanadium	7440-62-2	3.6 µg/L	50 µg/L	N/A	50 µg/L	TBD	50 µg/L
Zinc	7440-66-6	1100 µg/L	60 µg/L	N/A	60 µg/L	TBD	60 µg/L
Cyanide	57-12-5	73 µg/L[4]	10 µg/L	N/A	10 µg/L	TBD	10 µg/L

[1] Analytical QLs are those documented in EPA CLP ILM05.3 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] Federal Action Level.

[4] Based on free cyanide

* = Chromium VI PRG value used as surrogate PRG value for chromium
Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.
Thallium action limit is a Site Specific criteria for this project.
Shading represents Screening Values which are below Project Quantitation Limits.
Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-40
Reference Limits and Evaluation Table

Matrix: Surface Water
Analytical Group: TAL Metals (Total and Dissolved)
Concentration Level: Low/Medium (ILM05.3)

Analyte	CAS Number	Human Health Project Screening Values	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater [3]	Marine [3]		MDLs	Method QLs[3]	MDLs	QLs
Aluminum	7429-90-5	3600 µg/L	87 µg/L	NA	200 µg/L	N/A	200 µg/L	TBD	200 µg/L
Antimony	7440-36-0	1.5 µg/L	14 µg/L	4300 µg/L	60 µg/L	N/A	60 µg/L	TBD	60 µg/L
Arsenic	7440-38-2	0.045 µg/L	0.18 µg/L	1.4 µg/L	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Barium	7440-39-3	260 µg/L	NA	NA	200 µg/L	N/A	200 µg/L	TBD	200 µg/L
Beryllium	7440-41-7	7.3 µg/L	NA	NA	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Cadmium	7440-43-9	1.8 µg/L	0.27 µg/L [4]	8.85 µg/L [4]	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Cadmium, dissolved	7440-43-9		0.25 µg/L [4]	8.8 µg/L [4]	5 µg/L	N/A	5 µg/L	TBD	5 µg/L
Calcium	7440-70-2	NA	NA	NA	5000 µg/L	N/A	5000 µg/L	TBD	5000 µg/L
Chromium	7440-47-3	11 µg/L*	11.4 µg/L [4]	50.4 µg/L [4]	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Chromium, dissolved	7440-47-3		11 µg/L [4]	50 µg/L [4]	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Cobalt	7440-48-4	73 µg/L	NA	NA	50 µg/L	N/A	50 µg/L	TBD	50 µg/L
Copper	7440-50-8	150 µg/L	9.33 µg/L [4]	NA	25 µg/L	N/A	25 µg/L	TBD	25 µg/L
Copper, dissolved	7440-50-8		8.96 µg/L [4]	3.1 µg/L	25 µg/L	N/A	25 µg/L	TBD	25 µg/L
Iron	7439-89-6	1100 µg/L	1000 µg/L [4]	NA	100 µg/L	N/A	100 µg/L	TBD	100 µg/L
Lead	7439-92-1	15 µg/L[5]	3.18 µg/L [4]	NA	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Lead, dissolved	7439-92-1		2.52 µg/L [4]	8.1 µg/L	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Magnesium	7439-95-4	NA	NA	NA	5000 µg/L	N/A	5000 µg/L	TBD	5000 µg/L
Manganese	7439-96-5	88 µg/L	NA	NA	15 µg/L	N/A	15 µg/L	TBD	15 µg/L
Mercury	7439-97-6	1.1 µg/L	0.05 µg/L	0.051 µg/L	0.2 µg/L	N/A	0.2 µg/L	TBD	0.2 µg/L
Nickel	7440-02-0	73 µg/L	52.2 µg/L [4]	NA	40 µg/L	N/A	40 µg/L	TBD	40 µg/L
Nickel, dissolved	7440-02-0		52 µg/L [4]	8.2 µg/L	40 µg/L	N/A	40 µg/L	TBD	40 µg/L
Potassium	7440-09-7	NA	NA	NA	5000 µg/L	N/A	5000 µg/L	TBD	5000 µg/L
Selenium	7782-49-2	18 µg/L	5 µg/L [4]	NA	35 µg/L	N/A	35 µg/L	TBD	35 µg/L
Selenium, dissolved	7782-49-2		4.6 µg/L [4]	71 µg/L	35 µg/L	N/A	35 µg/L	TBD	35 µg/L
Silver	7440-22-4	18 µg/L	4.1 µg/L	2 µg/L	10 µg/L	N/A	10 µg/L	TBD	10 µg/L
Sodium	7440-23-5	NA	NA	NA	5000 µg/L	N/A	5000 µg/L	TBD	5000 µg/L
Thallium	7440-28-0	0.24 µg/L	NA	NA	2.4 µg/L	N/A	25 µg/L	TBD	25 µg/L
Vanadium	7440-62-2	3.6 µg/L	NA	NA	50 µg/L	N/A	50 µg/L	TBD	50 µg/L
Zinc	7440-66-6	1100 µg/L	119.8 µg/L	NA	60 µg/L	N/A	60 µg/L	TBD	60 µg/L
Zinc, dissolved	7440-66-6		118 µg/L [4]	81 µg/L	60 µg/L	N/A	60 µg/L	TBD	60 µg/L
Cyanide	57-12-5	73 µg/L[5]	5.2 µg/L	1 µg/L	10 µg/L	N/A	10 µg/L	TBD	10 µg/L

[1] Analytical QLs are those documented in EPA CLP ILM05.3 . MDLs are rarely specified in the analytical method.

[2] Achievable MDLs are laboratory-specific and to be determined when a laboratory is selected.

[3] Puerto Rico Water Quality Standards, unless otherwise noted (2003)

[4] National Recommended Water Quality Criteria, EPA, 2002

[5] Federal Action Level.

[6] Based on free cyanide

* = Chromium VI PRG value used as surrogate PRG value for chromium

Human Health Project Action Limits are from the October 2004 Region IX Preliminary Remediation Goals (PRGs), and are subject to change when PRGs are updated.

Thallium action limit is a Site Specific criteria for this project.

Shading represents Screening Values which are below Project Quantitation Limits.

NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-41
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Total Petroleum Hydrocarbons
Concentration Level: Low/Medium (SW-846 8015M)

Analyte	CAS Number	Human Health Project Screening Values[3]	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs	MDLs	QLs
Gasoline Range Organics (GRO)	TPH-GRO	50000 µg/L	TBD	N/A	N/A	TBD	TBD
Diesel Range Organics (DRO)	TPH-DRO	50000 µg/L	TBD	N/A	N/A	TBD	TBD
Oil Range Organics (ORO)	TPH-ORO	50000 µg/L	TBD	N/A	N/A	TBD	TBD

[1] Analytical QLs are those documented in the analytical method. MDLs are rarely specified in the analytical method.

[2] Achievable MDLs and QLs are laboratory-specific and to be determined when a laboratory is selected.

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-42
Reference Limits and Evaluation Table

Matrix: Surface Water
Analytical Group: Total Petroleum Hydrocarbons
Concentration Level: Low/Medium (SW-846 8015M)

Analyte	CAS Number	Human Health Project Screening Values[3]	Ecological Project Screening Values		Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
			Freshwater	Marine		MDLs	Method QLs	MDLs	QLs
Gasoline Range Organics (GRO)	TPH-GRO	50000 µg/L	NA	NA	TBD	N/A	N/A	TBD	TBD
Diesel Range Organics (DRO)	TPH-DRO	50000 µg/L	NA	NA	TBD	N/A	N/A	TBD	TBD
Oil Range Organics (ORO)	TPH-ORO	50000 µg/L	NA	NA	TBD	N/A	N/A	TBD	TBD

[1] Analytical QLs are those documented in the analytical method. MDLs are rarely specified in the analytical method.
[2] Achievable MDLs and QLs are laboratory-specific and to be determined when a laboratory is selected.
NA = Not Available

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-43
Reference Limits and Evaluation Table

Matrix:Groundwater
Analytical Group: Wet Chemistry
Concentration Level: Medium (MCAWW 160.2, MCAWW 130.2, EPA 300.0)

Analyte	CAS Number	Human Health Project Screening Values[3]	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
				MDLs	Method QLs	MDLs	QLs
Total suspended solids	TSS		TBD	N/A	N/A	TBD	TBD
Hardness	HARDNESS		TBD	N/A	N/A	TBD	TBD
Sulfate	14808-79-8		TBD	N/A	N/A	TBD	TBD
Nitrate	14797-55-8	1000 µg/L	TBD	N/A	N/A	TBD	TBD

[1] Analytical QLs are those documented in the analytical method. MDLs are rarely specified in the analytical method.

[2] Achievable MDLs and QLs are laboratory-specific and to be determined when a laboratory is selected.

NA - Not Applicable

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #15-44
Reference Limits and Evaluation Table

Matrix:Surface Water
Analytical Group: Wet Chemistry
Concentration Level: Medium (MCAWW 160.2, MCAWW 130.2, EPA 300.0)

Analyte	CAS Number	Human Health Project Screening Values[3]	Ecological Project Screening Values	Project Quantitation Limit Goal	Analytical Method[1]		Achievable Laboratory Limits[2]	
					MDLs	Method QLs	MDLs	QLs
Total suspended solids	TSS		NA	TBD	N/A	N/A	TBD	TBD
Hardness	HARDNESS		NA	TBD	N/A	N/A	TBD	TBD
Sulfate	14808-79-8		NA	TBD	N/A	N/A	TBD	TBD
Nitrate	14797-55-8	1000 µg/L	NA	TBD	N/A	N/A	TBD	TBD

[1] Analytical QLs are those documented in the analytical method. MDLs are rarely specified in the analytical method.

[2] Achievable MDLs and QLs are laboratory-specific and to be determined when a laboratory is selected.

NA - Not Applicable

Note: Screening values in this table are only intended for evaluating laboratory limits. Values used in human health and ecological risk assessments may differ for some chemicals based on site specific conditions.

QAPP Worksheet #16
Project Schedule/Timeline Table

Project-specific schedules will be included in project-specific QAPPs.

QAPP Worksheet #17
Sampling Design and Rationale

Describe and provide a rationale for choosing the sampling approach (e.g., grid system, biased statistical approach):

Detailed sampling design and rationale will be provided in project-specific work plans.

Describe the sampling design and rationale in terms of what matrices will be sampled, what analytical groups will be analyzed and at what concentration levels, the sampling locations (including QC, critical, and background samples), the number of samples to be taken, and the sampling frequency (including seasonal considerations) [May refer to map or Worksheet #18 for details]:

Project-specific work plans will define this information. General sampling and analysis tasks comprise those listed on Worksheet #14.

QAPP Worksheet #18
Sampling Locations and Methods/SOP Requirements Table

Sampling Location/ID Number	Matrix	Depth (Units)	Analytical Group	Concentration Level	Number of Samples (Identify Field Duplicates)	Sampling SOP Reference[1]	Rationale for Sampling Location
Project-specific	Groundwater, surface water, sediment, and soil	Project-specific	Project-specific	Project-specific	Project-specific	See attachment 1	See Worksheet #17

[1] Specify the appropriate letter or number from the Project Sampling SOP References table (Worksheet #21).

QAPP Worksheet #19
Analytical SOP Requirements Table

Matrix	Analytical Group	Concentration Level	Analytical and Preparation Method/SOP Reference1	Sample Volume	Containers (Number, Size, and Type)	Preservation Requirements (Chemical, Temperature, Light Protected)	Maximum Holding Times (Preparation/ Analysis)2
Soil/Sediment	VOC	Low/Medium	EPA CLP SOM01.1	5g	3 of 5g EnCores	Cool to 4°C	48 hrs/14 days
Soil/Sediment	SVOC	Low/Medium	EPA CLP SOM01.1	30g	1 of 8oz glass jar	Cool to 4°C	14 days/40 days
Soil/Sediment	Organochlorine Pesticides	Low/Medium	EPA CLP SOM01.1	30g	1 of 8oz glass jar	Cool to 4°C	14 days/40 days
Soil/Sediment	PCBs	Low/Medium	EPA CLP SOM01.1	30g	1 of 8oz glass jar	Cool to 4°C	14 days/40 days
Soil/Sediment	Explosives	Medium	SW-846 8330/SW-846 8330	2g	1 of 8oz glass jar	Cool to 4°C	14 days/40 days
Soil/Sediment	Perchlorate	Medium	Method approved in DoD Perchlorate Handbook	2g	1 of 8oz glass jar	Cool to 4°C	14 days/40 days
Soil/Sediment	TPH GRO	Medium	SW-846 8015M/SW-846 8015M	5g	3 of 5g EnCores	Cool to 4°C	48 hrs/14 days
Soil/Sediment	TPH DRO/ORO	Medium	SW-846 8015M/SW-846 8015M	20g	1 of 8oz glass jar	Cool to 4°C	14 days/40 days
Soil/Sediment	Metals	Medium	EPA CLP ILM05.3	1.0g	1 of 4oz glass jar	Cool to 4°C	6 months
Soil/Sediment	Mercury	Medium	EPA CLP ILM05.3	0.2g	1 of 4oz glass jar	Cool to 4°C	28 days

QAPP Worksheet #19
Analytical SOP Requirements Table

Soil/Sediment	Cyanide	Medium	EPA CLP ILM05.3	1.0g	1 of 4oz glass jar	Cool to 4°C	14 days
Soil/Sediment	pH	Medium	SW-846 9045C	10g	1 of 4oz glass jar	Cool to 4°C	ASAP
Soil/Sediment	Redox Potential	Medium	SW-846 2580B	5-10g	1 of 8oz glass jar	Cool to 4°C	ASAP
Soil/Sediment	Cation Exchange Capacity	intermediate	SW-846 9081	5-10g	1 of 8oz glass jar	Cool to 4°C	ASAP
Soil/Sediment	Total Organic Carbon	Medium	SW-846 9060/SW-846 9060	0.010g	1 of 4oz glass jar	Cool to 4°C	28 days
Waters/ Groundwater	VOC	Low/Medium	EPA CLP SOM01.1	5ml	3 of 40mL VOA vial	1 HCl to pH < 2, Cool to 4°C	14 days
Waters/ Groundwater	VOC	Low	EPA CLP SOM01.1	5ml	3 of 40mL VOA vial	2 HCl to pH < 2, Cool to 4°C	14 days
Waters/ Groundwater	SVOC	Low/Medium	EPA CLP SOM01.1	1000ml	2 of 1L amber	Cool to 4°C	7 days/40 days
Waters/ Groundwater	SVOC	Low	EPA CLP SOM01.1	1000ml	2 of 1L amber	Cool to 4°C	7 days/40 days
Waters/ Groundwater	Organochlorine Pesticides	Low/Medium	EPA CLP SOM01.1	1000ml	2 of 1L amber	Cool to 4°C	7 days/40 days
Waters/ Groundwater	Organochlorine Pesticides	Low	EPA CLP SOM01.1	1000ml	2 of 1L amber	Cool to 4°C	7 days/40 days
Waters/ Groundwater	PCBs	Low/Medium	EPA CLP SOM01.1	1000ml	2 of 1L amber	Cool to 4°C	7 days/40 days
Waters/ Groundwater	Explosives	Medium	SW-846 8330/SW-846 8330	500ml	1 of 1L amber	Cool to 4°C	7 days/40 days
Waters/ Groundwater	Perchlorate	Medium	Method approved in DoD Perchlorate Handbook	50ml	1 of 100mL poly	Cool to 4°C	7 days/40 days

QAPP Worksheet #19
Analytical SOP Requirements Table

Waters/ Groundwater	TPH GRO	Medium	SW-846 8015M/SW-846 8015M	5ml	3 of 40mL VOA vial	HCl to pH < 2, Cool to 4°C	14 days
Waters/ Groundwater	TPH DRO/ORO	Medium	SW-846 8015M/SW-846 8015M	500ml	2 of 1L amber	Cool to 4°C	7 days/40 days
Waters/ Groundwater	Metals (Total and Dissolved)	Medium	EPA CLP ILM05.3	50ml	1 of 1L poly	HNO3 to pH < 2, Cool to 4°C	6 months
Waters/ Groundwater	Mercury	Medium	EPA CLP ILM05.3	100ml	1 of 1L poly	HNO3 to pH < 2, Cool to 4°C	28 days
Waters/ Groundwater	Cyanide	Medium	EPA CLP ILM05.3	100ml	1 of 500mL poly	NaOH to pH < 2, Cool to 4°C	14 days
Waters/ Groundwater	Total Suspended Solids (TSS)	Medium	MCAWW 160.2	200ml	1 of 500mL poly	Cool to 4°C	7 days
Waters/ Groundwater	Total Dissolved Solids (TDS)	Medium	MCAWW 160.1	200ml	1 of 500mL poly	Cool to 4°C	7 days
Waters/ Groundwater	Hardness	Medium	MCAWW 130.2	10ml	1 of 250mL poly	HNO3 to pH < 2, Cool to 4°C	6 months
Waters/ Groundwater	Ion Chromatography Anions Group	Medium	EPA 300.0	10 ml	1 of 250mL poly or glass	Cool to 4°C	48 hours

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

[2] Preparation holding time is analogous to sample extraction holing time. Sample digestate or extract must be analyzed within analysis holding time.

Note: Sample containers and sample volume are subject to slight change depending upon laboratory, and will be updated as needed in site specific plans.

QAPP Worksheet #20
Field Quality Control Sample Summary Table

The actual number of field QC samples is project-specific. Field QC samples are based on the following:

Field blanks at 1 per week; field duplicates at 1 in every 10 samples per matrix; MS/MSD pair at 1 in 20 samples per matrix; equipment blanks at 1 per sampling day per matrix; trip blanks at 1 per cooler of VOCs per sampling day.

QAPP Worksheet #21
Project Sampling SOP References Table

Reference Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
A-1	Shallow Soil Sampling	CH2M HILL	Hand Auger	N	
A-2	Soil Sampling	CH2M HILL	Hand Tools or Split Spoon	N	
A-3	Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils, March 1999	ASTM	Drill Rig	N	ASTM D1586
A-4	Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes, December 2000	ASTM	Drill Rig, Direct Push	N	ASTM D1587
A-5	Homogenization of Soil and Sediment Samples	CH2M HILL	Pan, spoon, etc.	N	
A-6	Soil Sampling for VOCs Using the EnCore® Sampler	CH2M HILL	EnCore	N	
A-7	Soil Boring Sampling-Split Spoon	CH2M HILL	Split Spoon	N	
A-8	Direct-Push Soil Sample Collection	CH2M HILL	Direct Push	N	
A-9	Standard Practice for Description and Identification of Soils, May 2000	ASTM	n/a	N	ASTM D2488
A-10	Soil Boring Drilling and Abandonment	CH2M HILL	Drill Rig	N	
B-1	USEPA Region II Groundwater Sampling Procedure Low Stress (low Flow) Purging and Sampling	CH2M HILL	GW Pump	N	
B-2	Direct-Push Groundwater Sample Collection	CH2M HILL	Direct Push	N	
B-3	VOC Sampling - Water	CH2M HILL	GW Pump	N	
B-4	Preserving Non-VOC Aqueous Samples	CH2M HILL	Sample Containers	N	

QAPP Worksheet #21
Field Quality Control Sample Summary Table

C-1	Calibration and Measurement with Field Instruments	CH2M HILL	Water quality probe	N	
C-2	Bacharach Combustible Gas/Oxygen Meter and Personal Gas Monitor	CH2M HILL	CGI	N	
C-3	Explosimeter	CH2M HILL	Explosimeter	N	
C-4	Operation of Dräger Gas Detector	CH2M HILL	Dräger pump/tubes	N	
C-5	Miniram Personal Monitor	CH2M HILL	Miniram	N	
C-6	Use of Data Loggers and Pressure Transducers	CH2M HILL	Pressure transducer	N	
C-7	Volatiles Monitoring with an OVA	CH2M HILL	OVA	N	
C-8	Volatiles Monitoring by OVM	CH2M HILL	OVM	N	
D-1	General Guidance for Monitoring Well Installation	CH2M HILL	Drill Rig	N	
D-2	Installation of Shallow Monitoring Wells	CH2M HILL	Drill Rig	N	
D-3	Installation of Surface-Cased Monitoring Wells	CH2M HILL	Drill Rig	N	
D-4	Installation of Bedrock Monitoring Wells	CH2M HILL	Drill Rig	N	
D-5	Monitoring Well and borehole Abandonment	CH2M HILL	Drill Rig	N	
E-1	Decontamination of Personnel and Equipment	CH2M HILL	Personnel	N	
E-2	Decontamination of Drilling Rigs and Equipment	CH2M HILL	Drill Rig	N	
F-1	Concrete Core Sampling	CH2M HILL	Drill	N	
F-2	Concrete Chip Sampling	CH2M HILL	Hammer	N	
F-3	Concrete Wipes	CH2M HILL	Wipes	N	
G-1	Flat Bottom Boat/Canoe Sampling Operations	CH2M HILL	Boat	N	

QAPP Worksheet #21
Field Quality Control Sample Summary Table

G-2	Surface Water Sampling	CH2M HILL	Bottles, Dips, etc.	N	
G-3	Clean Sampling for Trace Metals in Surface Water	CH2M HILL	Bottles, Dips, etc.	N	
G-4	Streamflow Measurements	CH2M HILL	Current meter	N	
G-5	Sediment Sampling	CH2M HILL	Dredge, etc.	N	
H-1	Preparing Field Log Books	CH2M HILL	None	N	
H-2	Water-Level Measurements	CH2M HILL	DTW Probe	N	
H-3	Aquifer Slug Testing	CH2M HILL	Aquifer Slug	N	
H-4	Trenching for Landfill Delineation	CH2M HILL	Backhoe	N	
H-5	Buried Metal Investigations	CH2M HILL	Backhoe	N	
H-6	Sampling Contents of Tanks and Drums	CH2M HILL	Drum thief	N	
H-7	Disposal of Waste Fluids and Solids	CH2M HILL	Drums	N	
H-8	Chain-of-Custody	CH2M HILL	None	N	
H-9	Packaging and Shipping Procedures for Low-Concentration Samples	CH2M HILL	Coolers, etc.	N	
H-10	Equipment Blank and Field Blank Preparation	CH2M HILL	Related equipment	N	
H-11	Civil Surveying	CH2M HILL	Surveyor	N	
H-12	MEC Avoidance Procedure	CH2M HILL	None	N	
H-13	MEC Avoidance during Vegetation Clearing	CH2M HILL	None	N	

Note: SOPs describe general procedures associated with data collection. The actual procedures implemented may vary from those described but still achieve the substantive intent of the standard procedure.

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

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Horiba® U-22 pH Probe	Calibrate probe using Horiba® U-22 Auto-Calibration Standard Solutions				Daily before use, and when drift is suspected or readings are unstable and at end of day if practicable.	pH reads 4.0, 7.0 or 10.0 depending on which two solutions used. Acceptance criteria Std X -0.2< Reading<Std X +0.2	Clean probe with deionized water and calibrate again. Do not use this instrument if unable to calibrate properly.	Field Team Lead	C-1 (not specific to Horiba)
Horiba® U-22 Specific conductance Probe	Calibrate probe using Horiba® U-22 Auto-Calibration Standard Solution				Daily before use, and when drift is suspected or readings are unstable and at end of day if practicable.	conductivity reads 1,000 uS +/- 3% of Std.	Clean probe with deionized water and calibrate again. Do not use this instrument if unable to calibrate properly.	Field Team Lead	C-1 (not specific to Horiba)
Horiba® U-22 Turbidity Probe	Calibrate probe using Horiba® U-22 Auto-Calibration Standard Solution				Daily before use, and when drift is suspected or readings are unstable and at end of day if practicable.	Std = 0.1 – 10 NTU acceptance: within 10% Std = 11 - 40 NTU acceptance: within 8% Std = 41 - 100 NTU acceptance: within 6.5% Std = > 100 NTU acceptance: within 5%	Clean probe with deionized water and calibrate again. Do not use this instrument if unable to calibrate properly.	Field Team Lead	C-1 (not specific to Horiba)
Horiba® U-22 Dissolved oxygen and Temperature Probes			During calibration of other probes, check these readings against the day's atmospheric pressure and ambient temperature		Daily before use, and when drift is suspected or readings are unstable and at end of day if practicable.	Calibrate at 100% saturation with acceptance criteria of +/- 0.3 mg DO/L.	Clean probe with deionized water and calibrate again. Do not use this instrument if unable to calibrate properly.	Field Team Lead	C-1 (not specific to Horiba)
Horiba® U-22 Oxidation Reduction Potential (ORP)	Calibrate probe using Horiba® U-22 Auto-Calibration Standard Solution				Daily before use, and when drift is suspected or readings are unstable and at end of day if practicable.	Use standard solution. Reading must be within +/- 10 mV from the theoretical redox std at that temperature	Clean probe with deionized water and calibrate again. Do not use this instrument if unable to calibrate properly	Field Team Lead	C-1 (not specific to Horiba)
Horiba® U-22		Check mechanical and electronic parts, verify system continuity, check battery, and clean probes. Calibration check.	Visual inspection		Daily before use, and when drift is suspected or readings are unstable and at end of day if practicable.	Stable readings after 3 minutes pH reads 4.0 +/- 3% conductivity reads 4.49 +/- 3% turbidity reads 0 +/- 3%	Clean probe with deionized water and calibrate again. Do not use this instrument if unable to calibrate properly.	Field Team Lead	C-1 (not specific to Horiba)
Bacharach Sentinel 4	Calibrate the combustible gas, hydrogen sulfide, and carbon monoxide sensors using compressed gas cylinders. Calibrate the oxygen sensor with atmospheric air	Recharge and the outside of the instruments should be wiped clean with a soft cloth. Check alarm and settings Clean screens and gaskets around sensors Replace sensors			Daily, before use After each use Monthly and before each use Monthly Biannually or when calibration is unsuccessful	Calibrates in accordance with instruction manual	If meter fails to calibrate, do not use this meter.	Field Team Lead	C-2

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Bacharach Sniffer® 503-A	Calibrate the oxygen detector and percent LEL with compressed gas cylinders.	Recharge and the outside of the instruments should be wiped clean with a soft cloth. Check alarm and settings Clean screens and gaskets around sensors Replace sensors			Daily, before use After each use if practicable. Monthly and before each use Monthly Biannually or when calibration is unsuccessful	Calibrates in accordance with instruction manual	If meter fails to calibrate, do not use this meter.	Field Team Lead	C-2
Dräger Gas Detector		Leak testing Clean the metal screen Flush the pump with air			Prior to use Monthly (if used frequently) After each use if practicable.	If the bellows has not completely expanded after 30 seconds. Metal screen is no longer blocked	For Model 31, any leak can usually be eliminated by cleaning the valve	Field Team Lead	C-4
Industrial Scientific (MX251) Combustible Gas and Oxygen Indicator	Calibrate for percent LEL and percent O_2	Charge battery			Daily, before use and after each use if practicable.	After stabilization, LEL reads 50 percent +/-5 percent; O_2 reads 15 percent +/- 5 percent	If meter fails to calibrate, do not use this meter.	Field Team Lead	C-3
Miniram Model PDM-3	Zero the Miniram using a Z-Bag TM Calibrator which provides a clean-air environment	Recharge and the outside of the instruments should be wiped clean with a soft cloth			Daily, before use and after each use if practicable.	A zero value less than 3 mg/m2	When the zero value exceeds 3 mg/m^3, the sensing chamber may need to be cleaned following the instructions provided in the manufacturer's operating manual	Field Team Lead	C-5
OVA Organic Vapor Analyzer	Calibrate for organic vapors using compressed gas cylinders	Charge batteries Allow the batteries to totally discharge before recharging to prevent battery memory from occurring			Daily, before each use. Occasionally, as needed and after each use if practicable.	Check operations manual for acceptable range of calibrated probe for the specific lamp model	If meter fails to calibrate, do not use this meter.	Field Team Lead	C-7
OVM Organic Vapor Monitor	Calibrate for organic vapors using compressed gas cylinders	Charge batteries Allow the batteries to totally discharge before recharging to prevent battery memory from occurring			Daily, before each use. Occasionally, as needed, and after each use if practicable.	Check operations manual for acceptable range of calibrated probe for the specific lamp model	If meter fails to calibrate, do not use this meter.	Field Team Lead	C-8
Groundwater sampling pumps and tubing				Inspect pumps, tubing and air/sample line quick-connects	Regularly	Maintained in good working order per manufacturer's recommendations	Replace items	Field Team Lead	B 1 thru 5

QAPP Worksheet #23
Analytical SOP References Table

Reference Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
Laboratory specific; to be determined						

QAPP Worksheet #24
Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
GCFID						1.1.3.1
GCFID						1.1.3.2
GC/MS – VOA						1.2.3.4
GC/MS – VOA						1.2.3.5
GC/MS – VOA						1.2.4.2
GC/MS – SVOA						2.4.4.3
GCECD– Pest						2.1.2.3
GCECD - PCB						2.1.2.4
GC/HPLC						2.3.2.4
HPLC/EIS/MS						HPLC-DoDPerchlorate
ICP/AES - Metals						3.1.1.4
pH Meter						3.5.14.3
ORP						09WC-1498.I
CEC						09WC-9081.I
DC-180 TOC Analyzer						3.6.2.2
TSS						3.5.19.1
TDS						3.5.19.1
Hardness						3.5.7.1
IC, Lachat						3.5.22.1

[1] Specific information for each instrument is found in the attached CD, Attachment A of this QAPP.

SOP	Description
1.1.3.1	Preparation and GC Analysis of Gasoline Range Organics (GROs) in Aqueous Samples by Purge and Trap following SW-846, CA LUFT, and TN GRO
1.1.3.2	Preparation and Analysis of Gasoline Range Organics (GRO) in Soil/Sediment Samples by Purge and Trap Following SW-846, CA LUFT, and TN GRO
1.2.3.4	GC/MS Analysis of Aqueous and Medium Level Solids for Volatile Organic Compounds using USEPA SOW SOM01.1
1.2.3.5	GC/MS Analysis of Low Level Solids for Volatile Organic Compounds using USEPA SOW SOM01.1
1.2.4.2	GC/MS Analysis of Trace Level Volatiles in Water Scan and Selected Ion Monitoring using EPA CLP SOW SOM01.1
2.1.2.3	GC/ECD Analysis of Pesticides in Aqueous and Solid Sample Extracts by EPA CLP SOW SOM01.1 and NYSASP
2.1.2.4	GC/ECD Analysis of Polychlorinated Biphenyls (PCBs) as Aroclors in Water and Soil Extracts by CLP SOW SOM01.1
2.3.2.4	Analysis of Nitroaromatics and Nitramines in Water and Soil Samples by HPLC in SW-846 and NYSASP
2.4.4.3	GC/MS Scan and SIM Analysis of Semivolatiles in Water and Soil Matrices by EPA CLP SOM01.1
3.1.1.4	Determination of Metals by Inductively Coupled Plasma (ICP) by EPA CLP and NYSASP
3.5.7.1	Total Hardness as Calcium Carbonate in Water by Lachat and MCAWW
3.5.14.3	Soil and Waste pH by Method 9045C (SW-846 + NYSASP)
3.5.19.1	Nonfilterable Residue; Total Suspended Solids, by MCAWW
3.5.19.2	Filterable Residue, Total Dissolved Solids, by MCAWW
3.5.22.1	Determination of Inorganic Anions by Ion Chromatography
3.6.2.2	Analysis of Soil Samples for Total Organic Carbon (TOC) by SW-846 and Lloyd Kahn
	Oxidation-Reduction Potential by ASTM Method 1498
	Cation Exchange Capacity by SW-846 Method 9081
	Perchlorate in Water, Soils and Solid Wastes Using High Performance Liquid Chromatography/Electrospray Ionization/Mass Spectrometry (HPLC/ESI/MS) for Dod

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SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire block below (except effective date).

This is a new procedure _____ revised procedure ✓ outdated procedure (archive) _____

- Procedure Code: 1P178 SOP Section #: 1.1.3.1 Revision #: 9

SOP Title: Preparation and GC Analysis of Gasoline Range Organics (GROs) in Aqueous Samples by Purge & Trap Following SW-846, CA Luft & TN GRO

Effective date: (QA fills in) 8/23/05

- Procedure prepared by: Joan Ockenlander Date: 8-22-05
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) [signature] Date: 8-23-05
- Reason for change: Change standard preparation amounts and cosmetic changes throughout
- This procedure meets the requirements of the following approved method references: SW-846, 3RD Edition, Update III, Method 8015B, NYSASP, June 2000 plus Revisions, TN DEC UST Division Lab Methods "Method for Determination of Gasoline Range Organics"

Procedure approved by Quality Assurance Representative: Date:
(Not needed if signed above)

Effective 1-1-96, on an annual basis: Lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary, indicate by your signature that the SOP has been reviewed.

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Instrument Procedure 178: Preparation and GC Analysis of Gasoline Range Organics (GROs) in Aqueous Samples by Purge and Trap Following SW-846, CA LUFT, and TN GRO

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Instrument Procedure 178: Preparation and GC Analysis of Gasoline Range Organics (GROs) in Aqueous Samples by Purge and Trap Following SW-846, CA LUFT, and TN GRO

1.0 Scope and Application

This method is used to detect purgeable total petroleum hydrocarbons (TPH), including gasoline range organics (GRO), in aqueous samples by GC/FID analysis using Method 8015B and the purge and trap technique in Method 5030B. GROs correspond to the range of alkanes from C_6 to C_{10} and covering a boiling point range of approximately 60° C – 170° C. Qualitative and quantitative data are generated using an FID detector. This standard operating procedure (SOP) describes the analytical requirements for the CA LUFT method.

Method detection limits (MDLs) and reporting limit are included in Attachment 1. The reporting limit is the low level calibration standard concentration.

Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

2.0 Summary of Method

2.1 Sample Preparation

Five milliliters of sample are aliquotted into a 5 **mL** syringe and spiked with 5 **µL** of a 5 mg/**mL** surrogate solution of 1,4-dichlorobutane for method 8015B and 10 **µL** of a 50 **µg**/**mL** surrogate solution of p-isopropyltoluene for the TN GRO method.

2.2 Analysis

This method provides GC conditions for the detection of the purgeable components of gasoline. Helium is bubbled through 5 **mL** of sample contained in a specially designed purge chamber at ambient temperature. The target analytes are efficiently transferred from the aqueous phase to the vapor phase. The vapor is then swept through a sorbent trap where the target analytes are trapped. After

purging is completed, the trap is heated and back flushed with helium to desorb the target analytes onto a GC column. The GC is temperature programmed to separate the target compounds. The trap is desorbed onto a capillary column and detected by an FID.

The FID, which is generally non-selective and responsive to all organic compounds, is used to sum the areas of all the peaks over a given range. The order of analysis for this method is:

- initial calibration
- initial calibration verification (LCS)
- method blank/instrument blank
- samples/spikes
- continuing calibration (after every 10 samples)

3.0 Definitions

3.1 Method detection limit (MDL) – The minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR, Part 136, Appendix B.)

3.2 Reporting Limit – The laboratory reporting limit is based on the lowest multipoint calibration standard concentration. For organic methods, values detected below the reporting limit and above the MDL may be reported and qualified as an estimated concentration.

3.3 Reporting Units – mg/L

3.4 An SDG is defined by the following, whichever is more frequent:

- each 20 field samples received within a case, or
- each 7 calendar day period during which field samples in a case are received (14 calendar days if requested by the client) beginning with the receipt of the first sample.

NOTE: The Army Corps of Engineers (US ACE) and SC DHEC do not accept the SDG approach, unless the samples are prepared in a single batch. When a group of up to 20 field samples of a similar matrix are prepared as one batch, method-specified QC samples such as a method blank, laboratory control sample, matrix spike, matrix spike duplicate, and matrix duplicate must also be prepared together at a rate of 5% for US ACE and 10% for SC DHEC. If samples are batched together from different sites, project-specific QC must be processed.

3.5 Surrogate – The surrogate for method 8015B is 1,4-dichlorobutane. The surrogate for the TN GRO method is p-isopropyltoluene. These surrogates provide a measure of purging efficiency in the studied matrix.

3.6 FID – a detector that measures the electrical current from ions produced by controlled combustion of chromatographic eluates.

3.7 GALP – good automated laboratory practices; a quality assurance (QA) measure to document that the computer and data acquisition systems are sufficiently protected from tampering and that any changes made to the data have a documented audit trail.

3.8 SC DHEC – South Carolina Department of Health and Environmental Control

4.0 Interferences

4.1 Samples can be contaminated by diffusion of volatile organics through the sample container septum during shipment and storage. A trip blank carried through sampling and storage serves as a check of contamination.

4.2 Contamination by carryover is possible when a high concentration sample is analyzed. Any sample analyzed after a high concentration sample should be reanalyzed.

4.3 The vessel that a sample is run in must be verified as clean by running a blank in it or a clean sample previously. Check blank for the appearance of non-target as well as checking target values.

5.0 Safety

5.1 All samples and standard reference materials must be assumed to be hazardous/toxic and must be handled to minimize exposure.

5.2 All samples must be prepared under a laboratory fume hood. Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous. During sample preparation, glasses, gloves and lab coats are a minimum requirement. The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

5.3 Laboratory staff are encouraged to review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets for reagents used in the laboratory. The MSDS are located in the Quality Assurance department.

6.0 Equipment & Supplies

6.1 Two 10 **µL** gastight syringes, Hamilton 1701N or equivalent

6.2 One 5 **mL** gastight syringe, Hamilton or equivalent

6.3 Two 25 **µL** gastight syringes, Hamilton or equivalent

6.4 One 50 **µL** gastight syringe, Hamilton or equivalent

6.5 Gas chromatograph, Varian 3400 (See Table 1 for GC conditions)

Table 1 GC Conditions – All Methods

Specification	Values
Carrier gas	Helium
Final temperature	220 °C
Initial Temperature	45° C
Initial Time	5.0 min.
Flow Rate	8.2 **mL**/min.
Ramp Rate	• 45° C - 45° C hold for 5.0 min. (initial time) • 45° C - 100° C at 5° C/min; hold for 0.5 min. • 100° C - 220° C at 50.0° C/min. • 220° C – 220° C hold for 2.0 min.
GC Mode	Capillary
Detector temperature	250° C
Final hold time	2.0 min.
Makeup flow	20 **mL**/min.
Injector temperature	50° C
Method completion time	20.90 minutes

6.6 Columns: RTX - Volatiles

6.7 Injection port, not used. A stainless steel low dead volume connector is used to connect the transfer line from the purge and trap directly to the capillary column.

6.8 Detector, Varian FID Detector Model 3400 (See Table 2 for detector specifications)

Table 2. Detector Conditions

Specification	Values
hydrogen flow rate	30 **mL**/min
air flow rate	300 **mL**/min
polarizing voltage	100 V
attentuation	8-10

6.9 Purge device: Tekmar 2016. Purge flow is 35 **mL**/min. The transfer line is directly connected into a Tekmar LCS2000.

6.10 Trap and desorb device: The Tekmar LCS 2000 sample concentrator is used to trap the purgeables and then desorb the trap constituents onto the chromatographic column.

6.11 Autosampler Settings: Setting**s** apply to both 8015 GRO and TN GRO unless otherwise noted. **(Table continued to next page.)**

Specification	Values
Standby	40° C
Pre-purge	0.00 minutes
Pre-heat	1.25 minutes (8015 GRO soil)/ 0.00 (TN GRO & 8015 GRO water)
Sample	0° C (8015 GRO) / 40°C (TN GRO)
Purge	8.00 minutes
Dry purge	0.00 minutes
MCM cool down	NI
Cap cool down	NI
Desorb pre-heat	NA
Desorb	4.0 minutes at 240° C
Bake	8.00 minutes at 260° C
BG13	OFF
BG13 delay	60 seconds
Auto drain	OFF
Valve	120° C
Line	120° C
Mount	30° C
Aux. heater	NI
2016 value	120° C
Line	**120°C**
2032 value	**NI**
Line	**NI**

Specification	Values
Cap union	**NI**
MCM heat	**NI**
Runs per sample	**1**

7.0 Reagents and Standards

Refer to the Standards Preparation Logbook 22 F for details on preparation of standards used in this procedure.

7.1 DI water – All water used in this procedure must be equivalent to ASTM Type II water (as it relates to specific conductance and specific resistance) which is subsequently purged with an inert gas and demonstrated to meet the blank contamination acceptance criteria contained in this Standard Operating Procedure (SOP). It is referred to throughout the remained of this SOP as DI water.

7.2 Methanol – Purge and trap grade methanol is used to prepare the surrogate standard. The gasoline is prepared in GC/GC/MS solvent grade methanol. All standards are stored at -10 to -20° C.

7.3 **Primary** calibration standard at 2.5 mg/**mL** - used for 8015B and NYSASP initial calibration standard. Also used for continuing calibration standard.

7.3.1 Prepare **this** calibration standard at 2**.**5 mg/**mL** by adding **250 µL** Restek unleaded gasoline composite standard (50 mg/**mL**) to an amount of purge and trap methanol in a **5 mL** volumetric flask and bring to volume.

7.3.1.1 Prepare this standard every six months.

7.3.**2** Dilutions are made in the laboratory for the working level calibration standards according to the instructions in Section 10.0.

7.4 Second source 8015B and NYSASP calibration verification standard (also used to generate the LCS, MS and MSD)

7.4.1 Prepare **this** standard at 2**.**5 mg/**mL** by adding 1 **mL AccuStandard** Gasoline **Composite Mix** standard (5**.**0 mg/**mL**) to an amount of purge and trap methanol in a 2 **mL** volumetric flask and bring to volume.

7.4.1.1 Prepare this standard every six months.

7.4.**2** **This standard and 5 µL regular GRO surrogate is added to 5 mL DI water to produce an LCS/LCSD or added to the sample aliquot to produce an MS/MSD. The amount of the standard added is usually 10 µL but could vary with the application.**

7.5 TN GRO 5.0 mg/**mL** calibration standard – used to generate lowest three points on calibration curve. Also used for continuing calibration standard.

7.5.1 Prepare the standard by adding 1 **mL** AccuStandard TN GRO standard (10,000 **µg**/**mL** total components) to an amount of purge and trap methanol in a 2 **mL** volumetric flask and bring to volume.

7.5.1.1 Prepare this standard every six months.

7.6 TN GRO 10.0 mg/**mL** calibration standard purchased as 10 mg/**mL** from AccuStandard and used to generate highest two points on calibration curve by diluting as indicated in Section 10.0.

7.6.1 This standard is used to prepare a 20 mg/L level standard (See Section 10.1.3) when the 72 hour retention time window study is performed for 8015B GRO. The standard is made up of individual alkane compounds including 2-methylpentane (first eluting compound) and 1,2,4-trimethylbenzene (last eluting compound). (See Attachment 4.)

7.6.1.1 The 20mg/L TN GRO standard is also used prior to performing initial calibrations and daily calibration verifications. This establishes the retention time range. (See 10.1.6.)

7.6.2 Replace this standard every six months.

7.7 Second source TN GRO 5.0 mg/**mL** standard – used to generate LCS, LCSD, MS, and MSD.

7.7.1 Prepare the standard by adding 1 **mL** TN GRO standard (NSI UST) to an amount of purge and trap methanol in a 2**mL** volumetric flask and bring to volume.

7.7.1.1 Prepare this standard every six months.

7.8 **Regular GRO** Surrogate Spiking Solution, 5.0 mg/**mL** concentration of 1,4-dichlorobutane

7.8.1 Prepare **this** standard by **adding 500 µL** of **AccuStandard** 1,4-Dichlorobutane **(20.0 mg/mL)** into an amount of purge and trap methanol in a **2 mL** volumetric flask and bring to volume.

7.8.1.1 Prepare this standard every six months.

7.9 TN Surrogate Spiking Solution at 50 **µg**/mL

7.9.1 Prepare the standard by adding 0.25 **mL** of AccuStandard p-Isopropyltoluene (2000 **µg**/**mL**) to an amount of toluene in a 10 **mL** volumetric flask and bring to volume.

7.9.1.1 Prepare this standard every three months.

7.10 Preparation of the laboratory control sample (LCS), matrix spike and matrix spike duplicate (MS/MSD), and blank are detailed in Section 11.0.

7.11 Preparation of the initial and continuing calibration standards are given in section 10.0.

7.12 Standard Storage Requirements

7.12.1 Standards are be stored in the freezer at -10° C to -20° C.

8.0 Sample Collection, Preservation, & Storage

8.1 Samples are collected, preserved, and stored according to the tables in Sample Control SOP 4.1, "Receiving Samples" and 4.6, "Storing Samples." Sample holding times are also listed.

8.2 GRO water samples are collected in two or three 40**mL** vials preserved with HCl. If samples are preserved, the holding time is 14 days from verified time of sample collection. If samples are unpreserved, the holding time is 7 days.

8.3 Always check and report sample pHs.

9.0 Quality Control

9.1 Initial Calibration

If the technical acceptance criteria for the initial calibration are not met, inspect the system for problems. It may be necessary to clean the FID, change the column, service the purge and trap device, or take other corrective action to

achieve the technical acceptance criteria. Record all instrument maintenance in the appropriate logbook. Routine maintenance is recorded on the instrument runlog (Attachment 2) whereas non-routine maintenance activities are recorded in the maintenance logbook (Attachment 3).

Acceptance criteria and corrective action are described in Section 10.0. The calibration curve is verified using a second source standard from NSI or equivalent vendor. The LCS is prepared from the second source standard. Quality control requirements for the LCS as described in Section 9.5 below.

9.2 Continuing Calibration

If the continuing calibration fails technical acceptance criteria, it may be necessary to analyze instrument blanks to clean up the purge and trap system or to reveal the presence and source of contamination problems.

Column maintenance may also be used as a corrective action measure, with the analysis of a new initial calibration to demonstrate system integrity.

The first continuing calibration standard analyzed on each day must meet the +/- 15% criteria (10% for CA LUFT and 25% for TN GRO) before any samples may be run. An acceptable ending calibration must be analyzed within twelve hours of the injection time of the daily continuing calibration. All samples must be bracketed by acceptable CCV's unless the CCV is biased high and the previous samples were nondetects. Otherwise, all samples not bracketed by acceptable continuing calibrations within this twelve-hour period must be reanalyzed and corrective action must take place. The corrective action may involve instrument maintenance, running an instrument blank, or performing a new initial calibration. The 10 samples analyzed after a passing continuing and before a failing continuing calibration standard are acceptable. However, no more samples can be analyzed until another continuing calibration meets criteria or a new initial calibration is performed.

9.3 Surrogates

9.3.1 Surrogate recoveries must be within 43-124% (50-150% for TN GRO) for all samples, blanks, blank spikes, matrix spikes, and matrix spike duplicates.

9.3.2 If acceptance criteria are outside this control range on the column, the sample must be re-analyzed.

9.4 Method Blanks

Method blanks are prepared and analyzed with every 12 hour calibration period or batch. The presence of analyte in the blank cannot exceed the reporting limit. If the method blank exceeds acceptance criteria, the source of the problem must be investigated and appropriate corrective action taken. All samples processed with a method blank that does not meet acceptance
criteria must be reanalyzed.

Any value present in the blank that falls between the MDL and the reporting limit must also be investigated and corrective action taken as indicated. At a minimum any associated samples must be qualified with a "B" flag on the report form and explained in the SDG narrative.

9.5 Laboratory Control Sample (LCS)

9.5.1 A LCS is DI water fortified with the gasoline spiking solution and surrogate. The spiking solution is from a different source than that used to prepare the calibration curve and therefore, serves to verify the calibration curve as well as to determine the accuracy of the method. The LCS is prepared with every 20 samples or calibration batch, whichever is more frequent. For NYSASP, the blank spike is called the matrix spike blank.

9.5.2 The results of the LCS are used to confirm that any failing spiked gasoline in the MS/MSD tests are a result of sample matrix interference and not due to an out of control analytical system. The results are also used to indicate problems with the calibration curve.

9.5.3 LCS recovery limits are 63-110% (50-150% for TN GRO).

9.5.3.1 The LCS must meet criteria or the entire batch must be repeated.

9.5.4 For TN GRO, a LCS duplicate (LCSD) is also required. The percent recovery criteria for the LCS/LCSD are 50-150% for TN GRO and the RPD criteria are 20%.

9.5.4.1 The LCS/LCSD must meet criteria or the entire batch must be repeated.

9.6 Matrix Spike/Matrix Spike Duplicate (MS/MSD)

9.6.1 A matrix spike and matrix spike duplicate must be performed for each group of samples of a similar matrix per each sample delivery group.

9.6.2 A matrix interference can be confirmed through evaluation of the LCS. The percent recovery criteria of the matrix spikes are 50-142% (50-150% for TN GRO) and the RPD criteria are 20%.

9.6.3 The objective for the MS/MSD tests is for the spiked compound to be recovered within criteria and the RPD value to be within criteria. However, the recoverability of spiked analytes in environmental samples is very much influenced by the particular matrix and, therefore, these objectives may not be able to be met. When recoveries do not meet the acceptance criteria or interferences preclude proper assessment of the data, results of the laboratory control sample (LCS, sometimes referred to in the laboratory as a blank spike or BS) are evaluated to verify that the analytical system is in control.

9.6.4 If surrogate recovery in the original unspiked sample is not within acceptance limits and the MS/MSD surrogate recoveries are within limits, the original sample should be reanalyzed. If the original sample and the MS/MSD tests yield the same unacceptable surrogate recoveries, then the sample does not require reanalysis since matrix interferences would be confirmed.

9.7 Duplicates, at a frequency of 5%, are required when processing samples submitted to meet the regulatory requirements of the State of North Carolina DENR. The MS/MSD fulfills this requirement.

9.8 MDL Check Samples

9.8.1 On an annual basis a method detection limit (MDL) study is performed on a single instrument per method and matrix. When multiple instruments are used for the analysis of U.S. Army Corps of Engineers samples (or samples from other programs with the same requirement), individual instrument MDL studies are replaced by the analysis of an MDL check sample. The MDL check sample must be analyzed on all instruments, where the MDL study was not performed and that U.S. Army Corps of Engineers samples (or other program-specific samples) are analyzed on, to demonstrate equivalent sensitivity.

The MDL check sample is prepared at about 2x the MDL and is analyzed on a quarterly basis for each matrix. A response must be detected in the 2x MDL check sample. For more information on MDL studies, refer to QC SOP 13.11, “Performing Annual Method Detection Limit (MDL) Studies.”

9.9 Retention Time Window Study

9.9.1 A 72 hour retention time window study is performed once per year or when changes in instrumentation occur, including a column change. The standard used to establish the window contains 2-methypentane and 1,2,4-trimethylbenzene as markers of the elution pattern of gasoline range organics. A TN GRO standard , at 20 mg/L, is used for the study.

10.0 Calibration & Standardization

10.1 Initial Calibration

10.1.1 Before analyzing samples and required blanks, establish the retention time range with the 20mg/L TN GRO standard (See 10.1.6) and calibrate each instrument at five concentrations to determine the instrument sensitivity and linearity of the GC/FID response for the purgeable target compounds.

10.1.2 All standards are prepared by spiking the appropriate volume of the gasoline standard and 1,4-dichlorobutane surrogate for 8015B GRO (or p-isopropyltoluene surrogate for TN GRO) into gastight syringes containing 5 **mL** of sparged DI water. All of the primary analytical standards are stored in a freezer when not in use.

10.1.3 Five levels of working standards are prepared for the calibration curve by the analyst using a 2.5 mg/**mL** gasoline standard for 8015B GRO and a 5.0 and 10 mg/**mL** gasoline standards for TN GRO.

Note: The quantitation report header for the on-column amount displays the units incorrectly as (Ng). Due to software limitations, this header cannot be corrected to (**µg**) at this time.

Note: The low standard is the reporting limit.

Calibration Curve Standards - 8015 and NYSASP GRO Table

Amount of 2.5 mg/mL std. added	**Concentration**	**On-column amount**
1 **µL**	0.5 mg/L	2.5 **µg**
2 **µL**	1.0 mg/L	5.0 **µg**
10 **µL**	5.0 mg/L	25.0 **µg**
20 **µL**	10.0 mg/L	50.0 **µg**
50 **µL**	25.0 mg/L	125.0 **µg**

Calibration Curve Standards - TN GRO Table

Amount of 10 mg/mL std. (for 2 highest) & 5 mg/mL std. (for all others) added	Concentration	On-column amount
1 **µL**	1.0 mg/L	5.0 **µg**
5 **µL**	5.0 mg/L	25.0 **µg**
10 **µL**	10.0 mg/L	50.0 **µg**
10 **µL**	20.0 mg/L	100.0 **µg**
20 **µL**	40.0 mg/L	200.0 **µg**

To each standard, 1,4-dichlorobutane surrogate (p-isopropyltoluene for TN GRO) is added at varying concentrations. The calibration curve is established by dividing the total area of the surrogate by the mass injected for the five different concentrations of the standard. The surrogate levels are listed below.

Surrogates for Calibration - 8015 and NYSASP GRO Table

Standard Concentration	Amount of 5.0 mg/mL surrogate added	Concentration	On-column amount
0.5 mg/L	1 **µL**	1.0 mg/L	5.0 **µg**
1.0 mg/L	2 **µL**	2.0 mg/L	10.0 **µg**
5.0 mg/L	5 **µL**	5.0 mg/L	25.0 **µg**
10.0 mg/L	10 **µL**	10.0 mg/L	50.0 **µg**
25.0 mg/L	20 **µL**	20.0 mg/L	100.0 **µg**

Surrogates for Calibration - TN GRO Table **(Continued on next page)**

Standard Concentration	Amount of 50.0 µg/mL surrogate added	Concentration	On-column amount
1.0 mg/L	1 **µL**	0.01 mg/L	0.05 **µg**
5.0 mg/L	5 **µL**	0.05 mg/L	0.25 **µg**
10.0 mg/L	10 **µL**	0.1 mg/L	0.5 **µg**
20.0 mg/L	20 **µL**	0.2 mg/L	1.0 **µg**
40.0 mg/L	25 **µL**	0.25 mg/L	1.25 **µg**

10.1.4 The percent Relative Standard Deviation (%RSD) of the calibration factors for the initial calibration must be less than or equal to 20% (25% for TN GRO) for all analytes. If the %RSDs over the five levels is $\leq$20% (25% for TN GRO), then the mean calibration factor (CF) can be used to calculate the gasoline or other petroleum hydrocarbons. (See Method 8000, section 7.4.2.2.)

If the %RSD is >20% (25% for TN GRO), a calibration curve must be used to calculate sample results. If the %RSD is >20% (25% for TN GRO), the following items should first be checked:

10.1.4.1 If CFs have random variation, check for leaks in the purge vessels.

10.1.4.2 If CFs increase with concentration, check for active sites in the chromatographic system.

10.1.4.3 If CFs from direct injections remain consistent, the active sites are probably in the purge and trap system.

10.1.4.4 If CFs decrease with concentration, check for contamination of the system by analyzing a blank.

10.1.4.5 When the problem is identified and corrected, the calibration standards must be reanalyzed.

10.1.5 The validity of the calibration curve is verified using a second source standard. For this method, the LCS serves this purpose and is prepared following the preparation procedure in 11.1.3 below.

10.1.6 The retention time range is calculated from the retention time window study by subtracting the 3SD value (determined from the most current 72 hour retention time study) from the elution time of 2-methylpentane (first component in the elution order of the TN GRO standard), and adding the 3SD value to the elution time of 1,2,4-trimethylbenzene (last component in the elution order of the TN GRO standard).

10.2 Continuing Calibration (CCAL)

10.2.1 A continuing calibration verification standard must be analyzed, after establishing the retention time range with the 20mg/L TN GRO standard, to start a daily sequence and must meet acceptance criteria in order for sample analysis to proceed. A 5 ppm gasoline standard is used as the check standard. Each calibration factor must be <15% difference (%D) (10%D for CA LUFT and 25%D for TN GRO) when compared to the mean calibration factor of the most recent acceptable initial calibration on both analytical columns.

If the %D exceeds 15% (10% for CA LUFT and 25% for TN GRO), then corrective action must be taken and the calibration verification re-injected.

If the calibration still exceeds the criteria, a new initial calibration must be analyzed.

10.2.2 Once the daily continuing calibration standard meets criteria, samples are run and subsequently an acceptable continuing calibration must be analyzed within twelve hours of the injection time of the daily continuing calibration. Additional continuing calibration standards can be analyzed within this twelve-hour period to bracket sample analyses.

11.0 Procedure

Documentation must follow the requirements in QC SOP: Proper Documentation Procedures.

11.1 Sample and Quality Control Preparation

11.1.1 Thoroughly mix sample before aliquotting. Aliquot 5 **mL** of sample into 5 **mL** syringe and spike with 5 **µL** of a 5.0 mg/**mL** surrogate solution of 1,4-dichlorobutane for 8015 GRO. For TN GRO add 10 uL of a 50 **µg**/mL surrogate solution of p-isopropyltoluene.

11.1.2 Prepare a method blank by filling a 5 **mL** gastight syringe with 5 **mL** of DI water and 5 **µL** of the surrogate solution. The method blank is analyzed before samples and after the continuing calibration.

11.1.3 Prepare a blank spike (laboratory control sample) by filling a 5 **mL** gastight syringe with 5 **mL** of DI water, appropriate surrogate solution, and 10 µl of a 2.5 mg/**mL** second source gasoline standard for 8015B GRO. Add 10 µl of a 5.0 mg/**mL** second source standard for TN GRO. For TN GRO, prepare a duplicate LCS.

11.1.4 Prepare a matrix spike by taking a 5 **mL** aliquot of thoroughly mixed sample and adding appropriate surrogate solution and 10 µl of a 2.5 mg/**mL** of second source gasoline standard for 8015B GRO. Add 10 µl of the 5.0 mg/**mL** second source standard for TN GRO.

11.1.5 Prepare a matrix spike duplicate following step 11.1.4.

11.2 Autosampler Setup

The autosampler (2016) is controlled by the Tekmar LCS 2000 and operated in the following manner.

11.2.1 On the front panel of the LCS 2000, push the "F2" button for ALS.

11.2.2 For sequential vessels, arrow to the "Start" position and press "Enter." Enter the position number for the first analysis and press "Enter." Use the arrow key to go to the last position ("Stop"). Use the "Enter" key to enter the vessel number for the last analysis. Push the "F2" key and check that the enable schedule is "N" for "No.". Push "F4" two times to exit.

11.2.3 To schedule samples to run in vessels that are not in sequential order, push the "F2" button for "Schedule." Answer "Enable schedule?" with "Y" for "Yes". Arrow to each start and stop position and enter the numbers by pressing "Enter", the number then "Enter" again. Press "F4" to exit when complete.

11.3 Trap and Desorb

NOTE: See section 6.9 for additional information and details.

The Tekmar LCS 2000 sample concentrator traps the purgeable organic compounds and then desorbs the trap constituents onto the chromatographic column.

11.3.1 Set the transfer line and valve temperature to 120° C.

11.3.2 Set the purge time at 8.0 minutes and desorb time at 4.0 min.

11.3.3 Set the bake time to 8.0 minutes and the bake temperature to 260° C.

11.3.4 Set "GC Ready" temperature to whatever the thermocouple is reading. This is usually 50° C. Variable response and purge flow as observed in the vessel are usually due to incomplete switching of the 6-port valve and adjustments by the service department need to be made.

11.3.5 Sample Trap – The purge gas is swept through a trap that absorbs all of the target compounds. The trap should be below 25° C during the purge process. The transfer line between the autosampler and the trap is maintained at 120° C.

11.3.6 Sample Desorption – During the desorb procedure, the target compounds are backflushed off of the trap and enter the carrier gas stream to the chromatographic column. The gas flow and trap temperatures are controlled so that all the compounds are removed from the trap in as short a time as possible.

12.0 Data Analysis & Calculations

Calculations must be consistent with the QC SOP: Numerical Data Reduction.

12.1 Calculation of the mean or average of a set of values:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where: n = total number of values
x_i = each individual value used to calculate the mean
x = the mean of n

12.2 Calculation of the standard deviation of a set of values:

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n}\left(X_n - \overline{X}\right)^2}{n-1}}$$

12.3 Calculation of percent recovery:

12.3.1 LCS and surrogates:

$$\%R = \frac{Amount\ found}{Amount\ spiked}\ x\ 100$$

12.3.2 Matrix spikes:

$$\%\ \text{R} = \frac{Amount\ in\ spiked\ sample - Amount\ in\ unspiked\ (native)\ sample}{Amount\ spiked}\ x\ 100$$

12.4 Calculation of % RSD

$$\%\text{RSD} = \left(\frac{Standard\ deviation}{\overline{\text{X}}}\right) \times 100$$

12.5 Calculation of RPD

$$RPD = \frac{|Value\ 1 - Value\ 2|}{(Value\ 1 + Value\ 2)/2} x100$$

12.6 Calculation of %Difference (%D)

$$\%Diff = \frac{Value - \overline{Reference\ \ value}}{\overline{Reference\ \ value}} \times 100$$

12.7 Calibration factors for GC analysis are calculated by dividing the total peak area in the standard by the total mass injected (in micrograms).

$$Calibration\ Factor\ (CF) = \frac{Peak\ area}{Total\ mass\ injected}$$

12.8 Quantitation of Results

Positive results in samples are determined using the external standard technique. A processed GC file is obtained. The file contains the sum of the response of individual peaks in the gasoline fuel pattern within the elution of the first and last components in the standard. The mean CF from the initial calibration is used in the calculation.

The concentration of the gasoline is determined by the following formula:

$$\text{Conc. (mg/L)} = \frac{\text{area x dilution}}{\text{CF x volume purged}}$$

No area may be subtracted from the GRO retention time windows in calculating results except the area contributed by the surrogate. In that case, only the area of a surrogate peak "riding" the hydrocarbon envelope may be subtracted. Peak area measured from blanks may not be subtracted from sample area peaks.

12.8.1 Reporting Results for the Modified 8015B CA LUFT Method

Integration is performed using the flattest baseline possible from the beginning of the gasoline peak pattern to the end of the peak pattern.

12.8.2 Report the presence of significant peaks that are in the gasoline range even if they do not match the standard peak pattern. This should be noted in the SDG narrative when it occurs.

12.8.3 Report the presence of significant peaks outside the chromatographic window. Peaks are significant if they can be distinguished above the noise in a chromatogram. Any peak three times the standard deviation of the signal to noise ratio is statistically significant. All peaks (and baseline rises) outside the window are to be reported.

12.9 The daily retention time window is established using the 20mg/L TN GRO standard by subtracting the 3SD value, determined from the 72 hour retention time study, from the elution time for 2-methylpentane, and adding the 3SD value to the elution time of 1,2,4-trimethylbenzene.

12.10 Calculating Dilutions

If a sample concentration exceeds the high level standard a dilution must be performed. Determine a level of dilution that will result in a value within the upper half of the calibration range. This is an acceptable dilution. A 10x dilution is performed using 1 mL sample plus 9 mL diluent for a total volume of 10 mL. It should be recorded on the run log as "10x (1 mL in 10 mL)."

$$Dilution\ factor = \frac{\mu L\ most\ conc.\ extract\ used\ to\ make\ dilution + \mu L\ clean\ solvent}{\mu L\ most\ conc.\ extract\ used\ to\ make\ dilution}$$

13.0 Method Performance

This method was validated through in-house laboratory studies of method detection limits (attachment 1) and precision and accuracy for single analyst (Attachment 5). The data are retained by the QA department.

14.0 Pollution Prevention

The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 thing.

15.0 Waste Management

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Samples preserved with HCl, HNO_3, or H_2SO_4 to pH <2 are hazardous and must be neutralized before being disposed, or must be handled as hazardous waste.

Refer to the Hazardous Waste Management and Safety SOPs located in the lab.

16.0 References

16.1 "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods", SW846, 3rd Edition, Update III, 12/96, Methods 8015A modified, 8015B and 5030B

16.2 Leaking Underground Fuel Tank Field Manual: Guidelines for Site Assessment, Cleanup, and Underground Storage Tank Closure. State of California. Leaking Underground Fuel Tank Task Force. May 1988

16.3 Standard Methods for the Examination of Water and Wastewater, 20th (1998) Edition, Method 1080

16.4 New York State Analytical Services Protocol (NYSASP), approved May 2001, plus revisions

16.5 U.S. Army Corps of Engineers Chemical Data Quality Management (CDQM) Policy for USACE Hazardous, Toxic and Radioactive Waste (HTRW) Projects: "Shell for Analytical Chemistry Requirements", November 1998.

16.6 QCSOP: Proper Documentation Procedures & Numerical Data Reduction

16.8 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477

16.9 Hazardous Waste Management & Safety SOPs: "Hazardous Waste Disposal" and "Spill Control & Cleanup."

16.10 NELAC Standards, July **2003**, plus revisions

16.11 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995

16.12 New York State Environmental Laboratory Approval Program, Certification Manual, October 15, 1999, plus revisions

16.13 CompuChem Quality Manual, Revision **6, Update 1**, **5/20/05**, plus revisions

16.14 Standards SOP: "Secondary Calibration Standard, ID # 2146, GRO, Water & Soil, SW-846 Method 8015B/California L.U.F.T."

16.15 Standards SOP: "Surrogate Spiking Solution, ID # 434, GRO, Water & Soil, SW-846 Method 8015B/California L.U.F.T."

16.17 Tennessee Department of Environment and Conservation, UST Division Lab Methods, "Method for Determination of Gasoline Range Organics"

16.18 Sample Control SOP 4.1, "Receiving Samples" & SOP 4.6, "Storing Samples"

16.20 QC SOP 13.11, "Performing Annual Method Detection Limit (MDL) Studies"

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.1 Attachment 1 – Method Detection Limit Study

17.2 Attachment 2 – Instrument Run Log

17.3 Attachment 3 – Maintenance Log

17.4 Attachment 4 – Standard Certificate of Analysis

17.5 Attachment 5 –Single Analyst Capability Study

Attachment 1

Preparation Date: Not Applicable				Gasoline Range Organics (GRO) in Water, Method 8015A modified/8015B & 5030B, CA LUFT										
Analysis Date: January 16, 2004														
Instrument/Column:Varian 68,FID,RTX-Volatiles														
Compound Name	Rep#1	Rep#2	Rep#3	Rep#4	Rep#5	Rep#6	Rep#7	Rep#8	Rep#9	Mean	Test Conc.	S.Dev.	MDL	Report Limit
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Gasoline Range Organics	0.32	0.31	0.31	0.31	0.32	0..30	0.30	0.30	NA	0.31	0.25	0.0082	0.026	0.50

Study date: January 14, 2002				Gasoline Range Organics (GRO) in Water, Tennessee VPH Method										
Instrument:Varian 68,FID,RTX - volatiles														
Compound Name	Rep#1	Rep#2	Rep#3	Rep#4	Rep#5	Rep#6	Rep#7	Rep#8	Rep#9	Mean	Amt.	S.Dev.	MDL	Report Limit
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
TN GRO	0.440	0.460	0.400	0.430	0.440	0.450	0.460	0.420	0.430	0.437	0.50	0.0194	0.056	1.0

NOTE: This attachment is subject to change without notice.
NOTE: The estimated detection limit is 1/5 the reporting limit.

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Attachment 2

COMPUCHEM a division of Liberty Analytical Corp DATE ____/____/____INITIAL TIME OF TUNE_____ SHIFT/S(A)_____(B)_____(C)_____
GC VOLATILE RUN LOG TIME TUNE EXPIRES_____ LINKER /METHOD_____
COMPUCHEM LOGBOOK 11 G(4) 1 (GC68)
REJECTED REPORTED SEQUENCE ID: _____ PREVENTIVE MAINTENANCE_____

REJECTED	FILE NAME	REPORTED	DATE	TIME	CLIENT ID#	CASE/SDG#	AMOUNT INJECTED	CHEMIST	STANDARD AMOUNTS	COMMENTS(ETC.)	TEKMAR POSITION
			/ /								
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STANDARDS

SUPERVISOR APPROVAL_____

Std. ID 1,4-Dichlorobutune GRO Std. GRO NSI Std.

DATE _____

Lot # _____ _____ _____

The presence of the Chemist's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist together with the chemist's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

4/26/01:mlj

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Attachment 3

CompuChem a division of Liberty Analytical Corp. Logbook 11 SSS 1

GC VOA Maintenance Log: 68

Date: _____ Time:_____

System: _____

Problem: _____

_____

_____

_____

_____

Action Taken: _____

_____

_____

_____

_____

_____

Parts used:

Part Number	Description	Quantity

File Name Indicating Instrument In Control: _____

Performed By: _____ Date: _____

Reviewed By: _____ Date: _____

3/31/00:mlj

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Attachment 4

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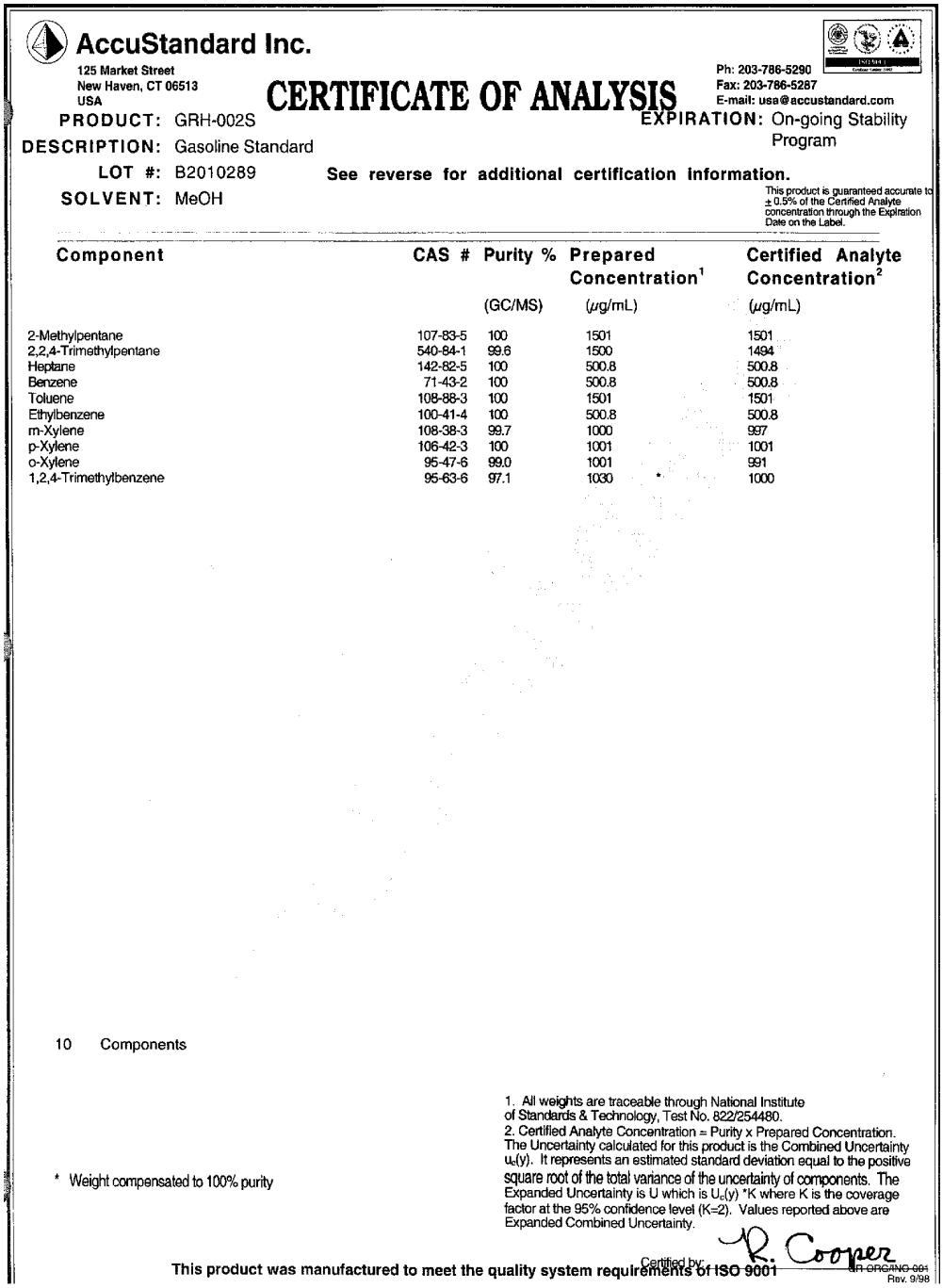

AccuStandard Inc.

125 Market Street
New Haven, CT 06513
USA

Ph: 203-786-5290
Fax: 203-786-5287
E-mail: usa@accustandard.com

CERTIFICATE OF ANALYSIS

PRODUCT: GRH-002S
DESCRIPTION: Gasoline Standard
LOT #: B2010289
SOLVENT: MeOH

EXPIRATION: On-going Stability Program

See reverse for additional certification information.

This product is guaranteed accurate to ± 0.5% of the Certified Analyte concentration through the Expiration Date on the Label.

Component	CAS #	Purity % (GC/MS)	Prepared Concentration[1] (µg/mL)	Certified Analyte Concentration[2] (µg/mL)
2-Methylpentane	107-83-5	100	1501	1501
2,2,4-Trimethylpentane	540-84-1	99.6	1500	1494
Heptane	142-82-5	100	500.8	500.8
Benzene	71-43-2	100	500.8	500.8
Toluene	108-88-3	100	1501	1501
Ethylbenzene	100-41-4	100	500.8	500.8
m-Xylene	108-38-3	99.7	1000	997
p-Xylene	106-42-3	100	1001	1001
o-Xylene	95-47-6	99.0	1001	991
1,2,4-Trimethylbenzene	95-63-6	97.1	1030 *	1000

10 Components

* Weight compensated to 100% purity

1. All weights are traceable through National Institute of Standards & Technology, Test No. 822/254480.
2. Certified Analyte Concentration = Purity x Prepared Concentration. The Uncertainty calculated for this product is the Combined Uncertainty $u_c(y)$. It represents an estimated standard deviation equal to the positive square root of the total variance of the uncertainty of components. The Expanded Uncertainty is U which is $U_c(y)$ *K where K is the coverage factor at the 95% confidence level (K=2). Values reported above are Expanded Combined Uncertainty.

Certified by: R. Cooper

This product was manufactured to meet the quality system requirements of ISO 9001

QR ORGANO 001
Rev. 9/98

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Attachment 5

Laboratory Name/North Carolina Certificate Number: CompuChem/79												
Analyst: Joann Ockerlander												
Study Date: 8/28/01												
Method: California LUFT Gasoline Range Organics in Water, Method 8015B (TN GRO WATER)												
Instrument/Column: Varian 68/RTX-VOLATILES												
Compound	TrueVal	Rep #1	Rep #2	Rep #3	Rep #4	Mean	SD(n-1)	-3SD	+3SD	- 3SD	+3SD	RSD
	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	%R	%R	%
Gasoline	10.00	10.38	9.81	9.93	9.81	9.98	0.27	9.2	10.8	92	108	2.7

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CompuChem
a division of Liberty Analytical Corporation
501 Madison Avenue
Cary, NC 27513

NELAP accredited

SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire block below (except effective date).

This is a new procedure _____ revised procedure X outdated procedure (archive) _____

- Procedure Code: IP 179 SOP Section #: 1.1.3.2 Revision #: 16.0

SOP Title: Preparation & Analysis of Gasoline Range Organics (GRO) in Soil/Sediment Samples by Purge & Trap Following SW-846, CALWP and TN GRO

Effective date: (QA fills in) 8/23/05

- Procedure prepared by: Joan Ockelinde Date: 8-22-05
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) Date: 8-23-05
- Reason for change: Change standard preparation amounts and cosmetic changes throughout
- This procedure meets the requirements of the following approved method references: SW-846, 3RD Edition, Update III, Method 8015B, NYSASP, June 2000, plus Revisions, TN DEC UST Division Lab Methods "Method for Determination of Gasoline Range Organics"

Procedure approved by Quality Assurance Representative: Date:
(Not needed if signed above)

Effective 1-1-96, on an annual basis: Lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary, indicate by your signature that the SOP has been reviewed.

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Instrument Procedure 179: Preparation and Analysis of Gasoline Range Organics (GRO) in Soil/Sediment Samples by Purge and Trap Following SW-846, CA LUFT, and TN GRO

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Instrument Procedure 179: Preparation and Analysis of Gasoline Range Organics (GRO) in Soil/Sediment Samples by Purge and Trap Following SW-846, CA LUFT, and TN GRO

1.0 Scope and Application

This method is used to detect purgeable total petroleum hydrocarbons (TPH), including gasoline range organics (GRO), in soil or sediment samples by GC/FID analysis using Method 8015A modified or Method 8015B. GROs correspond to the range of alkanes from C_6 to C_{10} and covering a boiling point range of approximately 60° C - 170° C. Qualitative and quantitative data are generated using an FID detector.

The method detection limit (MDL) and reporting limits are listed in Attachment 1. The reporting limit is the low level calibration standard concentration.

Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

2.0 Summary of Method

2.1 Sample Preparation for Method 8015A modified.

Five grams of sample, collected unpreserved in a glass jar, are weighed into a sparging bottle containing 5 **mL** of DI water and spiked with surrogate solution. An appropriate column and temperature program is used in the gas chromatograph to separate the organic compounds. Detection is achieved by a flame ionization detector (FID). Quantitation is by means of the external standard technique. Quality is measured through surrogate recovery, LCS and matrix spike precision and accuracy.

NOTE: This option is not allowed for South Carolina samples.

If it is determined that the sample needs to be diluted, no less than 1 g of the sample can be analyzed in order to bring the analytes into the upper half of the analytical range.

2.2 Sample Preparation for Method 5035/8015B

Samples collected in EnCore sampling devices without sodium bisulfate are preserved 1:1 in methanol in the laboratory within 48 hours. Based on client reporting requirements, during calibration and analysis 100 **µL** – 250 **µL** of the methanol extract are injected.

2.3 Analysis

This method provides GC conditions for the detection of the purgeable components of gasoline. Helium is bubbled through 5 **mL** of DI water to which has been added a 5 g soil sample contained in a specially designed purge chamber at 45° C. The target analytes are efficiently transferred from the aqueous phase to the vapor phase. The vapor is then swept through a sorbent trap where the target analytes are trapped. After purging is completed, the trap is heated and back flushed with helium to desorb the target analytes onto a GC column. The GC is temperature programmed to separate the target compounds. The trap is desorbed onto a capillary column and detected by an FID.

The FID, which is generally non-selective and responsive to all organic compounds, is used to sum the areas of all the peaks over a given range. The order of analysis for this method is:

- initial calibration
- initial calibration verification (LCS)
- method blank/instrument blank
- samples/spikes
- continuing calibration (after every 10 samples)

3.0 Definitions

3.1 Method detection limit (MDL) – The minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR, Part 136, Appendix B.)

3.2 Reporting Limit – The laboratory reporting limit is based on the lowest multipoint calibration standard concentration. For organic methods, values detected below the reporting limit and above the MDL may be reported and qualified as an estimated concentration.

For CLP the reporting limit is the Contract Required Quantitation Limit (CRQL) for organics.

3.3 Reporting Units – mg/Kg

3.4 An SDG is defined by the following, whichever is more frequent:

- each 20 field samples received within a case, or
- each 7 calendar day period during which field samples in a case are received (14 calendar days if requested by the client) beginning with the receipt of the first sample.

NOTE: The Army Corps of Engineers (US ACE) and SC DHEC do not accept the SDG approach, unless the samples are prepared in a single batch. When a group of up to 20 field samples of a similar matrix are prepared as one batch, method-specified QC samples such as a method blank, laboratory control sample, matrix spike, matrix spike duplicate, and matrix duplicate must also be prepared together at a rate of 5% for US ACE and 10% for SC DHEC. If samples are batched together from different sites, project-specific QC must be processed.

3.5 Surrogate – The surrogate for method 8015A modified/8015B is 1,4-dichlorobutane. The surrogate for the TN GRO method is p-isopropyltoluene. These surrogates provide a measure of purging efficiency in the studied matrix.

3.6 FID – a detector that measures the electrical current from ions produced by controlled combustion of chromatographic eluates.

3.7 GALP – good automated laboratory practices; a quality assurance (QA) measure to document that the computer and data acquisition systems are sufficiently protected from tampering and that any changes made to the data have a documented audit trail.

3.8 SC DHEC – South Carolina Department of Health and Environmental Control

4.0 <u>Interferences</u>

4.1 Samples can be contaminated by diffusion of volatile organics through the sample container septum during shipment and storage. A trip blank carried through sampling and storage serves as a check of contamination.

4.2 Contamination by carryover is possible when a high concentration sample is analyzed. Any sample analyzed after a high concentration sample should be reanalyzed.

4.3 The vessel that a sample is run in must be verified as clean by running a blank in it or a clean sample previously. Check blank for the appearance of non-target as well as checking target values.

5.0 Safety

5.1 All samples and standard reference materials must be assumed to be hazardous/toxic and must be handled to minimize exposure.

5.2 All samples must be prepared under a laboratory fume hood. Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous. During sample preparation, glasses, gloves and lab coats are a minimum requirement. The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

5.3 Laboratory staff are encouraged to review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets for reagents used in the laboratory. The MSDS are located in the Quality Assurance department.

6.0 Equipment & Supplies

6.1 Two 10 **µL** gastight syringes, Hamilton 1701N or equivalent

6.2 One 5 **mL** gastight syringe, Hamilton or equivalent

6.3 Two 25 **µL** gastight syringes, Hamilton or equivalent

6.4 One 50 **µL** gastight syringe, Hamilton or equivalent

6.5 Top-loading balance, capable of weighing accurately to 0.01 g

6.6 Column: RTX-Volatiles

6.7 Injection port, not used. A stainless steel low dead volume connector is used to connect the transfer line from the purge and trap directly to the capillary column.

6.8 Gas chromatograph, Varian 3400 (See Table 1 for GC Conditions)

Table 1. GC Conditions

Specification	Values
Carrier gas	Helium
Final temperature	240 °C
Initial Temperature	50° C
Initial Time	4.0 min.
Flow Rate	8.2 **mL**/min.
Ramp Rate	• 50° C - 50° C hold for 4.0 min. (initial time) • 50° C - 100° C at 4° C/min. hold for 1.0 min. • 100° C - 220° C at 25° C/min. • 220° C - 220° C hold for 2.0 min.
GC Mode	capillary
Detector temperature	250° C
Final hold time	2.0 min.
Makeup flow	20 **mL**/min.

6.9 Detector, Varian FID Detector Model 3400 (See Table 2 for Detector Conditions)

Table 2. Detector Conditions

Specification	Values
hydrogen flow rate	30 **mL**/min
air flow rate	300 **mL**/min
polarizing voltage	100 V
Attentuation	8-10

6.10 Purge device: Tekmar 2016. Purge flow is 35 **mL**/min. The transfer line is directly connected into a Tekmar LCS 2000.

6.11 Trap and desorb device: The Tekmar LCS 2000 sample concentrator is used to trap the purgeables and then desorb the trap constituents onto the chromatographic column.

7.0 Reagents & Standards

Refer to the Standards Preparation Logbook 22 F for details on preparation of standards used in this procedure.

7.1 DI water – All water used in this procedure must be equivalent to ASTM Type II water (as it relates to specific conductance and specific resistance) which is subsequently purged with an inert gas and demonstrated to meet the blank contamination acceptance criteria contained in this Standard Operating Procedure (SOP). It is referred to throughout the remained of this SOP as DI water.

7.2 Methanol – Purge and trap grade methanol is used to prepare the surrogate standard. The gasoline is prepared in GC/GC/MS solvent grade methanol. All standards are stored at -10 to -20° C.

7.3 **Primary** calibration standard at 2.5 mg/**mL** - used for 8015A modified, 8015B and NYSASP initial calibration standard. Also used for continuing calibration standard.

7.3.1 Prepare **this** standard at 2**.**5 mg/**mL** by adding **250 µL** Restek unleaded gasoline composite standard (50 mg/**mL**) to an amount of purge and trap methanol in a **5 mL** volumetric flask and bring to volume.

7.3.1.1 Prepare this standard every six months.

7.3.**2** Dilutions are made in the laboratory for the working level calibration standards according to the instructions in Section 10.0.

7.4 Second source 8015A modified, 8015B and NYSASP calibration verification standard (also used to generate LCS, LCSD, MS, and MSD)

7.4.1 Prepare **this** standard at 2**.**5 mg/**mL** by adding 1 **mL AccuStandard** Gasoline **Composite Mix** (5**.**0 mg/**mL**) to an amount of purge and trap methanol in a 2 **mL** volumetric flask and bring to volume.

7.4.1.1 Prepare this standard every six months.

7.4.**2** **This standard and 5 µL regular GRO surrogate is added to a sand blank with 5 mL DI water to produce a LCS/LCSD or to a sample with 5 mL water to produce an MS/MSD. The amount of the standard added is usually 10 µL but could vary with the application.**

7.5 GRO Medium Level LCS Standard

7.5.1 Transfer 50 mg/mL NSI gasoline standard to a miniert vial for use. This standard expires in 6 months or at manufacturer's expiration date, whichever occurs sooner.

7.6 GRO Medium Level Surrogate

7.6.1 Transfer 20 mg/mL AccuStandard1,4-Dichlorobutane to a miniert vial for use. This standard expires in 6 months or at manufacturer's expiration date, whichever occurs sooner.

7.**7** TN GRO 5.0 mg/**mL** calibration standard – used to generate lowest three points on calibration curve. Also used for continuing calibration standard.

7.**7**.1 Prepare the standard by adding 1 **mL** AccuStandard TN GRO standard (10,000 **µ**g/**mL** total components) to an amount of purge and trap methanol in a 2 **mL** volumetric flask and bring to volume.

7.**7**.1.1 Prepare this standard every six months.

7.**8** TN GRO 10.0 mg/**mL** calibration standard purchased as 10 mg/**mL** from AccuStandard and used to generate highest two points on calibration curve by diluting as indicated in Section 10.0.

7.**8**.1 This standard is used to prepare a 20 mg/L level standard (See Section 10.1.4) when the 72 hour retention time window study is performed for 8015A modified/8015B GRO. This standard is made up of individual alkane compounds including 2-methypentane (first eluting compound) and 1,2,4-trimethylbenzene (last eluting compound). (See Attachment 4.)

7.**8**.1.1 The 20 mg/L TN GRO standard is also used prior to performing initial calibrations and daily calibration verifications. This establishes the retention time range. (See 10.1.7.)

7.**8**.2 Replace this standard every six months.

7.**9** Second source TN GRO 5.0 mg/**mL** standard – used to generate LCS, LCSD, MS, and MSD.

7.**8**.1 Prepare the standard by adding 1 **mL** TN GRO standard (NSI UST) to an amount of purge and trap methanol in a 2 **mL** volumetric flask and bring to volume.

7.**8**.1.1 Prepare this standard every six months.

7.**10** **Regular GRO** Surrogate Spiking Solution**,** 5.0 mg/**mL** concentration of 1,4-dichlorobutane

7.**10**.1 Prepare the standard by **adding 500 µL AccuStandard** 1,4-Dichlorobutane **(20.0 mg/mL)** into an amount of purge and trap methanol in a **2 mL** volumetric flask and bring to volume.

7.**10**.1.1 Prepare this standard every six months.

7.**11** TN Surrogate Spiking Solution at 50 **µ**g/mL

7.**11**.1 Prepare the standard by adding 0.25 **mL** of AccuStandard p-Isopropyltoluene (2000 **µ**g/**mL**) to an amount of toluene in a 10 **mL** volumetric flask and bring to volume.

7.**11**.1.1 Prepare this standard every three months.

7.**12** Preparation of the laboratory control sample (LCS), matrix spike and matrix spike duplicate (MS/MSD), and blank are detailed in Section 11.0.

7.**13** Preparation of the initial and continuing calibration standards are given in section 10.0.

7.**14** Standard Storage Requirements

7.**14**.1 Standards are **to** be stored in the freezer at -10° C to -20° C.

8.0 Sample Collection, Preservation, & Storage

8.1 Samples are collected, preserved, and stored according to the tables in Sample Control SOP 4.1, "Receiving Samples" and 4.6, "Storing Samples." Sample holding times are also listed.

8.2 Soil samples may be collected in unpreserved glass containers for Method 8015A modified. Holding time is 7 days from sample collection.

8.3 Unpreserved EnCore samplers must be preserved by the laboratory 1:1 with methanol within 48 hours from sample collection and analyzed as a medium level methanol preparation. Analytical holding time after preservation is 14 days from sample collection.

8.4 Sample collection requirements of Method 5035 refer to Sample Preparation Procedure –238, "Preparation of Soil/Sediment/Sludge Samples for the Analysis of Volatile Organic Compounds by Closed-System Purge and Trap using SW-846 Method 5035."

9.0 Quality Control

9.1 Initial Calibration

If the technical acceptance criteria for the initial calibration are not met, inspect the system for problems. It may be necessary to clean the FID, change the column, service the purge and trap device, or take other corrective action to achieve the technical acceptance criteria. Record all instrument maintenance in the appropriate logbook. Routine maintenance is recorded on the instrument run log (Attachment 2) whereas non-routine maintenance activities are recorded in the maintenance logbook (Attachment 3).

Acceptance criteria and corrective action are described in Section 10.0. The calibration curve is verified using a second source standard as described in Section 9.5 following.

9.2 Continuing Calibration

If the continuing calibration fails technical acceptance criteria, it may be necessary to analyze instrument blanks to clean up the purge and trap system or to reveal the presence and source of contamination problems.

Column maintenance may also be used as a corrective action measure, with the analysis of a new initial calibration to demonstrate system integrity.

The first continuing calibration standard analyzed on each day must meet the +/- 15% criteria (10% for CA LUFT and 25% for TN GRO) before any samples may be run. An acceptable ending calibration must be analyzed within twelve hours of the injection time of the daily continuing calibration. All samples must be bracketed by acceptable CCV's unless the CCV is biased high and the previous samples were non-detects. Otherwise, all samples not bracketed by acceptable continuing calibrations within this **twelve**-hour period must be reanalyzed and corrective action must take place. The corrective action may involve instrument maintenance, running an instrument blank, or performing a new initial calibration. The 10 samples analyzed after a passing continuing and before a failing continuing calibration standard are acceptable. However, no more samples can be analyzed until another continuing calibration meets criteria or a new initial calibration is performed.

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9.3 Surrogates

9.3.1 All client and QC samples are spiked with 1,4-dichlorobutane (p-isopropyl toluene) as the surrogate.

9.3.2 Surrogate recovery criteria for all samples, blanks, blank spikes, matrix spikes, and matrix spike duplicates are listed below.

Parameter	% Recovery - Soil
GRO (8015A modified/8015B & CA LUFT)	51-122
TN GRO	53-113

9.3.3 If acceptance criteria are outside this control range on the column, the sample must be re-analyzed.

9.4 Method Blanks

Method blanks are prepared and analyzed with every 12 hour calibration period or batch. The presence of analyte in the blank cannot exceed the reporting limit. If the method blank exceeds acceptance criteria, the source of the problem must be investigated and appropriate corrective action taken. All samples processed with a method blank that does not meet acceptance criteria must be reanalyzed.

Any value present in the blank that falls between the MDL and the reporting limit must also be investigated and corrective action taken as indicated. At a minimum any associated samples must be qualified with a "B" flag on the report form and explained in the SDG narrative.

9.5 Laboratory Control Sample (LCS)

9.5.1 A LCS is DI water and Ottawa sand fortified with the gasoline spiking solution and surrogate. The spiking solution is from a different source than that used to prepare the calibration curve and therefore, serves to verify the calibration curve as well as to determine the accuracy of the method. The LCS is prepared with every 20 samples or calibration batch, whichever is more frequent. For NYSASP, the blank spike is called the matrix spike blank.

9.5.2 The results of the LCS are used to confirm that any failing spiked gasoline in the MS/MSD tests are a result of sample matrix interference and not due to an out of control analytical system. The results are also used to indicate problems with the calibration curve.

9.5.3 Precision and accuracy criteria for the LCS are given below.

Parameter	% Recovery - Soil
GRO (8015A mod./8015B)	75-110
TN GRO	50-150

9.5.3.1 The LCS must meet criteria or the entire batch must be repeated.

9.5.4 For TN GRO, a LCS duplicate (LCSD) is also required. The percent recovery criteria for the LCS/LCSD are 50 -150% for TN GRO and the RPD criteria are 20%.

9.5.4.1 The LCS/LCSD must meet criteria or the entire batch must be repeated.

9.6 Matrix Spike / Matrix Spike Duplicate (MS/MSD)

9.6.1 A matrix spike and matrix spike duplicate must be performed for each group of samples of a similar matrix per each sample delivery group, with the exception noted in the Definitions, Section 3.0.

9.6.2 Precision and accuracy criteria for the MS/MSD are given below. A matrix interference can be confirmed through evaluation of the LCS.

Parameter	RPD	% Recovery
	Soil	
GRO(8015A/mod/8015B)	20	50-142
TN GRO	20	50-150

9.6.3 The objective for the MS/MSD tests is for the spiked compound to be recovered within criteria and the RPD value to be within criteria. However, the recoverability of spiked analytes in environmental samples is very much influenced by the particular matrix and, therefore, these objectives may not be able to be met. When recoveries do not meet the acceptance criteria or interferences preclude proper assessment of the data,

results of the laboratory control sample (LCS, sometimes referred to in the laboratory as a blank spike or BS) are evaluated to verify that the analytical system is in control.

9.6.4 If surrogate recovery in the original unspiked sample is not within acceptance limits and the MS/MSD surrogate recoveries are within limits, the original sample should be reanalyzed. If the original sample and the MS/MSD tests yield the same unacceptable surrogate recoveries, then the sample does not require reanalysis since matrix interferences would be confirmed.

9.7 Duplicates, at a frequency of 5%, are required when processing samples submitted to meet the regulatory requirements of the State of North Carolina DENR. The MS/MSD fulfills this requirement.

9.8 MDL Check Samples

9.8.1 On an annual basis a method detection limit (MDL) study is performed on a single instrument per method and matrix. When multiple instruments are used for the analysis of U.S. Army Corps of Engineers samples (or samples from other programs with the same requirement), individual instrument MDL studies are replaced by the analysis of an MDL check sample. The MDL check sample must be analyzed on all instruments, where the MDL study was not performed and that U.S. Army Corps of Engineers samples (or other program-specific samples) are analyzed on, to demonstrate equivalent sensitivity.

The MDL check sample is prepared at about 2x the MDL and is analyzed on a quarterly basis for each matrix. A response must be detected in the 2x MDL check sample. For more information on MDL studies, refer to QC SOP 13.11, "Performing Annual Method Detection Limit (MDL) Studies."

9.9 Retention Time Window Study

9.9.1 A 72 hour retention time window study is performed once per year or when changes in instrumentation occur, including a column change. The standard used to establish the window contains 2-methypentane and 1,2,4-trimethylbenzene as markers of the elution pattern of gasoline range organics. A TN GRO standard, at 20 mg/L, is used for the study.

10.0 <u>Calibration & Standardization</u>

10.1 Initial Calibration

10.1.1 Before analyzing samples and required blanks, establish the retention time range with the 20 mg/L TN GRO standard (See 10.1.7) and calibrate each instrument at five concentrations to determine the instrument sensitivity and linearity of the GC/FID response for the purgeable target compounds.

10.1.2 For Method 8015A modified, all standards are prepared by spiking the appropriate volume of the gasoline standard and 1,4-dichlorobutane surrogate (or p-isopropyltoluene surrogate for TN GRO) into gastight syringes containing 5 **mL** of sparged DI water which is added to a glass purge tube that contains 5 g Ottawa sand. The tube is then quickly attached to the purge and trap. All of the primary analytical standards are stored in a freezer when not in use.

10.1.3 For the medium level Method 8015B, all standards are prepared by spiking the appropriate volume of the gasoline standard and 1,4-dichlorobutane surrogate for 8015B GRO (or p-isopropyltoluene surrogate for TN GRO) into gastight syringes containing 5 **mL** of sparged DI water. All of the primary analytical standards are stored in a freezer when not in use.

10.1.4 Five levels of working standards are prepared for the calibration curve by the analyst using a 2.5 mg/**mL** gasoline standard for 8015A modified and 8015B GRO and a 5.0 and 10 mg/**mL** gasoline standards for TN GRO.

Note: The low standard is the reporting limit.

Calibration Curve Standards – 8015A modified, 8015B, and NYSASP GRO Table

Amount 2.5 mg/mL std. added	**Concentration**	**On-column amount**
1 **µL**	0.5 mg/L	2.5 **µg**
2 **µL**	1.0 mg/L	5.0 **µg**
10 **µL**	5.0 mg/L	25.0 **µg**
20 **µL**	10.0 mg/L	50.0 **µg**
50 **µL**	25.0 mg/L	125.0 **µg**

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Calibration Curve Standards - TN GRO Table

Amount of 10 mg/mL std. (for 2 highest) & 5 mg/mL std. (for all others) added	**Concentration**	**On-column amount**
1 **µL**	1.0 mg/L	5.0 **µg**
5 **µL**	5.0 mg/L	25.0 **µg**
10 **µL**	10.0 mg/L	50.0 **µg**
10 **µL**	20.0 mg/L	100.0 **µg**
20 **µL**	40.0 mg/L	200.0 **µg**

To each standard, 1,4-dichlorobutane surrogate (p-isopropyltoluene for TN GRO) is added at varying concentrations. The calibration curve is established by dividing the total area of the surrogate by the mass injected for the five different concentrations of the standard. The surrogate levels are listed below.

Surrogates for Calibration – 8015A modified, 8015B, and NYSASP GRO

Standard Concentration	**Amount of 5.0 mg/mL surrogate added**	**Concentration**	**On-column amount**
1 **µL**	1 **µL**	1.0 mg/L	5.0 **µg**
2 **µL**	2 **µL**	2.0 mg/L	10.0 **µg**
10 **µL**	5 **µL**	5.0 mg/L	25.0 **µg**
20 **µL**	10 **µL**	10.0 mg/L	50.0 **µg**
50 **µL**	20 **µL**	20.0 mg/L	100.0 **µg**

Surrogates for Calibration - TN GRO Table

Standard Concentration	**Amount of 50.0 µg/mL surrogate added**	**Concentration**	**On-column amount**
1.0 mg/L	1 **µL**	0.01 mg/L	0.05 **µg**
5.0 mg/L	5 **µL**	0.05 mg/L	0.25 **µg**
10.0 mg/L	10 **µL**	0.1 mg/L	0.5 **µg**
20.0 mg/L	20 **µL**	0.2 mg/L	1.0 **µg**
40.0 mg/L	25 **µL**	0.25 mg/L	1.25 **µg**

10.1.5 If the %RSDs over the five levels is ≤20% (25% for TN GRO), then the mean calibration factor (CF) can be used to calculate the gasoline or other petroleum hydrocarbons. (See Method 8000, section 7.4.2.2.).

If the %RSD is >20% (25% for TN GRO), a calibration curve must be used to calculate sample results. If the %RSD is >20% (25% for TN GRO), the following items should first be checked:

10.1.5.1 If CFs have random variation, check for leaks in the purge vessels.

10.1.5.2 If CFs increase with concentration, check for active sites in the chromatographic system.

10.1.5.3 If CFs from direct injections remain consistent, the active sites are probably in the purge and trap system.

10.1.5.4 If CFs decrease with concentration, check for contamination of the system by analyzing a blank.

10.1.5.5 When the problem is identified and corrected, the calibration standards must be reanalyzed.

10.1.6 The validity of the calibration curve is verified using a second source standard. For this method, the LCS serves this purpose and is prepared following the preparation procedure in **Section** 11.1.3 **following**.

10.1.7 The retention time range is calculated from the retention time window study by subtracting the 3SD value (determined from the most current 72 hour retention time study) from the elution time of 2-methylpentane (first component in the elution order of the TN GRO standard), and adding the 3SD value to the elution time of 1,2,4-trimethylbenzene (last component in the elution order of the TN GRO standard).

10.2 Continuing Calibration (CCAL)

10.2.1 A continuing calibration verification standard must be analyzed, after establishing the retention time range with the 20 mg/L TN GRO standard, to start a daily sequence and must meet acceptance criteria in order for sample analysis to proceed. A 5 ppm gasoline standard is used as the check standard. Each calibration factor, including surrogates, must be <15% difference (%D) (10%D for CA LUFT and 25%D for TN GRO) when compared to the mean calibration factor of the most recent acceptable initial calibration on both analytical columns.

If the %D exceeds 15% (10% for CA LUFT and 25% for TN GRO), then corrective action must be taken and the calibration verification re-injected. If the calibration still exceeds the criteria, a new initial calibration must be analyzed.

10.2.2 Once the daily continuing calibration standard meets criteria, samples are run and subsequently an acceptable continuing calibration must be analyzed within twelve hours of the injection time of the daily continuing calibration. Additional continuing calibration standards can be analyzed within this twelve hour period to bracket sample analyses.

10.3 Balance Calibration

10.3.1 Ensure the balance is calibrated for the day prior to weighing samples. Refer to Quality Control SOP 13.16, "Top Loading Balance Calibration and Maintenance."

11.0 Procedure

Documentation must follow the requirements in QC SOP: Proper Documentation Procedures. Also refer to Sample Preparation Procedure –238, "Preparation of Soil/Sediment/Sludge Samples for the Analysis of Volatile Organic Compounds by Closed System Purge and Trap using SW-846, Method 5035."

11.1 Low Level Sample Preparation-Method 8015A modified

Mix sample well, discard any foreign objects such as sticks, stones/rocks, and leaves. (Note: This option is not allowed for South Carolina Samples.)

11.1.1 Weigh out 5 g of sample into a sparging tube. Add 5 **mL** of DI water spiked with 5 **µL** of 5.0 mg/**mL** 1,4-dichlorobutane surrogate solution for 8015A modified GRO. For TN GRO add 10 **µL** of a 50 **µg**/**mL** surrogate solution of p-isopropyltoluene.

11.1.2 Prepare a method blank by filling a 5 **mL** gastight syringe with 5 **mL** of DI water and 5 **µL** of the surrogate solution, which is added to a glass purge tube that contains 5 g laboratory pure sand, such as Ottawa. The method blank is analyzed before samples and after the continuing calibration.

11.1.3 Prepare a laboratory control sample by adding to 5 **mL** of DI water to 5 g laboratory pure sand. Add appropriate surrogate and 10 **µL** of a 2.5

mg/**mL** second source gasoline standard for 8015A modified GRO. Add 10 **µL** of a 5.0 mg/**mL** second source standard for TN GRO. For TN GRO, prepare a duplicate LCS.

11.1.4 Prepare a matrix spike by taking a 5 g aliquot of sample and adding appropriate surrogate and 10 **µL** of 2.5 mg/**mL** second source gasoline standard 8015A modified GRO. Add 10 **µL** of the 5.0 mg/**mL** second source standard for TN GRO.

11.1.5 Prepare a matrix spike duplicate following step 11.1.4.

11.2 Medium Level Sample Preparation for Method 8015B, NYSASP, and TN GRO

Note: This preparation deviates from the TN GRO method. The TN GRO method requires 10 g of soil and 10 **mL** of methanol for the extraction.

11.2.1 Extract samples by weighing out 5.0 g in 5 **mL** of methanol to which is added 65 **µL** of 20 mg/**mL** 1,4-dichlorobutane surrogate solution for 8015B and NYSASP (0.5 **mL** of 50 **µg**/**mL** p-isopropyltoluene for TN GRO) when using 100 **µL** of extract. Some clients require the use of 250 **µL** of extract. In this case, 5.0 g of sample are added to 5 **mL** of methanol and to that 25 **µL** 20mg/**mL** 1,4-dichlorobutane is added. Shake the sample for 2 minutes, then allow the soil to settle.

11.2.2 Prepare a method blank by weighing out 5.0 g of Ottawa sand in 5 **mL** of methanol to which is added 65 **µL** of 20 mg/**mL** 1,4-dichlorobutane surrogate solution for 8015B and NYSASP (0.5 **mL** of 50 **µg**/**mL** p-isopropyltoluene for TN GRO) when using 100 **µL** of extract. Some clients require the use of 250 **µL** of extract. In this case, 5.0 g of sand are added to 5 **mL** of methanol and to that 25 **µL** 20 mg/**mL** 1,4-dichlorobutane is added. Shake the sample for 2 minutes, then allow the soil to settle.

11.2.3 Prepare a laboratory control sample by weighing out 5.0 g of Ottawa sand in 5 **mL** of methanol to which is added 65 **µL** of 20 mg/**mL** 1,4-dichlorobutane surrogate solution for 8015B and NYSASP (p-isopropyltoluene for TN GRO) and 50 **µL** of 25 mg/**mL** second source standard for 8015B and NYSASP (0.5 **mL** of 5 mg/**mL** second source standard for TN GRO) when using 100 **µL** of extract. Some clients require the use of 250 **µL** of extract. In this case, 5.0 g of Ottawa sand are put into 5 **mL** of methanol to which 65 **µL** of 20 mg/**mL** 1,4-dichlorobutane surrogate solution for 8015B and NYSASP (p-

isopropyltoluene for TN GRO), and 20 **µL** of 50 mg/**mL** NSI Gasoline Standard are added.

11.2.4 For duplicate matrix spikes follow steps in 11.2.3 and use 5.0 g of sample is rather than Ottawa sand.

11.2.5 For samples and QC, put 4.9 **mL** of DI water into a syringe and add 100 **µL** of the methanol extract. Certain clients request 250 **µL** of extract be added to 4.75 **mL** of DI water.

11.3 Autosampler Setup

The autosampler is accessed on the front left key panel. Note that all changes to screen displays are made by pressing the Up | or Down | arrow keys.

11.4 Trap and Desorb

The Tekmar LCS 2000 sample concentrator traps the purgeables and then desorbs the trap constituents onto the chromatographic column using Sulpeco 602/603 "J" trap.

NOTE: Sample heating is required for 8015A modified and 8015B but not TN GRO soils.

11.4.1 Set the transfer line and valve temperature to 150° C.

11.4.2 Set purge time at 8.0 minutes and desorb time for 2.0 minutes.

11.4.3 Set bake time to 10.0 minutes. Bake temperature should be 225° C.

11.4.4 Purge the suspect position on the A/S when measuring the flow from the vent on the LCS 2000. It should be 36 – 38 **mL**/min. If there is little flow, check the thin tubing between the A/S and the vessel for constriction or obstruction. Next, consider 6 port value.

11.4.5 Set GC Ready temperature to whatever the thermocouple is reading. This is usually 50° C. Variable response and purge flow as observed in the vessel are usually due to incomplete switching of the 6 port valve and adjustments by the service department need to be made.

11.4.6 Sample Trap -- The purge gas is swept through a trap that absorbs all of the target compounds. The trap should be below 25° C during the purge

process. The transfer line between the ALS2016 autosampler and the trap is maintained at 120° C.

11.4.7 Sample Desorption -- During the desorb procedure, the target compounds are back flushed off of the trap and enter the carrier gas stream to the chromatographic column. The gas flow and trap temperature are controlled so that all the compounds are removed from the trap in as short a time as possible. The trap is desorbed at 180° C for 2.0 minutes. The trap is then baked at 225° C for 10.0 minutes before being cooled to room temperature.

12.0 Data Analysis & Calculations

Calculations must be consistent with the QC SOP: Numerical Data Reduction.

12.1 Calculation of the mean or average of a set of values:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where: n = total number of values
x_i = each individual value used to calculate the mean
x = the mean of n

12.2 Calculation of the standard deviation of a set of values:

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n} \left(X_n - \overline{X}\right)^2}{n-1}}$$

12.3 Calculation of percent recovery:

12.3.1 LCS and surrogates:

$$\%R = \frac{Amount\ found}{Amount\ spiked}\ x\ 100$$

12.3.2 Matrix spikes:

$$\%\,R = \frac{Amount\ in\ spiked\ \ sample - Amount\ in\ unspiked\ (native)\ sample}{Amount\ spiked} \ x\ 100$$

12.4 Calculation of % RSD

$$\%RSD = \left(\frac{Standard\ deviation}{\overline{X}}\right) \times 100$$

12.5 Calculation of RPD

$$RPD = \frac{|Value\ 1 - Value\ 2|}{(Value\ 1 + Value\ 2)/2} x100$$

12.6 Calculation of %Difference (%D)

$$\%Diff = \frac{Value - \overline{Reference\ \ value}}{\overline{Reference\ \ value}} \ x\ 100$$

12.7 Calibration factors for GC analysis are calculated by dividing the total peak area in the standard by the total mass injected (in nanograms).

$$Calibration\ Factor\ (CF) = \frac{Peak\ area}{Total\ mass\ injected}$$

12.7 Quantitation of Results

Positive results in samples are determined using the external standard technique. A processed GC file is obtained. The file contains the sum of the response of individual peaks in the gasoline fuel pattern within the elution of the first and last components in the standard. The mean CF from the initial calibration is used in the calculation.

The concentration of the gasoline is determined by the following formula:

$$\text{Conc. (mg/kg)} = \frac{\text{area } \mathbf{x} \text{ dilution } \mathbf{x} \text{ dry wt. factor}}{\text{CF } \mathbf{x} \text{ weight extracted (purged)}}$$

No area may be subtracted for the GRO retention time windows in calculating results except the area contributed by the surrogate. In that case, only the area of

a surrogate peak "riding" the hydrocarbon envelope may be subtracted. Peak area measured from blanks may not be subtracted from sample area peaks.

12.7.1 Reporting Results for the 8015A modified/8015B/CA LUFT Method

Integration is performed using the flattest baseline possible from the beginning of the gasoline peak pattern to the end of the peak pattern.

Report the presence of significant peaks that are in the gasoline range even if they do not match the standard peak pattern. This should be noted in the SDG narrative when it occurs.

12.7.2 Report the presence of significant peaks outside the chromatographic window. Peaks are significant if they can be distinguished above the noise in a chromatogram. Any peak three times the standard deviation of the signal to noise ratio is statistically significant. All peaks (and baseline rises) outside the window are to be reported.

12.8 The daily retention time window is established using the 20 mg/L TN GRO standard by subtracting the 3SD value, determined from the 72 hour retention time study, from the elution time for 2-methylpentane, and adding the 3SD value to the elution time of 1,2,4-trimethylbenzene.

12.9 Calculating Dilutions

If a sample concentration exceeds the high level standard a dilution must be performed. Determine a level of dilution that will result in a value within the upper half of the calibration range. This is an acceptable dilution. A 10x dilution is performed using 1 mL sample plus 9 mL diluent for a total volume of 10 mL. It should be recorded on the run log as “10x (1 mL in 10 mL).”

12.9.1 Dilution factor

$$Dilution\ factor = \frac{\mu L\ most\ conc.\ extract\ used\ to\ make\ dilution + \mu L\ clean\ solvent}{\mu L\ most\ conc.\ extract\ used\ to\ make\ dilution}$$

13.0 Method Performance

This method was validated through in-house laboratory studies of method detection limits (attachment 1) and precision and accuracy for single analyst (Attachment 5). The data are retained by the QA department.

14.0 Pollution Prevention

The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 thing.

15.0 Waste Management

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Samples preserved with HCl, HNO_3, or H_2SO_4 to pH <2 are hazardous and must be neutralized before being disposed, or must be handled as hazardous waste.

Refer to the Hazardous Waste Management and Safety SOPs located in the lab.

16.0 References

16.1 "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods", SW-846, 3rd Edition, Update III, 12/96, Methods 8015A modified, 8015B, 5030B and 5035.

16.2 Leaking Underground Fuel Tank Field Manual: Guidelines for Site Assessment, Cleanup, and Underground Storage Tank Closure. State of California. Leaking Underground Fuel Tank Task Force. May 1988.

16.3 "Method for Determination of Gasoline Range Organics", TN DEC, March 1999

16.4 Standard Methods for the Examination of Water and Wastewater, 20th (1998) Edition, Method 1080

16.5 New York State Analytical Services Protocol (NYSASP), June 2000, plus revisions

16.6 U.S. Army Corps of Engineers Chemical Data Quality Management (CDQM) Policy for USACE Hazardous, Toxic and Radioactive Waste (HTRW) Projects: "Shell for Analytical Chemistry Requirements", November 1998

16.7 QCSOP: Proper Documentation Procedures

16.8 QCSOP: Numerical Data Reduction

16.9 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477.

16.10 Hazardous Waste Management & Safety SOPs: "Hazardous Waste Disposal" and "Spill Control & Cleanup."

16.11 NELAC Standards, July **2003**, plus revisions

16.12 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995

16.13 New York State Environmental Laboratory Approval Program, Certification Manual, **April 2005**, plus revisions

16.14 CompuChem Quality Manual, Revision **6**, **Update 1, 5**/**20**/**05**, plus revisions

16.15 Quality Control SOP 13.16, "Top Loading Balance Calibration and Maintenance."

16.16 Sample Preparation Procedure –238, "Preparation of Soil/Sediment/Sludge Samples for the Analysis of Volatile Organic Compounds by Closed System Purge and Trap using SW-846, Method 5035."

16.17 Sample Control SOP 4.1, "Receiving Samples"

16.18 Sample Control SOP 4.6, "Storing Samples"

16.19 QC SOP 13.11, "Performing Annual Method Detection Limit (MDL) Studies"

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.1 Attachment 1 – Method Detection Limit Study

17.2 Attachment 2 –Instrument Run Log

17.3 Attachment 3 – Instrument Maintenance Log

17.4 Attachment 4 – Standard Certificate of Analysis

17.5 Attachment 5 – Single Analyst Capability Study

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Attachment 1

Preparation Date: Not Applicable				Gasoline Range Organics (GRO) in Soil, Method 8015A Modified and Method 5030A									
Analysis Date: January 21, 2004													
Instrument/Column:Varian 58,FID,RTX Volatiles													
Compound Name	Rep#1	Rep#2	Rep#3	Rep#4	Rep#5	Rep#6	Rep#7	Rep#8	Rep#9	Mean	Test Conc.	S.Dev.	MDL	ReportLimit
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
Gasoline Range Organics	0.26	0.27	0.31	0.32	0.30	0.33	0.34	0.31	NA	0.31	0.25	0.028	0.083	0.50

Study Date: January 19, 2004				Gasoline Range Organics (GRO), Medium Level Soil, Method 8015B amd Method 5035										
Instrument/Column:Varian 68,FID,RTX Volatiles														
Compound Name	Rep#1	Rep#2	Rep#3	Rep#4	Rep#5	Rep#6	Rep#7	Rep#8	Rep#9	Mean	Test Conc.	S.Dev.	MDL	ReportLimit
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
Gasoline Range Organics	13.73	14.20	11.28	14.22	13.75	13.87	13.99	14.44	NA	13.69	12.50	1.003	3.01	25.0

Study date: January 29, 2002				Gasoline Range Organics (GRO) in Soil, Tennessee EPH Method										
Instrument:Varian 58,FID,RTX - volatiles														
Compound Name	Rep#1	Rep#2	Rep#3	Rep#4	Rep#5	Rep#6	Rep#7	Rep#8	Rep#9	Mean	Amt.	S.Dev.	MDL	Report Limit
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
TN GRO	0.97	0.90	1.01	1.00	1.04	1.10	0.98	1.00	NA	1.00	1.00	0.057	0.17	1.0

NOTE: This attachment is subject to change without notice.
NOTE: The estimated detection limit is 1/5 the reporting limit.

Attachment 2

COMPUCHEM a division of Liberty Analytical Corp DATE ____/____/____INITIAL TIME OF TUNE_____ SHIFT/S(A)_____(B)_____(C)_____
GC VOLATILE RUN LOG TIME TUNE EXPIRES_____ LINKER /METHOD_____
COMPUCHEM LOGBOOK 11 G(4) 1 (GC68)
SEQUENCE ID: _____ PREVENTIVE MAINTENANCE_____

REJECTED	FILE NAME	REPORTED	DATE	TIME	CLIENT ID#	CASE/SDG#	AMOUNT INJECTED	CHEMIST	STANDARD AMOUNTS	COMMENTS(ETC.)	TEKMAR POSITION
			/ /								
			/ /								
			/ /								
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STANDARDS

SUPERVISOR APPROVAL_____

Std. ID 1,4-Dichlorobutune GRO Std. GRO NSI Std.

DATE _____

Lot # _____ _____ _____

The presence of the Chemist's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist together with the chemist's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

4/26/01:mlj

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Attachment 3

CompuChem a division of Liberty Analytical Corp.

GC VOA Maintenance Log: 68

Date: Time:_____

System:

Problem: _____

_____

_____

_____

_____

Action Taken:

_____

_____

_____

_____

_____

Parts

Part	Descriptio	Quantit

File Name Indicating Instrument In Control:

Performed By: Date:

Reviewed By: Date

3/31/00:mlj

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Attachment 4

AccuStandard Inc.

125 Market Street
New Haven, CT 06513
USA

Ph: 203-786-5290
Fax: 203-786-5287
E-mail: usa@accustandard.com

CERTIFICATE OF ANALYSIS

PRODUCT: GRH-002S
DESCRIPTION: Gasoline Standard
LOT #: B2010289
SOLVENT: MeOH

EXPIRATION: On-going Stability Program

See reverse for additional certification information.

This product is guaranteed accurate to ± 0.5% of the Certified Analyte concentration through the Expiration Date on the Label.

Component	CAS #	Purity % (GC/MS)	Prepared Concentration[1] (µg/mL)	Certified Analyte Concentration[2] (µg/mL)
2-Methylpentane	107-83-5	100	1501	1501
2,2,4-Trimethylpentane	540-84-1	99.6	1500	1494
Heptane	142-82-5	100	500.8	500.8
Benzene	71-43-2	100	500.8	500.8
Toluene	108-88-3	100	1501	1501
Ethylbenzene	100-41-4	100	500.8	500.8
m-Xylene	108-38-3	99.7	1000	997
p-Xylene	106-42-3	100	1001	1001
o-Xylene	95-47-6	99.0	1001	991
1,2,4-Trimethylbenzene	95-63-6	97.1	1030 *	1000

10 Components

* Weight compensated to 100% purity

1. All weights are traceable through National Institute of Standards & Technology, Test No. 822/254480.
2. Certified Analyte Concentration = Purity x Prepared Concentration. The Uncertainty calculated for this product is the Combined Uncertainty $u_c(y)$. It represents an estimated standard deviation equal to the positive square root of the total variance of the uncertainty of components. The Expanded Uncertainty is U which is $U_c(y)$ *K where K is the coverage factor at the 95% confidence level (K=2). Values reported above are Expanded Combined Uncertainty.

Certified by: R. Cooper

This product was manufactured to meet the quality system requirements of ISO 9001

QR-ORGING-001 Rev. 9/98

NOTE: This attachment is subject to change without notice.

Attachment 5

Laboratory Name/North Carolina Certificate Number: CompuChem/79															
Extractor: Norma Bolton,1151/ Jenny Smith, 2449/ Gracure Bailey, 2378															
Study Date: 11/6/01															
Method: TN DRO in soil															
Instrument/Column: Various															
Compound	TrueVal	Rep #1	Rep #2	Rep #3	Rep #4	Mean	Mean	SOP	SD(n-1)	-3SD	+3SD	- 3SD	+3SD	SOP	RSD
	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	%R	%R	ug/Kg	ug/Kg	ug/Kg	%R	%R	%RSD	%
TN DRO	24	19.0	18.0	17.0	22.0	19.0	79	50-150	2.16	12.5	25.5	66	134	20	11.4

NOTE: This attachment is subject to change without notice.

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CompuChem
a division of Liberty Analytical Corporation
501 Madison Avenue
Cary, NC 27513

NELAP accredited

SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire block below (except effective date).

This is a new procedure _____ revised procedure ✓ outdated procedure (archive) _____

- Procedure Code: IP/402 SOP Section #: 1.2.3.4 Revision #: 1

SOP Title: GC/MS Analysis of Aqueous and Medium Level Solids for Volatile Organic Compounds Using USEPA SOW SOM01.1

Effective date: (QA fills in) 6/19/06

- Procedure prepared by: Respass — Date: 6/19/06
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) Bob McGinn — Date: 6-19-06
- Reason for change: Revisions requested by NJ DEP
- This procedure meets the requirements of the following approved method references: "US EPA CLP SOW for Organic Analysis Multi-Media, Multi-Concentration SOM01.1

Procedure approved by Quality Assurance Representative: (Not needed if signed above) _____ Date: _____

Effective 1-1-96, on an annual basis: Lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary, indicate by your signature that the SOP has been reviewed.

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Instrument Procedure 1402: GC/MS Analysis of Aqueous and Medium Level Solids for Volatile Organic Compounds using USEPA SOW SOM01.**1**

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Instrument Procedure 1402: GC/MS Analysis of Aqueous and Medium Level Solids for Volatile Organic Compounds using USEPA SOW SOM01.**1**

1.0 Scope and Application

The method described is designed to analyze water and medium level soil/sediment samples from hazardous waste sites for the volatile organic compounds listed in Attachment 1. The actual analysis is based on a purge and trap gas chromatograph/mass spectrometer (GC/MS) method for aqueous and medium level soil samples.

Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

2.0 Summary of Method

2.1 Aqueous

An inert gas (helium) is bubbled through 5 mL of sample spiked with internal standard and deuterated monitoring compounds (DMC). The sample is purged at ambient temperature, causing the purgeable volatile organic compounds to be transferred from the aqueous phase to the vapor phase. The vapor is swept onto a sorbent column where the purgeable volatile organic compounds are trapped.

2.2 Medium Level Soil/Sediment

Medium level soil samples are collected and preserved in methanol or extracted with methanol. An aliquot **(generally 100 µL)** of methanol extract is added to 5 mL of reagent water, spiked with internal standard and DMC solutions. The sample is purged at ambient temperature, causing the purgeable volatile organic compounds to be transferred from the aqueous phase to the vapor phase. The vapor is swept onto a sorbent column where the purgeable volatile organic compounds are trapped.

After purging is completed, the sorbent column is heated and back flushed with the inert gas to desorb the purgeable volatile organic compounds onto a gas chromatograph wide-bore capillary column. The gas chromatograph is temperature programmed to separate the purgeable volatile organic compounds that are then detected with a mass spectrometer.

3.0 Definitions

3.1 Method detection limit (MDL) – The minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR, Part 136, Appendix B.)

3.2 Reporting Limit- The reporting limit for CLP is the Contract Required Quantitation Limit (CRQL)

3.3 Reporting Units – µg/L for water and µg/Kg for soils

3.4 A sample delivery group (SDG) is defined by the following, whichever is more frequent:

- each 20 field samples received within a case, or
- each 7 calendar day period (3 calendar day period for 7 day turnaround) during which field samples in a case are received beginning with the receipt of the first sample.

3.5 Analytical range – The range of concentrations that comprise the initial calibration (i.e., 5 to 200 µ/L for non-ketone compounds). Samples containing target analyte(s) above the analytical range must be diluted, or a lesser amount of sample analyzed, in order to bring the concentration to within the upper half of the analytical range. The upper half of the analytical range is defined as the concentration between the midpoint standard and the high standard.

3.6 BFB - Bromofluorobenzene

3.7 EICP - Extracted Ion Current Profile

3.8 VOA – Volatile Organic Analysis

3.9 VTSR – Validated Time of Sample Receipt

4.0 Interferences

4.1 Impurities in the purge gas or methanol, organic compounds out gassing from the plumbing ahead of the trap, and solvent vapors in the laboratory account for the majority of contamination problems. Gas lines from the gas tanks to the instrument must be either stainless steel or copper tubing. Non-

polytetrafluoroethylene (PTFE) thread sealants, or flow controllers with rubber components are not to be used. When potential interfering peaks are noted in laboratory method blanks, it may be necessary to reduce solvent contamination in the laboratory, purge the methanol used to prepare standard solutions, purge the reagent water with helium or nitrogen, change the purge gas source, or regenerate the molecular sieve purge gas filter.

4.2 Samples can be contaminated by diffusion of purgeable organics (particularly methylene chloride, fluorocarbons, and other common laboratory solvents) through the septum seal into the sample during storage and handling. Therefore, these samples are stored in GC/MS VOA laboratory refrigerator separate from laboratory standards, and analyzed in a room whose atmosphere is demonstrated to be free of all potential contaminants that will interfere with the analysis.

4.3 Laboratory clothing worn by analysts must be **devoid** of solvents because clothing previously exposed to methylene chloride and other laboratory solvent fumes during common liquid/liquid extraction procedures can contribute to sample contamination.

4.4 Contamination by carryover can occur whenever a sample is analyzed after a sample that contains high levels of organic compounds. Whenever an unusually concentrated sample is encountered, it must either be followed by analysis of an instrument blank or the next sample must be closely monitored to check for cross-contamination. For samples containing large amounts of water soluble materials, suspended solids, high boiling compounds, or high purgeable levels, it may be necessary to clean the purge and trap apparatus by purging a 10 - 20% methanol solution, followed by baking the purge and trap apparatus and the analysis of a reagent water blank to confirm that the system is free from contamination. The trap and other parts of the system are also subject to contamination; therefore, frequent bake out and purging of the entire system may be required.

4.5 Method interferences caused by contaminants in solvents, reagents, glassware, purge gas, sorbents, laboratory air, and other sample storage and processing hardware that lead to discrete artifacts and/or elevated baselines in gas chromatograms must be eliminated. The chromatographic system must be inspected for malfunctions and corrections must be made as required before more samples are analyzed.

4.6 Instrument problems/preventative maintenance

4.6.1 If a low response is observed for the early eluting compounds such as the gases, replacement of the trap or septum may be necessary. In addition, adjustments to the purge flow may be necessary to achieve a desired

response for these compounds. If such adjustments do not help, it may be necessary to check the fittings on the purge and trap device and on the column for leaks. This is done with a helium leak detector and certain software utility programs.

4.6.2 Column maintenance or replacement may be necessary if peak tailing or broad chromatographic peaks are observed.

5.0 Safety

5.1 Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous. During sample preparation, glasses, gloves and lab coats are a minimum requirement. The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

5.2 Laboratory staff **must** review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets (MSDS) for solvents and reagents used in the laboratory. The MSDSs are located in the Quality Assurance department.

5.3 The toxicity and carcinogenicity of many chemicals used in this method have not been precisely determined. Each chemical should be treated as a potential health hazard. Exposure to these chemicals should be minimized. Preparation of calibration standards, blanks, and samples is performed in a fume hood to minimize risk.

5.4 The following method analytes have been tentatively classified as known or suspected human or mammalian carcinogens: benzene, carbon tetrachloride, chloroform, vinyl chloride, and 1,4-dioxane.

6.0 Equipment & Supplies

6.1 Syringes

6.1.1 5 mL **– SGE International gastight syringe**

6.1.2 1 mL **– SGE International gastight syringe**

6.1.3 10 µL **– Hamilton microsyringe**

6.1.4 25 µL **– Hamilton microsyringe**

6.1.5 100 µL **– Hamilton microsyringe**

6.2 Analytical column

6.2.**1** Restek RTX-624, 60 M, 0.32 mm ID, 1.8 µm film thickness**, used in instrument 90 (HP5973MSD)**

6.2.**2** Supelco SPB-624, 60 M, 0.32 mm ID, 1.4 µm film thickness**, used in instruments 71 (HP6890MSD) and 73 (HP5972MSD)**

6.2.**3** Zebron EB-624, 60 M, 0.32 mm ID, 1.8 µm film thickness**, used in instrument 59 (HP5973MSD)**

6.2.**4** **Restek RTX-VMS 20 M, 0.18 mm ID, 1.8 µm film thickness , used in instruments 61/62 (dual P&T GC/MS with HP5973MSD)**

6.3 Gas Chromatograph (GC)

6.3.1 Varian 3400

6.3.2 Hewlett Packard 5890 Series

6.3.3 Hewlett Packard 6890 Series

6.4 Mass Spectrometer

6.4.**1** Hewlett Packard 5972 Mass Selective Detector (MSD)

6.4.**2** Hewlett Packard 5973 MSD

6.4.3 Hewlett Packard 6890 MSD

6.5 Interface (GC to mass spectrometer)

6.5.1 Jet separator

6.5.2 Direct capillary insertion

6.6 Data System

6.6.1 For data acquisition, the INCOS500 GC/MS systems use the ProLab Resources system, with EnviroLink software. The Hewlett Packard GC/MS systems utilize ChemServer software.

6.6.2 For data processing, the laboratory uses the Hewlett Packard HP 9000 series 735 Unix Workstation employing Target 3 and Envision software by Thru-Put Systems.

6.6.3 The reference library used is the NBS129K.1 version.

6.7 Data storage

6.7.1 **Data are stored on the Target3 Unix Workstation, which is backed up incrementally on a daily basis.**

6.8 Purge and trap

6.8.1 Archon Model 5100 or 4552 purge and trap autosampler, interfaced with a Tekmar 3000 sample concentrator, with a Supelco K trap or equivalent.

6.5.1.1 The K (VOCARB 3000) trap consists of the following:

- **carbopack B, 10 cm**
- **carboxen - 1000, 6 cm**
- **carboxen – 1001, 1 cm**

6.8.2 Tekmar/Dohrmann Solatek 72 Multi-Matrix Vial Autosampler interfaced with a Tekmar/Dohrmann 3100 Sample Concentrator.

6.9 pH paper

6.9.1 wide range, capable of measuring pH 0-14.

6.10 Balance

6.10.1 The analytical balance **(Sartorius Model B410)** used must be capable of accurately weighing plus or minus 0.0001 grams.

6.10.2 The balance must be calibrated with Class S or known reference weights once per twelve-hour shift.

6.11 Disposable pasteur pipets

6.12 Volumetric flasks, Class A, 10 µL to 100 µL, with ground glass stoppers.

6.13 Vials and caps – assorted sizes

7.0 Reagents and standards

7.1 Reagent water

7.1.1 Reagent water – All water used in this procedure must be equivalent to ASTM Type I water**, with regard to resistivity of > 10 megohm-cm (19th and 20th Editions of Standard Methods, Method 1080),** which is subsequently purged with the inert gas, nitrogen, and demonstrated to meet the blank contamination acceptance criteria contained in this Standard Operating Procedure (SOP). It is referred to throughout the remain**d**er of this SOP as reagent water.

7.2 Methanol, purge and trap grade

7.3 Tuning standard

7.3.1 Bromofluorobenzene (BFB)**, Restek, 99% purity**

7.3.1.1 Standard ID# 7008, Standard Preparation SOP 7.2.1.4, at 25 µg/mL in methanol.

7.3.1.2 Prepare fresh BFB solution every six months or sooner if degradation or evaporation occurs.

7.4 Calibration Standards

7.4.1 The initial calibration consists of five standards containing all target compounds and DMC. Add a sufficient amount calibration standard solution to 5 mL of reagent water to result in the following concentrations:

7.4.1.1 **Prepare a**ll non-ketone target compounds and their associated DMCs at 5.0, 10, 50, 100, and 200 µg/L; all ketones and their DMCs are at 10, 20, 100, 200, and 400 µg/L; 1, 4-dioxane and its DMC are at 100, 200, 1250, 2000, and 4000 µg/L. The concentrations of the m,p-xylene isomers must total 5.0, 10, 50, 100, and 200 µg/L.

7.4.2 The opening and closing continuing calibration standards are prepared at or near the mid-point of the calibration range, 50 µg/L for non-ketones and their associated DMCs, 100 µg/L for ketones

and their associated DMCs, and 1250 µg/L for 1,4-dioxane and 1,4-dioxane-d_8.

7.4.**3** **Prepare s**tandards in a volumetric flask or **gastight** syringe**, depending on the volume needed**.

7.4.**4** The methanol contained in each aqueous calibration standard must not exceed 1.0 percent by volume.

7.4.**5** Prepare a fresh calibration standard solution monthly, or sooner if the solution has degraded or evaporated.

7.5 Internal Standard Solution

7.5.1 **Prepare t**he internal standard solution consist**ing** of 1,4-difluorobenzene, chlorobenzene-d_5, and 1,4-dichlorobenzene-d_4, **each at a concentration of 50 µg/**m**L**.

7.5.2 Add sufficient amount of internal standard to each calibration standard, blank, and sample including duplicate matrix spikes to result in 0.25 µg of each internal standard**.**

7.5.3 Prepare a fresh internal standard solution monthly, or sooner if the solution has degraded or evaporated.

7.6 DMC Standard solution

7.6.1 **Prepare a** DMC standard solution **consisting** of vinyl chloride-d_3, chloroethane-d_5, 1,1-dichloroethene-d_2, 2-butanone-d_5, chloroform-d, 1,2-dichloroethane-d_4, benzene-d_6, 1,2-dichloropropane-d_6, toluene-d_8, trans-1,3-dichloropropene-d_4, 2-hexanone-d_5, 1,4-dioxane-d_8, 1,1,2,2-tetrachlorothane-d_2, 1,2-dichlorobenzene-d_4, **each at a concentration of 50 µg/mL.**

7.6.2 Add a sufficient amount of DMC to each calibration standard, blank and sample including duplicate matrix spikes to result in 0.25 µg.

7.6.3 Prepare a fresh DMC standard solution monthly, or sooner if the solution has degraded or evaporated.

7.7 Matrix Spiking Solution

7.7.1 **Prepare a** matrix spiking solution **consisting** of 1,1-dichloroethene, trichloroethene, chlorobenzene, toluene, and benzene at 12.5 µg/mL.

7.7.2 Prepare a fresh matrix spiking solution monthly, or sooner if the solution has degraded or evaporated.

7.8 Storage of standards

7.8.1 Store the stock standards in Teflon®-sealed, screw-cap bottles with zero headspace at –10° C to –20° C. Protect the standards from light.

7.8.2 **Store a**queous standards for **up to** 24 hours in Teflon®-sealed, screw-cap bottles with zero headspace at 4° C (± 2° C). Protect the standards from light.

7.8.3 Aqueous standards not stored as in 7.8.2, must be discarded after one hour unless they are set up to be purged on an autosampler. When an autosampler is used, the standards may be kept up to 12 hours in purge vessels connected via the autosampler to the purge and trap device.

7.8.4 Purgeable standards must be stored in the GC/MS Freezer, separate from other standards and samples.

7.9 Standard Storage Records

7.9.1 All temperature records must be recorded daily following the procedures in QC SOP 13.15, "Documenting Refrigerator and Freezer Temperatures".

7.9.2 Corrective actions SOPs are required to be posted on refrigerators/freezers.

8.0 Sample Preservation, Storage, and Holding Time

8.1 Samples are preserved, and stored according to the tables in Sample Control SOP 4.1, "Receiving Samples" and 4.6, "Storing Samples." Sample holding times are also listed.

8.2 Analysis of water and soil sediment samples must be must be completed within 10 days of validated time of sample receipt. Analysis of unpreserved, unfrozen soil sediment samples must be completed within 24 hours of VTSR. These holding time requirements do not apply to performance evaluation (PE) samples.

8.3 Aqueous samples and storage blanks must be protected from light and stored at 4° C (± 2° C) in a VOA only storage unit.

8.4 Unpreserved medium soil samples and inert sand storage blanks must be protected from light and stored at less than -7 ^{o}C in a VOA only storage unit.

9.0 Quality Control

9.1 DMC

9.1.1 All samples, blanks and standards are fortified with DMC that are used to monitor performance of the entire purge and trap/GC/MS system.

9.1.2 The following table contains DMC recovery criteria.

DMC	Percent Recovery for Aqueous Samples	Percent Recovery for Soil Samples
Vinyl chloride-d_3	65-131	68-122
Chloroethane-d_5	71-131	61-130
1,1-Dichloroethene-d_2	55-104	45-132
2-Butanone-d_5	49-155	20-182
Chloroform-d	78-121	72-123
1,2-Dichloroethane-d_4	78-129	79-122
Benzene-d_6	77-124	80-121
1,2-Dichloropropane-d_6	79-124	74-124
Toluene-d_8	77-121	78-121
Trans –1,3-Dichloropropene-d_4	73-121	72-130
2-Hexanone-d_5	28-135	17-184
1,4-Dioxane-d_8	50-150	50-150
1,1,2,2-Tetrachloroethane-d_2	73-125	56-161
1,2-Dichlorobenzene-d_4	80-131	70-131

9.2 Internal Standards

9.2.1 **Add i**nternal standard compounds to every standard, blank and sample at a known concentration prior to analysis. Internal standards are used as the basis for quantitation of the DMC and target compounds.

9.2.1.1 The EICP area of each of the internal standards in the blanks and samples (including duplicate matrix spikes) must be in the range of 50% to 200% of its response in the most recent opening continuing calibration verification (CCV) standard.

9.2.1.2 If internal standard area response criteria is not met, corrective action **must** be taken. **Start with** actions such as checking

calculations and checking solution for degradation. Samples analyses not meeting internal standard response criteria must be reanalyzed.

9.2.1.3 The retention time (RT) shift of each internal standard in the blanks and samples (including duplicate matrix spikes) must be within ± 0.50 minutes (30 seconds) of its RT in the most recent opening CCV standard.

9.2.1.4 If internal standard RTs are not within limits, check the instrument for malfunctions. Sample analyses not meeting internal standard RT criteria must be reanalyzed.

9.3 Blanks

9.3.1 Method blank **(One per 12-hour period of operation)**

9.3.1.1 **Prepare t**he method blank using reagent water for water samples or a purified solid matrix **(Ottawa sand)** for soil/sediment samples, and **carry** through the entire analytical process for the purpose of measuring reagent and system contamination.

9.3.1.2 **A**nalyze immediately after the opening continuing calibration verification standard and before any field samples (including duplicate matrix spikes) are analyzed. **Analyze t**he method blank after the initial calibration if samples are analyzed during that tune batch.

9.3.1.3 Before any samples are analyzed, demonstrate that a laboratory method blank is free from contamination that would prevent the determination of any analyte of concern. Background contamination must be reduced to an acceptable level before proceeding with the next analysis.

9.3.1.4 The percent recovery of each of the DMC in the blank must meet the criteria listed in 9.1.2. The recovery for 1,4-dioxane is advisory.

9.3.1.5 The method blank must meet the internal standard acceptance criteria listed in 9.2.1.1 and 9.2.1.3.

9.3.1.6 The concentration of each target compound found in the method blank must be less than the CRQL listed in Attachment 1, except

methylene chloride, acetone, and 2-butanone which must be less than 2 times their respective CRQL.

9.3.2 Storage blanks **(One per matrix type)**

9.3.2.1 **On receipt of** the first samples in an SDG, **store** two vials of clean reference matrix (reagent water or inert sand) **at** 4° C ± 2° C for water and methanol preserved soil samples.

9.3.2.2 **Analyze t**he storage blank after all samples in a SDG have been analyzed.

Note: The storage blank indicates whether contamination may have occurred during storage of samples. The storage blank is analyzed once per SDG.

9.3.2.**3** The storage blank must meet all method blank acceptance criteria.

9.3.2.**4** If the storage blank does not meet the blank contamination criteria, reanalyze the storage blank to determine whether contamination occurred during analysis or during storage. If the results of the reanalysis do not meet blank contamination acceptance criteria, contamination occurred during storage. These results must be noted so that they can be discussed in the SDG narrative, along with appropriate corrective actions.

9.3.3 Instrument blanks

9.3.3.1 **Analyze i**nstrument blanks (5 mL of reagent water, spiked with internal standards and DMCs) after a sample analysis containing target compounds at concentrations that exceed the instrument**'**s analytical range.

Note: The results from the instrument blank analysis indicate whether there is contamination from a previous sample.

9.3.3.**2** The concentration of each target analyte in the instrument blank must be less than CRQL.

9.3.3.**3** **Do not resume s**ample analysis until the instrument blank meets the criteria in 9.3.3.**2**, along with meeting the internal standard and DMC recovery criteria.

9.3.4 **Analyze a**ll blanks on a GC/MS system meeting the BFB, initial calibration, and continuing calibration acceptance criteria.

9.4 Duplicate Matrix Spikes

9.4.1 **Analyze d**uplicate matrix spikes on a GC/MS system meeting the BFB, initial calibration, continuing calibration, and method blank acceptance criteria.

9.4.2 Duplicate matrix spikes are required (if requested by the **client**) for each group of 20 field samples in a SDG or for each SDG, which ever is most frequent.

9.4.3 Duplicate matrix spikes must meet the internal standard acceptance criteria in 9.2.1.1 and 9.2.1.3.

9.4.4 The table below contains the spike recovery and relative percent difference (RPD) criteria for duplicate matrix spikes. These limits are advisory and no further action by the laboratory is required. However, frequent recovery and RPD failures should be addressed by the laboratory.

Spike Compounds	Percent Recovery Aqueous	RPD Aqueous	Percent Recovery Soil	RPD Soil
1,1-Dichloroethene	61-145	0-14	59-172	0-22
Trichloroethene	71-120	0-14	62-137	0-24
Benzene	76-127	0-11	66-142	0-21
Toluene	76-125	0-13	59-139	0-21
Chlorobenzene	75-130	0-13	60-133	0-21

9.5 Samples

9.5.1 **Analyze a**ll samples on a GC/MS system meeting the BFB, initial calibration, continuing calibration, and method blank acceptance criteria.

9.5.2 **Analyze t**he samples within the contractual holding time.

9.5.3 Three DMC**s** may fail the criteria in 9.1.2, excluding 1,4-dioxane-d_8. The recovery for 1,4-dioxane-d_8 is advisory.

9.5.4 The area responses of the internal standards must be within 50 - 200% of their respective area responses in the opening CCV.

9.5.5 The RT shift of each of the internal standards in the sample must be less than 30 seconds from the corresponding internal standard in the most recent opening CCV.

9.5.6 If target compound concentrations exceed the instrument's analytical range, re-prepare at a dilution. The diluted analysis must bring the concentration of the compound(s) in question within the upper half of the analytical range for this method.

9.6 Contingency

9.6.1 If due to a lab accident or to QC failures, a re-preparation and analysis are required for the sample and insufficient sample volume remains, the Project Manager must be alerted and will contact the client for direction on how to proceed.

9.6.2 If persistent contamination occurs in the laboratory, analysis must be halted until the source of the contamination can be identified and isolated. When the contamination issue is resolved, samples analysis may proceed.

9.6.3 Refer to the corresponding Data Review SOP (number will vary among sections) for information on how to handle reporting of data that are unacceptable or out-of-control.

9.6.4 Any other issues that potentially effect data quality should also be addressed with the Project Manager.

10.0 Calibration & Standardization

10.1 BFB

10.1.1 A calibrant**,** perfluoro-tri-n-butylamine (FC-43)**, is** first used to tune the GC/MS system.

10.1.2 **Analyze** the instrument performance check solution by injecting 50 ηg of BFB (2 µL Std ID# 7008) into the GC using a 10 µL Hamilton syringe.

10.1.3 **Acquire** BFB by averaging three scans. The scan immediately prior to the apex, the apex scan, and the scan immediately following the apex are

averaged. Background subtraction is also required and must be accomplished by subtraction of a single scan no more than 20 scans prior to the elution of BFB. Do not subtract part of the BFB peak.

10.1.4 The analysis of the instrument performance check solution must meet the ion abundance criteria given in the table below.

BFB Key Ions and Ion Abundance Criteria

Key Ions	Ion Abundance Criteria
50	15.0 – 40.0% of **m/z** 95
75	30.0 – 80.0% of **m/z** 95
95	Base Peak; 100% relative abundance
96	5.0 – 9.0% of **m/z** 95
173	< 2.0% of **m/z** 174
174	50.0 – 120.0% of **m/z** 95
175	5.0 – 9.0% of **m/z** 174
176	95.0 – 101.0% of **m/z** 174
177	5.0 – 9.0% of **m/z** 176

Note: All ion abundances must be normalized to **m/z** 95, even though ion **m/z** 174 may be up to 120% of **m/z** 95.

10.1.5 If BFB technical acceptance criteria are not met, retune the GC/MS system. **If required,** clean the ion source, clean the **quadrapole** rods, or take other corrective action to achieve the technical acceptance criteria.

10.1.6 BFB technical acceptance criteria must be met before any standards, samples, or required blanks are analyzed.

10.2 Initial calibration

10.2.1 Prior to the analysis of samples and required blanks, and after the instrument performance check solution (BFB) criteria have been met, **calibrate the** GC/MS system at five concentrations (see 7.4.1.1) to demonstrate instrument sensitivity and the linearity of the GC/MS response for the purgeable target compounds.

10.2.1.1 If time remains in the 12 hour time period after meeting the technical acceptance criteria for the initial calibration, samples may be analyzed. It is not necessary to analyze an opening CCV.

10.2.1.2 A method blank is required. Quantify all blank and sample internal standard area response changes and retention time shifts, against the med-level initial calibration standard.

10.2.2 **Perform a**n initial calibration when the continuing calibration criteria cannot be met or whenever a column is changed or an ion source cleaned.

10.2.3 Excluding those ions in the solvent front, no ion may saturate the detector.

10.2.3.1 If a compound (s) in an initial calibration standard saturates the instrument's detector, terminate analysis. Tune the instrument, making adjustments such as lowering the electron multiplier, to reduce instrument sensitivity. After tuning, analyze the BFB. Resume calibration procedure, after BFB has met acceptance criteria.

10.2.**4** **Tabulate the area response of the characteristic ions in the extracted ion current profile (EICP) against the concentration for each compound and internal standard. Calculate relative response factors (RRF) for each compound. Calculate the mean RRF for all compounds**.

10.2.**5** The RRF at each calibration concentration for each DMC and target compound must be greater than of equal to the compounds minimum RRF listed in Attachment 2.

10.2.**6** The percent relative standard deviation (%RSD) for each DMC and target compound must be less than or equal to that listed in Attachment 2.

10.2.**7** Up to two compounds may fail to meet minimum RRF criteria and up to two compounds may fail the maximum %RSD criteria. However, none may fail with more than 40.0% RSD and none may have an RRF less than 0.010.

10.2.**7**.1 The exceptions are 1,4-dioxane and 1,4-dioxane-d_8, which must have a minimum RRF of ≥ 0.0050 and a maximum % RSD of ≤ 50.0%.

10.2.**8** If the initial calibration technical acceptance criteria are not met, inspect the system for problems. **If required,** clean the ion source, perform column maintenance, change the column, service the purge and trap

device, or take other corrective action to achieve the technical acceptance criteria

10.3 Opening and Closing Continuing Calibration Verification (CCV)

10.3.1 The CCV standards are at a concentration at or near the mid point of the initial calibration.

10.3.2 A check of the calibration of the GC/MC system must be performed once every 12 hours by the injection of BFB and the opening CCV standard.

10.3.2.1 The RRF percent difference (%D) for each DMC and target compound must be less than or equal to the maximum %D listed in Attachment 2.

10.3.2.2 The RRF for each DMC and target compound must be greater than or equal to the minimum RRF listed in Attachment 2.

10.3.2.3 Up to two compounds may fail the criteria in 10.3.2.1 and 10.3.2.2, however, these compounds must meet a minimum RRF of ≥ 0.01 and a maximum %D of ± 40. The exceptions are 1,4-dioxane and 1,4-dioxane-d_8, which must have a minimum RRF of ≥ 0.005 and a maximum %D of ± 50.

10.3.3 After all the samples are analyzed, and before the end of the twelve-hour time period, the closing CCV standard must be analyzed.

10.3.3.1 The RRF %D for each target compound must be ± 50.

10.3.3.2 The RRF for each DMC and target compound must be ≥ 0.01, except for 1,4 dioxane and its DMC, which must be at least 0.0050.

10.3.3.3 If the closing CCV meets the acceptance criteria for the opening CCV, sample analysis may continue without the analysis of BFB. The twelve-hour time period begins at the injection time of the closing CCV. However, a method blank must be analyzed.

10.3.4 Opening CCV acceptance criteria must be met before any samples, including duplicate matrix spikes, or blanks are analyzed. If the acceptance criteria are not met, recalibrate the GC/MS by performing another initial calibration. This may require some corrective action first.

10.3.5 Closing CCV acceptance criteria must be meet or all samples analyzed within the twelve-time period must be reanalyzed.

11.0 Procedure

Documentation must follow the requirements in QC SOP: Proper Documentation Procedures. Record all instrument information in the GC/MS VOA Run Log (Attachment 3).

11.1 Instrument Performance Check

11.1.1 Perform an instrument performance check by analyzing 50 ηg of BFB. The BFB **is** directly injected onto the GC column**.**

11.1.2 If BFB acceptance criteria are met, print the BFB mass spectrum, mass listing, and reconstructed ion chromatograph (RIC).

11.2 Initial Calibration Analysis

11.2.1 Prepare the five aqueous initial calibration standards **(See Section 7.4)** by adding calibration standard, DMC and internal standard solutions to 5 mL of reagent water in a gastight syringe. Inject syringe contents into a **40 mL** VOA vial and place vial on the purge-and-trap autosampler. **P**urge at ambient temperature.

11.2.1.1 Medium level soil analysis is performed using the aqueous initial calibration.

11.2.2 Analyze the initial calibration standards at the concentration listed in 7.4.1.1.

11.2.3 Process and review each standard analysis using the Target3 data system insuring that each DMC and target compound is present in each standard.

11.2.4 Check that the initial calibration met acceptance criteria by reviewing the initial calibration summary form on the Target3 data system.

11.2.5 If acceptance criteria are met, print the initial calibration summary form. Also print the RIC, quantitation report, and EICP for each calibration standard used.

11.2.6 If time remains in the twelve hour period after the initial calibration has been analyzed, samples may be analyzed without the analysis of an opening CCV.

11.2.7 If no samples are analyzed, complete the GC/MS run log. (Attachment 5) "Z" out any unused portion of the run log and have a supervisor or designee to review and sign it. Make a photocopy of the run log and attach it to the hard copy data for the BFB and initial calibration.

11.3 Opening CCV

11.3.1 After the BFB and the initial calibration have met acceptance criteria, the GC/MS must be routinely checked by analyzing the opening CCV standard.

11.3.2 Process and review the CCV using Target3 processing software insuring that each target compound is present in the analysis

11.3.3 Check that the CCV met acceptance criteria, by reviewing the continuing calibration summary form on the Target3 data system.

11.3.4 If opening CCV acceptance criteria are met print the continuing calibration summary form, RIC, quantitation report, and EICP.

11.4 Method Blank Analysis

11.4.1 **Analyze a method blank a**fter BFB, initial calibration, and opening CCV acceptance criteria are met **and** before any samples are analyzed.

11.4.**2 Prepare an** aqueous method blank by adding DMC and internal standard solutions to 5 mL of reagent water in a gastight syringe. The blank is injected into a 40 mL vial and placed in the autosampler for analysis.

11.4.3 Prepare the medium level blank by weighing 5 g of inert sand into a 40 mL vial. Add 5 mL of methanol to the vial and cap. Shake the vial for 2 minutes. Allow contents to settle. Transfer approximately 1 mL of the extract, with a disposable pipette, to a GC vial (2 mL vial). Store the extract at 4° C (± 2° C).

11.4.3.1 Prepare a medium level soil method blank by adding 100 µL of the blank extract to 5 mL of reagent water in a gastight syringe, then adding DMC and internal standard solutions. The blank is

injected into a 40 mL vial and placed in the autosampler for analysis.

11.4.**4** Process and review the method blank. After the method blank meets acceptance criteria, **analyze** samples.

11.5 Instrument Blank Analysis

11.5.1 **Prepare an i**nstrument blanks in the same manner as aqueous method blanks.

11.5.2 **Analyze i**nstrument blanks after samples containing target analytes that exceed the initial calibration range.

11.5.3 Process and review the instrument blank. **Resume s**ample analysis when no target compound detected is greater than CRQL.

11.6 Storage Blank Analysis

11.6.1 **Analyze s**torage blanks after all sample in the SDG have been analyzed.

11.6.2 **Prepare s**torage blanks in the same manner as the aqueous method blank for aqueous samples and preserved soil samples stored at 4°C (± 2° C). For soil samples stored at less than -7° C, **prepare** a storage blank consisting of blank sand.

11.7 Sample Preparation and Analysis

11.7.1 Aqueous samples are provided with zero headspace to the laboratory in 40 mL screw-cap vials with Teflon®-lined, silicon septa. **Store s**amples in a GC/MS laboratory refrigerator. **Allow s**amples to equilibrate to ambient temperature before analysis.

11.7.1.1 **P**repare an aqueous sample for analysis **by** pour**ing** the sample into a 5 mL gastight syringe, replace the plunger, adjust the volume to 5.0 mL, and add internal standard and DMC solutions.

11.7.1.2 If there is only one VOA vial, **fill** a second syringe to preserve sample integrity should a reanalysis be required. The reanalysis must occur within 24 hours.

11.7.1.3 **Take t**he pH of each water sample. After the sample aliquot is taken, add a couple of drops to pH paper. Do not add pH paper

to sample vials. Record the pH of each sample on the batch sheet **and GC/MS run log**. No pH adjustment is to be performed.

11.7.2 Soil samples for medium-level analysis may be received in 1) closed-system purge and trap containers or 40 mL vials pre-preserved in methanol or 2) in core sampler/storage containers (Encore™ or equivalent).

11.7.2.1 **Store s**amples**,** received pre-preserved in methanol**,** at 4º C until analysis. Prepare the sample for analysis by adding a 100 µL (undiluted extract volume) aliquot of the methanol extract to 5 mL of reagent water in a gas tight syringe. Add internal standard and DMC solutions to the syringe. **Inject t**he sample into a 40 mL vial and place **it** on the autosampler.

11.7.2.2 **Transfer s**amples received in Encore™ samplers**,** upon receipt**,** to 40 mL vials and store at -7º C until extraction. Just prior to extraction, allow the sample to equilibrate to ambient temperature. Remove cap, quickly add 5 mL of methanol and replace cap. Shake the sample vial for 2 minutes. Allow the contents to settle. Using a disposable pipette, transfer approximately 1 mL of the extract to a GC vial (2 mL vial) for storage. **Discard t**he remainder. Store the extract at 4º C (± 2º C) until analysis. Prepare the sample for analysis as in 11.7.2.1.

11.7.2.3 **To perform a** diluted analysis of the sample**,** us**e** a smaller aliquot of the extract. However, the total volume of methanol must equal 100 µL.

11.7.3 For duplicate matrix spikes, matrix spiking solution is added, along with the DMC and internal standard solutions, to each sample aliquot prior to analysis.

11.8 Purge and Trap Analysis

Recommended purge and trap analysis conditions.

11.8.1 After sample preparation, the purge vessel is loaded onto the closed-system autosampler that is interfaced with the purge and trap apparatus.

11.8.2 **P**urge at ambient temperature for 11.0 (± 0.1) minutes.

11.8.3 After purging, heat to 180° C and back-flush **contents** onto the GC column with helium at 15 mL/min for 4.0 (± 0.1) minutes **(d**esorb**)**.

11.8.4 After desorbing, **recondition** the trap by baking at 180° C for at least 7 minutes. **After** the trap has finished baking and is cool, it is ready for the next sample to be purged.

11.9. GC/**MS** Analysis

11.9.1 After desorbing, hold the GC temperature at 10° C for 1 to 5 minutes. Ramp at 6° C per minute to 160° C and hold until 3 minutes after the last target compound has eluted.

11.9.2 Once an initial hold time has been chosen and the GC conditions optimized, those same GC condition must be used for analysis.

11.9.3 The following are the required MS analytical conditions:

Parameter	
Electron Energy	**70 Volts (nominal)**
Mass Range	**35 - 300 amu**
Ionization Mode	**Electron Ionization (EI)**
Scan Time	**At least 5 scans per peak, not to exceed 2 seconds per scan for capillary column**

11.10 Sample Dilutions

11.10.1 **Perform a** dilution if a sample concentration exceeds the high level standard or because of excessive matrix interference. Determine a level of dilution that will result in a value within the upper half of the calibration range and/or to keep baseline height of the earliest **eluting** peak from exceeding one-half the relative height of the highest peak in the chromatogram.

11.10.2 **Analyze t**he sample and dilutions within the required holding time.

11.10.3 **Contact the client i**f more than one sample dilution (and the original analysis) is necessary to have all target analytes within the calibration range.

11.10.4 A 10x dilution is performed using 1 mL sample plus 9 mL diluent for a total volume of 10 mL. **Record all dilutions** on the run log.

11.11 Sample Quantitation

11.11.1 Process each sample.

11.11.2 Check that each sample meets internal standard response and RT criteria.

11.11.3 Check that each sample meets DMC recovery criteria.

11.11.4 Check that all target compound concentrations are within analytical range.

11.12. Closing CCV

11.12.1 **Analyze the closing CCV a**fter all samples have been analyzed and before the end of the twelve hour period.

11.12.3 Process and review the closing CCV using Target3 processing software insuring that each target compound is present.

11.12.4 Check that the CCV met acceptance criteria, by reviewing the continuing calibration summary form on the Target3 data system.

11.12.5 If the closing CCV meets the opening CCV criteria, **continue** sample analyses for 12 hours**,** without **performing another** instrument performance check (BFB) analysis.

11.12.6 If the closing CCV acceptance criteria are met, print the continuing calibration summary form, RIC, quantitation report and EICP.

11.12.7 Complete the GC/MS run log. ”Z” out any unused portion of the run log and have a supervisor or designee review and sign it. Make a photocopy of the run log and attach it to the hard copy data for the BFB and initial or continuing calibration.

11.13 Qualitative Identification of Target Compounds

11.13.1 **Compare and identify t**he **mass spectra of the** compounds listed in Attachment 1 **to those of the mass spectra of the standard. Verify** the identifications **with the following two criteria**:

11.13.1.1 Elution of the compound in the sample at the same RRT as the compound in the standard.

11.13.1.1.1 The RRT of the compound in the sample must compare within ± 0.06 RRT units of the compound in the reference standard. **Analyze t**he reference standard within the same twelve-hour time period as the sample.

11.13.1.2 Mass spectrum compound correspondence in the sample with the mass spectrum of the compound in the standard.

11.13.1.2.1 Obtain the mass spectra used for comparison from the laboratory's GC/MS that has met the acceptance criteria for BFB.

11.13.2 The guidelines for qualitative verification by comparison of mass spectrum are as follows:

11.13.2.1 All ions in the standard mass spectrum at a relative intensity of greater than 10% must be in the sample spectrum.

11.13.2.2 All ions present in the standard mass spectrum at intensities greater than 10% must agree within ± 20% of the relative intensities of the corresponding ions in the sample mass spectrum.

11.13.2.3 Ions greater than 10% on the sample spectrum**,** but not present**,** in the standard spectrum must be considered and accounted for **when** making the comparison. The verification process should favor false positives.

11.13.3 **Report a**ll compounds meeting the identification criteria with their spectra.

11.13.4 If a compound cannot be verified by all of the spectral identification criteria listed in section 11.13.2, but in the technical judgment of the mass spectra interpretation specialist, the identification is correct, then **report** the compound.

11.14 Qualitative Identification of Non-Target Compounds

11.14.1 A library search of the sample using the **NBS129K.1 version** mass spectral library is performed to tentatively identify non-target compounds.

11.14.2 **Tentatively identify a**ll organic compounds that have not been identified as target, internal standard or DMC compounds are **by performing** a forward search of the mass spectral library.

11.14.3 **Report u**p to 30 non-alkane Tentatively Identified Compounds (TICs) of greatest concentration on Form I VOA-TIC. **Do not report or count c**arbon dioxide**,** compounds with response less than 10% (based on the height of the nearest internal standard)**, or semivolatile TCL analytes** as part of the 30.

11.14.4 **Report c**ompounds tentatively identified as straight chain, branched, or cyclic alkanes, and are alone or part of an alkane series, as "total alkanes" on the Form I VOA-TIC. **Sum t**he concentration of each alkane and report as a single result for the "total alkanes".

11.14.5 Rules for making tentative identification:

11.14.5.1 **Report as presented** those TICs whose library search match is 85% or greater. If the mass spectral interpretation specialist feels there is **just evidence** not to report the compound as identified, an alternate identification is reported. An explanation as to why an alternate identification was reported must be included in the SDG narrative.

11.14.5.2 **Report the compound with the highest match (e.g., positional isomers),** if the library search produces more than one match at 85% or higher. If more than one compound has the same percent match, report the first compound. If in either case, the mass spectral interpretation specialist feels there is just evidence not to report the match, an alternate identification may be reported.

11.14.5.3 If the library search produces no matches above 85%, the mass spectral interpretation specialist is encouraged to make a valid tentative identification of the compound. **Report the compound as unknown if** a valid, tentative identification

cannot be made. **Give** additional classification of the unknown, if possible (e.g., unknown aromatic compound).

11.15 Sample Quantitation

11.15.1 The concentration of each target and non-target compound is calculated using the equations in Section 12.0. Concentrations are based on the dry weight of the sample, for medium level solids. Percent moisture is determined using SOP 2.8.1 "Undecanted Percent Moisture Determination in Soil/Sediment/Sludge by CLP and SW-846".

12.0 Data Analysis & Calculations

Calculations must be consistent with the QC SOP: Numerical Data Reduction.

12.1 Calculation of the mean or average of a set of values:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where:

n = total number of values
x_i = each individual value used to calculate the mean
x = the mean of n

12.2 Calculation of the standard deviation of a set of values:

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n} \left(X_n - \overline{X}\right)^2}{n-1}}$$

12.3 Calculation of percent recovery:

12.3.1 Surrogates:

$$\%R = \frac{Amount\ found}{Amount\ spiked}\ x\ 100$$

12.3.2 Matrix spikes:

$$\%\,R = \frac{Amount\ in\ spiked\ \ sample - Amount\ in\ unspiked\ (native)\ sample}{Amount\ spiked}\ x\ 100$$

12.4 Calculation of % RSD

$$\%RSD = \left(\frac{Standard\ deviation}{\overline{X}}\right) \times 100$$

12.5 Calculation of RPD

$$RPD = \frac{|Value\ 1 - Value\ 2|}{(Value\ 1 + Value\ 2)/2} x100$$

12.6 Calculation of %Difference (%D)

$$\%Diff = \frac{Value - \overline{Reference\ \ value}}{\overline{Reference\ \ value}}\ x\ 100$$

12.7 Calculation of Relative Response Factor (RRF)

$$RRF = \frac{Ax}{Ais}\ x\ \frac{Cis}{Cx}$$

Where:

Ax = area of the characteristic ion from the EICP for the compound to be measured
Ais = area of the characteristic ion for the EICP for the internal standard
Cis = concentration of the internal standard
Cx = concentration of the compound to be measured

12.8 Concentration of aqueous samples by GC/MS analysis

$$\mu g / L = \frac{(Ax)(Is)(Df)}{(Ais)(\overline{RRF})(Vo)}$$

where:

Ax = area of the characteristic ion from the EICP for the compound to be measured
Ais = area of the characteristic ion for the EICP for the internal standard
Is = amount of internal standard injected (ηg)

$\overline{RRF}$ = mean relative response factor from the ambient temperature purge of the calibration standard
Vo = volume of water purged (mL)
Df = dilution factor. If no dilution, Df = 1.0

12.9 Concentration of medium level soil samples (dry weight basis) by GC/MS

$$\mu g / Kg = \frac{(Ax)(Is)(Vt)(1000)(Df)}{(Ais)(\overline{RRF})(Va)(Ws)(D)}$$

where:

Ax, Ais, and Is are the same as given for water
$\overline{RRF}$ = Mean relative response factor from the ambient temperature purge of the calibration standard
Vt = Total volume of the methanol extract in mL, typically 10 mL although only one mL is transferred to the vial.
Va = Volume of the aliquot of the sample methanol extract, i.e., sample extract, not including the methanol added to equal 100 µL added to DI water.
Ws = Weight of soil/sediment sample extracted, in grams
D = Dry weight

$$\frac{100 - \%\ moisture}{100}$$

Df = Dilution factor. The dilution factor for analysis of soil/sediment samples for volatiles by medium level method is as follows.

$$Df = \frac{\mu L\ most\ conc.\ extract\ used\ to\ make\ dilution + \mu L\ clean\ solvent}{\mu L\ most\ conc.\ extract\ used\ to\ make\ dilution}$$

12.10 TICs are quantified by comparing the MS response from the RIC for the non-target compound peaks to the MS response for a peak produced by the nearest internal standard compound. A response factor of 1 is assumed.

12.10.1 Concentration of TICs in aqueous samples

$$TIC\ \ amount\ = \frac{A(tic)\ x\ Amt\,(std)(Df)}{A(IS)\ x\ (Vo)}$$

where:

Df and Vo are defined in 12.8
A(tic) = area response from RIC for non-target compound
Amt(std) = amount of internal standard added to the sample
A(I.S.) = area response of the nearest internal standard

12.10.2 Concentration of TICs in medium level soil samples

$$TIC\ \ amount\ = \frac{A(tic)\ x\ Amt\ (std\ )(Df\ )(Vt\ )\ \text{x}\ 1000}{A(IS\ )\ x\ 1\ \text{x}\ (Va\ )(Ws\ )\ \text{x}\ \text{D}}$$

where:

Df , Vt, Va , Ws and D are defined in 12.9
A(tic) = area response from RIC for non-target compound
Amt(std) = amount of internal standard added to the sample
A(I.S.) = area response of the nearest internal standard

13.0 Method Performance

This method was validated through in-house laboratory studies of method detection limits and precision and accuracy for single analyst. The data is retained by the QA department.

14.0 Pollution Prevention

The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 thing. **See SOP 12.1, Hazardous Waste Disposal, regarding laboratory procedures for recycling solvent waste streams.**

15.0 Waste Management

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and

controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Samples preserved with HCl are hazardous and must be handled as hazardous waste.

Refer to the Hazardous Waste Management and Safety SOPs located in the lab.

16.0 References

16.1 U.S. EPA CLP SOW for Organic Analysis, Multi-Media, Multi-Concentration, SOM01.**1** (**May 2005**)

16.2 "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods", SW-846, 3rd Edition, Update III, 12/96

16.3 Methods for Chemical Analysis of Water and Wastes, March 1983

16.4 Standard Methods for the Examination of Water and Wastewater, 20th (1998) Edition, Method 1080

16.5 Code of Federal Register, 40 CFR, Part 136, "Guidelines for Establishing Test Procedures for Priority Pollutants"

16.6 Q**uality** C**ontrol** SOP **13.6 "**Proper Documentation Procedures**"**

16.7 Q**uality** C**ontrol** SOP **13.4 "**Numerical Data Reduction**"**

16.8 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477.

16.9 Hazardous Waste Management & Safety SOPs: "Hazardous Waste Disposal" and "Spill Control & Cleanup."

16.10 NELAC Standards, **June 2003**, plus revisions

16.11 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995.

16.12 New York State Environmental Laboratory Approval Program, Certification Manual, **April 2005**, plus revisions.

16.13 CompuChem Quality Manual, Revision **7**, **Update 1, 12/13/05**, plus revisions

16.14 Sample Control SOP 4.1, "Receiving Samples"

16.15 Sample Control SOP 4.6, "Storing Samples"

16.16 QC SOP 13.15, "Documenting Refrigerator and Freezer Temperatures"

16.17 Sample Preparation Procedure –223, "Methanol Extraction of Soil/Sediment Samples for the Analysis of Medium Level Volatile Organics by EPA CLP and NYSASP".

16.18 Organic Standard Preparation Procedure, "Instrument Performance Check (Tuning) Solution, ID # 7008, VOA, Water & Soil"

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.1 Attachment 1 – Target Compound List (TCL) and CRQLs

17.2 Attachment 2 – Relative Response Factor Criteria for Initial and Continuing Calibration Verification of Volatile Organic Compounds

17.3 Attachment 3 – Characteristic Ions for Trace Volatile Target Compounds

17.4 Attachment 4 – Target Compounds and DMCs with Corresponding Internal Standards for Quantitation

17.5 Attachment 5 – DMCs and the Associated Target Compounds

17.6 Attachment 6 – GC/MS Volatile Run Log Example

Attachment 1

Volatiles Target Compound List (TCL) and
Contract Required Quantitation Limits (CQRLs)

Target Compound	Low Water µg/L	Medium Soil µg/Kg
Dichlorodifluoromethane	5.0	250
Chloromethane	5.0	250
Vinyl chloride	5.0	250
Bromomethane	5.0	250
Chloroethane	5.0	250
Trichlorofluoromethane	5.0	250
1,1-Dichloroethene	5.0	250
1,1,2-Trichloro-1,2,2-trifluoroethane	5.0	250
Acetone	10	500
Carbon disulfide	5.0	250
Methyl acetate	5.0	250
Methylene chloride	5.0	250
trans-1,2-Dichloroethene	5.0	250
Methyl tert-butyl ether	5.0	250
1,1-Dichloroethane	5.0	250
cis-1,2-Dichloroethene	5.0	250
2-Butanone	10	500
Bromochloromethane	5.0	250
Chloroform	5.0	250
1,1,1-Trichloroethane	5.0	250
Cyclohexane	5.0	250
Carbon tetrachloride	5.0	250
Benzene	5.0	250
1,2-Dichloroethane	5.0	250
1,4-Dioxane	100	5000
Trichloroethene	5.0	250
Methylcyclohexane	5.0	250
1,2-Dichloropropane	5.0	250
Bromodichloromethane	5.0	250
cis-1,3-Dichloropropene	5.0	250
4-Methyl-2-pentanone	10	500
Toluene	5.0	250

Attachment 1 (Continued)

Volatiles Target Compound List (TCL) and
Contract Required Quantitation Limits (CQRLs)

Target Compound	Low Water µg/L	Medium Soil µg/Kg
trans-1,3-Dichloropropene	5.0	250
1,1,2-Trichloroethane	5.0	250
Tetrachloroethene	5.0	250
2-Hexanone	10	500
Dibromochloromethane	5.0	500
1,2-Dibromoethane	5.0	250
Chlorobenzene	5.0	250
Ethylbenzene	5.0	250
o-Xylene	5.0	250
m-, p-Xylene	5.0	250
Styrene	5.0	250
Bromoform	5.0	250
Isopropylbenzene	5.0	250
1,1,2,2-Tetrachloroethane	5.0	250
1,3-Dichlorobenzene	5.0	250
1,4-Dichlorobenzene	5.0	250
1,2-Dichlorobenzene	5.0	250
1,2-Dibromo-3-chloropropane	5.0	250
1,2,4-Trichlorobenzene	5.0	250
1,2,3-Trichlorobenzene	5.0	250

Attachment 2

Technical Acceptance Criteria for Initial and Opening Continuing Calibration Verification for Trace Volatile Organic Compounds

Volatile Compounds	Minimum RRF	Maximum % RSD[1]	Maximum % Diff[1]
Dichlorodifluoromethane	0.010	40.0	± 40.0
Chloromethane	0.010	40.0	± 40.0
Vinyl chloride	0.100	20.0	± 25.0
Bromomethane	0.100	20.0	± 25.0
Chloroethane	0.010	40.0	± 40.0
Trichlorofluoromethane	0.010	40.0	± 40.0
1,1-Dichloroethene	0.100	20.0	± 25.0
1,1,2-Trichloro-1,2,2-trifluoroethane	0.010	40.0	± 40.0
Acetone	0.010	40.0	± 40.0
Carbon disulfide	0.010	40.0	± 40.0
Methyl acetate	0.010	40.0	± 40.0
Methylene chloride	0.010	40.0	± 40.0
trans-1,2-Dichloroethene	0.010	40.0	± 40.0
Methyl tert-butyl ether	0.010	40.0	± 40.0
1,1-Dichloroethane	0.200	20.0	± 25.0
cis-1,2-Dichloroethene	0.010	40.0	± 40.0
2-Butanone	0.010	40.0	± 40.0
Bromochloromethane	0.050	20.0	± 25.0
Chloroform	0.200	20.0	± 25.0
1,1,1-Trichloroethane	0.100	20.0	± 25.0
Cyclohexane	0.010	40.0	± 40.0
Carbon tetrachloride	0.100	20.0	± 25.0
Benzene	0.400	20.0	± 25.0
1,2-Dichloroethane	0.100	20.0	± 25.0
1,4-Dioxane	0.0050	50.0	± 50.0
Trichloroethene	0.300	20.0	± 25.0
Methylcyclohexane	0.010	40.0	± 40.0

[1]For a closing CCV, all target compounds and DMCs must meet a minimum RRF of 0.010 and a maximum percent difference of ± 50.0 , except for 1,4-dioxane and 1,4-dioxane-d_8, which must meet a minimum RRF of 0.0050 and a maximum percent difference of ± 50.0.

Attachment 2 (Continued)

Technical Acceptance Criteria for Initial and Opening Continuing Calibration Verification for Trace Volatile Organic Compounds

Volatile Compounds	Minimum RRF	Maximum % RSD[1]	Maximum % Diff[1]
1,2-Dichloropropane	0.010	40.0	± 40.0
Bromodichloromethane	0.200	20.0	± 25.0
cis-1,3-Dichloropropene	0.200	20.0	± 25.0
4-Methyl-2-pentanone	0.010	40.0	± 40.0
Toluene	0.400	20.0	± 25.0
trans-1,3-Dichloropropene	0.100	20.0	± 25.0
1,1,2-Trichloroethane	0.100	20.0	± 25.0
Tetrachloroethene	0.100	20.0	± 25.0
2-Hexanone	0.010	40.0	± 40.0
Dibromochloromethane	0.100	20.0	± 25.0
1,2-Dibromoethane	0.010	40.0	± 40.0
Chlorobenzene	0.500	20.0	± 25.0
Ethylbenzene	0.100	20.0	± 25.0
o-, m-, and p-xylene	0.300	20.0	± 25.0
Styrene	0.300	20.0	± 25.0
Bromoform	0.050	20.0	± 25.0
Isopropylbenzene	0.010	40.0	± 40.0
1,1,2,2-Tetrachloroethane	0.300	20.0	± 25.0
1,3-Dichlorobenzene	0.600	20.0	± 25.0
1,4-Dichlorobenzene	0.500	20.0	± 25.0
1,2-Dichlorobenzene	0.400	20.0	± 25.0
1,2-Dibromo-3-chloropropane	0.010	40.0	± 40.0
1,2,4-Trichlorobenzene	0.200	20.0	± 25.0
1,2,3-Trichlorobenzene	0.200	20.0	± 25.0

[1]For a closing CCV, all target compounds and DMCs must meet a minimum RRF of 0.010 and a maximum percent difference of ± 50.0 , except for 1,4-dioxane and 1,4-dioxane-d_8, which must meet a minimum RRF of 0.0050 and a maximum percent difference of ± 50.0.

Attachment 2 (Continued)

Technical Acceptance Criteria for Initial and Opening Continuing Calibration Verification for Trace Volatile Organic Compounds

Deuterated Monitoring Compounds	**Minimum RRF**	**Maximum % RSD[1]**	**Maximum % Diff[1]**
Vinyl chloride-d_3	0.010	20.0	± 25.0
Chloroethane-d_5	0.010	40.0	± 40.0
1,1-Dichloroethene-d_2	0.010	20.0	± 25.0
2-Butanone-d_5	0.010	40.0	± 40.0
Chloroform-d	0.010	20.0	± 25.0
1,2-Dichloroethane-d_4	0.010	20.0	± 25.0
Benzene-d_6	0.010	20.0	± 25.0
1,2-Dichloropropane-d_6	0.010	40.0	± 40.0
Toluene-d_8	0.010	20.0	± 25.0
trans-1,3-Dichloropropene-d_4	0.010	20.0	± 25.0
2-Hexanone-d_5	0.010	40.0	± 40.0
1,4-Dioxane-d_8	0.0050	50.0	± 50.0
1,1,2,2-Tetrachloroethane-d_2	0.010	20.0	± 25.0
1,2-Dichlorobenzene-d_4	0.010	20.0	± 25.0

[1]For a closing CCV, all target compounds and DMCs must meet a minimum RRF of 0.010 and a maximum percent difference of ± 50.0 , except for 1,4-dioxane and 1,4-dioxane-d_8, which must meet a minimum RRF of 0.0050 and a maximum percent difference of ± 50.0.

Attachment 3

Target Compounds and Deuterated Monitioring Compounds Quantitation and Secondary Ions

Target Compound	Quantitation Ion	Secondary Ion(s)
Dichlorodifluoromethane	85	87
Chloromethane	50	52
Vinyl chloride	62	64
Bromomethane	94	96
Chloroethane	64	66
Trichlorofluoromethane	101	103
1,1-Dichloroethene	96	61, 63
1,1,2-Trichloro-1,2,2-trifluoroethane	101	85, 151
Acetone	43	58
Carbon disulfide	76	78
Methyl acetate	43	74
Methylene chloride	84	49, 86
trans-1,2-Dichloroethene	96	61, 98
Methyl tert-butyl ether	73	43, 57
1,1-Dichloroethane	63	65, 83
cis-1,2-Dichloroethene	96	61, 98
2-Butanone	43*	72
Chloroform	83	85
Bromochloromethane	128	49, 130, 51
1,1,1-Trichloroethane	97	99, 61
Cyclohexane	56	69, 84
Carbon tetrachloride	117	119
Benzene	78	-
1,2-Dichloroethane	62	98
1,4-Dioxane	88	43, 58
Trichloroethene	95	97, 132, 130
Methylcyclohexane	83	55, 98
1,2-Dichloropropane	63	112
Bromodichloromethane	83	85, 127
cis-1,3-Dichloropropene	75	77
4-Methyl-2-pentanone	43	58, 100
Toluene	91	92
trans-1,3-Dichloropropene	75	77
1,1,2-Trichloroethane	97	83, 85, 99, 132, 134
Tetrachloroethene	164	129, 131, 166
2-Hexanone	43	58, 57, 100
Dibromochloromethane	129	127

* m/z 43 is used for quantitation of 2-Butanone, but m/z 72 must be present for positive identification

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Attachment 3 (Continued)

Target Compounds and Deuterated Monitioring Compounds Quantitation and Secondary Ions

Target Compound	**Quantitation Ion**	**Secondary Ion(s)**
1,2-Dibromoethane	107	109, 188
Chlorobenzene	112	77, 114
Ethylbenzene	91	106
o-, m-, p-xylene	106	91
Styrene	104	78
Bromoform	173	175, 254
Isopropylbenzene	105	120, 77
1,1,2,2-Tetrachloroethane	83	85, 131
1,3-Dichlorobenzene	146	111, 148
1,4-Dichlorobenzene	146	111, 148
1,2-Dichlorobenzene	146	111, 148
1,2-Dibromo-3-chloropropane	75	157, 155
1,2,4-Trichlorobenzene	180	182, 145
1,2,3-Trichlorobenzene	180	182, 145
Deuterated Monitoring Compounds	**Quantitation Ion**	**Secondary Ion(s)**
Vinyl chloride-d_3	65	67
Chloroethane-d_5	69	71, 51
1,1-Dichloroethene-d_2	63	98, 65
2-Butanone-d_5	46	77
Chloroform-d	84	86, 47, 49
1,2-Dichloroethane-d_4	65	67, 51
Benzene-d_6	84	82, 54, 52
1,2-Dichloropropane-d_6	67	65, 46, 42
Toluene-d_8	98	100, 42
trans-1,3-Dichloropropene-d_4	79	81, 42
2-Hexanone-d_5	63	46
1,4-Dioxane-d_8	96	51, 66
1,1,2,2-Tetrachloroethane-d_2	84	86
1,2-Dichlorobenzene-d_5	152	150
Internal Standards	**Quantitation Ion**	**Secondary Ion(s)**
1,4-Dichlorobenzene-d_4	152	115, 150
1,4-Difluorobenzene	114	63, 88
Chlorobenzene-d_{-5}	117	82, 119

Attachment 4

Target Compounds and Deuterated Monitioring Compounds (DMCs) with Corresponding Internal Standards for Quantitation

1,4-Difluorobenzene (IS)	**Chlorobenzene-d_5 (IS)**	**1,4-Dichlorobenzene-d_4 (IS)**
Dichlorodifluoromethane	1,1,1-Trichloroethane	Bromoform
Chloromethane	Cyclohexane	1,3-Dichlorobenzene
Vinyl Chloride	Carbon Tetrachloride	1,4-Dichlorobenzene
Bromomethane	Benzene	1,2-Dichlorobenzene
Chloroethane	Trichloroethene	1,2-Dibromo-3-chloropropane
Trichlorofluoromethane	Methylcyclohexane	1,2,4-Trichlorobenzene
1,1-Dichloroethene	1,2-Dichloropropane	1,2,3-Trichlorobenzene
1,1,2-Trichloro-1,2,2-trifluoroethane	Bromodichloromethane	1,2-Dichlorobenzene-d_4 (DMC)
Acetone	cis-1,3-Dichloropropene	
Carbon Disulfide	4-Methyl-2-pentanone	
Methyl Acetate	Toluene	
Bromochloromethane	trans-1,3-Dichloropropene	
Methylene Chloride	1,1,2-Trichloroethane	
trans-1,2-Dichloroethene	Tetrachloroethene	
Methyl tert-Butyl Ether	2-Hexanone	
1,1-Dichloroethane	Dibromochloromethane	
cis-1,2-Dichloroethene	1,2-Dibromoethane	
2-Butanone	Chlorobenzene	
Chloroform	Ethylbenzene	
1,2-Dichloroethane	m- and p- Xylenes	
1,4-Dioxane	o-Xylene	
Vinyl chloride-d_3 (DMC)	Styrene	
Chloroethane-d_2 (DMC)	Isopropylbenzene	
1,1-Dichloroethene-d_2 (DMC)	1,1,2,2-Tetrachloroethane	
2-Butanone-d_5 (DMC)	Benzene-d_6 (DMC)	
Chloroform-d	1,2-Dichloropropane-d_6 (DMC)	
1,2-Dichloroethane-d_4 (DMC)	trans-1,3-Dichloropropene-d_4 (DMC)	
1,4-Dioxane-d_8 (DMC)	Toluene-d_8 (DMC)	
	2-Hexanone-d_5 (DMC)	
	1,1,2,2-Tetrachloroethane-d_2 (DMC)	

Attachment 5
Deuterated Monitoring Compounds and the Associated Target Compounds

Chloroethane-d_5 (DMC)	**1,2-Dichloropropane-d_6 (DMC)**	**1,2-Dichlorobenzene-d_4 (DMC)**
Dichlorodifluoromethane	Cyclohexane	Chlorobenzene
Chloromethane	Methylcyclohexane	1,3-Dichlorobenzene
Bromomethane	1,2-Dichloropropane	1,4-Dichlorobenzene
Chloroethane	Bromodichloromethane	1,2-Dichlorobenzene
Carbon disulfide		1,2,4-Trichlorobenzene
		1,2,3-Trichlorobenzene
1, 4-Dioxane-d_8 (DMC)	**trans-1, 3-Dichloropropene-d_4 (DMC)**	**Chloroform-d (DMC)**
1,4-Dioxane	cis-1,3-Dichloropropene	1,1-Dichloroethane
	trans-1,3-Dichloropropene	Bromochloromethane
	1,1,2-Trichloroethane	Chloroform
		Dibromochloromethane
		Bromoform
2-Butanone-d_8 (DMC)	**1, 1-Dichloroethene-d_2 (DMC)**	**2-Hexanone-d_5 (DMC)**
Acetone	trans-1,2-Dichloroethene	4-Methyl-2-pentanone
2-Butanone	cis-1,3-Dichloroethene	2-Hexanone
Vinyl Chloride-d_3 (DMC)	**Benzene-d_6 (DMC)**	**1,1,2,2-Tetrachloroethane-d_2**
Vinyl chloride	Benzene	1,1,2,2-Tetrachloroethane
		1,2-Dibromo-3-chloropropane
1,2-Dichloroethane-d_4 (DMC)		**Toluene-d_8 (DMC)**
Trichlorofluoromethane		Trichloroethene
1,1-Dichloroethene		Toluene
1,1,2-Trichloro-1,2,2-trifluoroethane		Tetrachloroethene
Methyl acetate		Ethylbenzene
Methylene chloride		o-Xylene
Methyl-tert-butyl ether		m, p-Xylene
1,1,1-Trichloroethane		Styrene
Carbon tetrachloride		Isopropylbenzene
1,2-Dibromoethane		
1,2-Dichloroethane		

Attachment 6

COMPUCHEM a division of Liberty Analytical Corp DATE ___/___/___ INITIAL TIME OF TUNE_____ SHIFT/S(A)_____(B)_____(C)_____
GC/MS VOLATILE RUN LOG TIME TUNE EXPIRES_____ LINKER /METHOD_____
COMPUCHEM LOGBOOK 11 X 24 (f50052)

PREVENTIVE MAINTENANCE_____

		FILE NAME		pH	Vial	DATE	TIME	Client ID	SDG#	INJ. VOL.*	DF+	CHEMIST	COMMENTS(ETC.)/ DISPOSITION
1						/ /							
2						/ /							
3						/ /							
4						/ /							
5						/ /							
6						/ /							
7						/ /							
8						/ /							
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23						/ /							
24						/ /							

*On-column sample aliquot
+Not applicable to soil matrix

SUPERVISOR APPROVAL_____ Date_____

Tune (ID #7008) Lot No. _____

Calibration Group Code / Lot No. _____

The presence of the Chemist's/Analyst's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist/analyst together with the chemist's/analyst's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

10/26/05:jad

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Cary, NC 27513

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SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire block below (except effective date).

This is a new procedure _____ revised procedure _____ outdated procedure (archive) _____

- Procedure Code: IP 1403 SOP Section #: 1.2.3.5 Revision #: 1

SOP Title: GC/MS Analysis of Low Level Solids for Volatile Organic Compounds Using USEPA SOW SOM01.1

Effective date: (QA fills in) 7/20/06

- Procedure prepared by: Respass Date: 7/20/06
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) Bob McGinnis Date: 7-20-06
- Reason for change: Revisions requested by NT DEP
- This procedure meets the requirements of the following approved method references: USEPA CLP SOW for Organic Analysis, Multi-Media, Multi-Concentration "SOM01.1

Procedure approved by Quality Assurance Representative: **(Not needed if signed above)** Date:

Effective 1-1-96, on an annual basis: Lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary, indicate by your signature that the SOP has been reviewed.

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Instrument Procedure 1403: GC/MS Analysis of Low Level Solids for Volatile Organic Compounds using USEPA SOW SOM01.**1**

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Instrument Procedure 1403: GC/MS Analysis of Low Level Solids for Volatile Organic Compounds using USEPA SOW SOM01.**1**

1.0 Scope and Application

The method described is designed to analyze soil/sediment samples from hazardous waste sites for the volatile organic compounds listed in Attachment 1 **and** is based on a gas chromatograph/mass spectrometer (GC/MS) method for closed-system purge and trap for low-level soil samples.

Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

2.0 Summary of Method

Low Level Soil/Sediment

A pre-weighed, septum-sealed, screw-top vial containing 5 grams of sample, 10 mL of reagent water and a stirring bar is placed in the autosampler carousel. Before analysis, internal standard and DMC solution are added without opening the vial. The vial is heated to a suggested temperature of 40° C and purged causing the purgeable volatile organic compounds to be transferred from the aqueous phase to the vapor phase. The vapor is swept onto a sorbent column where the purgeable volatile organic compounds are trapped.

After purging is completed, the sorbent column is heated and back flushed with the inert gas to desorb the purgeable volatile organic compounds onto a gas chromatograph wide-bore capillary column. The gas chromatograph is temperature programmed to separate the purgeable volatile organic compounds that are then detected by a mass spectrometer.

Under limited situations, sodium bisulfate preservative may be used.

3.0 Definitions

3.1 Method detection limit (MDL) – The minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration

is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR, Part 136, Appendix B.)

3.2 Reporting Limit – The reporting limit for CLP is the Contract Required Quantitation Limit (CRQL)

3.3 Reporting Units – µg/Kg

3.4 A sample delivery group (SDG) is defined by the following, whichever is more frequent:

- each 20 field samples received within a case, or
- each 7 calendar day period (3 calendar day period for 7 day turnaround) during which field samples in a case are received beginning with the receipt of the first sample.

3.5 Analytical range – The range of concentrations that comprise the initial calibration (i.e.**,** 5 to 200 µ/L for non-ketone compounds). Samples containing target analyte(s) above the analytical range must be diluted, or a lesser amount of sample analyzed, in order to bring the concentration to within the upper half of the analytical range. The upper half of the analytical range is defined as the concentration between the midpoint standard and the high standard.

3.6 BFB - Bromofluorobenzene

3.7 EICP - Extracted Ion Current Profile

3.8 VOA – Volatile Organic Analysis

4.0 Interferences

4.1 Impurities in the purge gas or methanol, organic compounds out gassing from the plumbing ahead of the trap, and solvent vapors in the laboratory account for the majority of contamination problems. Gas lines from the gas tanks to the instrument must be either stainless steel or copper tubing. Non-polytetrafluoroethylene (PTFE) thread sealants, or flow controllers with rubber components are not to be used. When potential interfering peaks are noted in laboratory method blanks, it may be necessary to reduce solvent contamination in the laboratory, purge the methanol used to prepare standard solutions, purge the reagent water with helium or nitrogen, change the purge gas source, or regenerate the molecular sieve purge gas filter.

4.2 Samples can be contaminated by diffusion of purgeable organics (particularly methylene chloride, fluorocarbons, and other common laboratory solvents) through the septum seal into the sample during storage and handling. Therefore, these samples are stored in GC/MS VOA laboratory refrigerator separate from laboratory standards, and they must be analyzed in a room whose atmosphere is demonstrated to be free of all potential contaminants that will interfere with the analysis.

4.3 Laboratory clothing worn by analysts must be **devoid** of solvents because clothing previously exposed to methylene chloride and other laboratory solvent fumes during common liquid/liquid extraction procedures can contribute to sample contamination.

4.4 Contamination by carryover can occur whenever a sample is analyzed after a sample that contains high levels of organic compounds. Whenever an unusually concentrated sample is encountered, the next sample must be closely monitored to check for cross-contamination. **Additionally, an instrument blank is required to be run after a sample analysis in which target compounds are detected above the initial calibration range.** The trap and other parts of the system are also subject to contamination; therefore, frequent bake out and purging of the entire system **are** required.

4.5 Method interferences caused by contaminants in solvents, reagents, glassware, purge gas, sorbents, laboratory air, and other sample storage and processing hardware that lead to discrete artifacts and/or elevated baselines in gas chromatograms must be eliminated. The chromatographic system must be inspected for malfunctions and corrections must be made as required before more samples are analyzed.

4.6 Instrument problems/preventative maintenance

4.6.1 If a low response is observed for the early eluting compounds, such as the gases, replacement of the trap or septum may be necessary. In addition, adjustments to the purge flow may be necessary to achieve a desired response for these compounds. If such adjustments do not help, it may be necessary to check the fittings on the purge and trap device and on the column for leaks. This is done with a helium leak detector and certain software utility programs.

4.6.2 Column maintenance or replacement may be necessary if peak tailing or broad chromatographic peaks are observed.

5.0 Safety

5.1 Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous. During sample preparation, glasses, gloves and lab coats are a minimum requirement. The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

5.2 Laboratory staff are **required** to review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets (MSDS) for solvents and reagents used in the laboratory. The MSDS are located in the Quality Assurance department.

5.3 The toxicity and carcinogenicity of many chemicals used in this method have not been precisely determined. Each chemical should be treated as a potential health hazard. Exposure to these chemicals should be minimized. Preparation of calibration standards, blanks, and samples is performed in a fume hood to minimize risk.

5.4 The following method analytes have been tentatively classified as known or suspected human or mammalian carcinogens: benzene, carbon tetrachloride, chloroform, and vinyl chloride, and 1,4-dioxane.

6.0 Equipment & Supplies

6.1 **Hamilton micro syringes**

6.1.1 **10 µL**

6.1.2 **25 µL**

6.1.3 **50** µL

6.1.3 100 µL

6.2 SGE International gastight syringes

6.2.1 1 mL

6.2.2 5 mL

6.2.3 10 mL

6.2.4 25 mL

6.**3** Analytical column**s**

6.**3.1** Restek RTX-624, 60 M, 0.32 mm ID, 1.8 µm film thickness**, used in instruments 73 (HP5972 MSD) and 90 (HP5973 MSD)**

6.**3.2** Supelco SPB-624, 60 M, 0.32 mm ID, 1.4 µm film thickness**, used in instrument 71 (HP5972 MSD)**

6.**4** Gas Chromatograph (GC)

6.**4**.1 Varian 3400

6.**4**.2 Hewlett Packard 5890 Series

6.**4**.3 Hewlett Packard 6890 Series

6.**5** Mass Spectrometer

6.**5.1** Hewlett Packard 5972 Mass Selective Detector (MSD)

6.**5.2** Hewlett Packard 5973 MSD

6.**6** Interface (GC to mass spectrometer)

6.**6**.1 **Direct capillary insertion**

6.**7** Data System

6.**7**.1 For data acquisition, the INCOS500 GC/MS systems use the ProLab Resources system, with EnviroLink software. The Hewlett Packard GC/MS systems utilize ChemServer software.

6.**7**.2 For data processing, the laboratory uses the Hewlett Packard HP 9000 series 735 Unix Workstation employing HP ChemServer with Target3 and Envision software by Thru-Put Systems.

6.7.3 The reference library used is the NBS 129K.1 version.

6.**8** Data storage

6.8.1 Data is stored on the Target3 Unix Workstation. The Workstation is backed up incrementally on a daily basis and weekly to the lab's data servers.

6.**9** Purge and trap

6.**9**.1 Archon Model 5100, 4552 purge and trap autosampler, interfaced with a Tekmar 3000 sample concentrator, with a Supelco K trap or equivalent.

6.9.1.1 The Supelco K (VOCARB 3000) trap consists of the following:

- **Carbopack B, 10 cm**
- **Carboxen-1000, 6 cm**
- **Carboxen-1001, 1 cm**

6.9.2 Tekmar/Dohrmann Solatek 72 Multi-Matrix Vial Autosampler interfaced with a Tekmar/Dohrmann 3100 Sample Concentrator

6.**10** pH paper

6.**10**.1 Wide range, capable of measuring pH 0-14

6.**11** **Analytical** Balance

6.**11**.1 **Sartorius basic balance (B410)** capable of accurately weighing plus or minus 0.01 grams.

6.11.2 The balance **is checked** with known reference weights **on each day of use. These weights are checked once per year at a NVLAP accredited laboratory.**

6.11.3 The balance **is** c**alibrated twice** per year by a**n outside, certified source with NIST traceable weights**.

6.**12** Glass vials - 40 mL, screw-cap, PTFE-lined, septum-sealed

7.0 Reagents and standards

Reference standards are purchased as certified pure materials and concentrated solutions. Stock and working standard solutions are prepared by the analysts performing the analyses.

7.1 Reagent water – All water used **during preparation must be reagent-grade Type I with regard to resistivity of > 10 megohm-cm (19th and 20th Editions of Standard Methods, Method 1080), which is subsequently purged with the inert gas, nitrogen, and demonstrated to meet the blank contamination acceptance criteria contained in this Standard Operating Procedure (SOP). It is referred to throughout the remainder of this SOP as reagent water.**

7.2 Methanol, purge and trap grade

7.2.1 In some cases, sodium bisulfate (2 g reagent grade/5 mL water is used as a preservative.

7.3 Blank Sand - Standard Ottawa sand 20 - 30 mesh purchased from Unimim

7.**4** Tuning standard

7.4.1 Bromofluorobenzene (BFB)**, Restek, 99% purity**

7.4.1.1 Standard ID# 7008, Standard Preparation SOP 7.2.1.4, at 25 µg/mL in methanol.

7.4.1.2 Prepare fresh BFB solution every six months or sooner if degradation or evaporation occurs.

7.**5** Calibration Standards

7.5.1 Prepare five initial calibration standards containing all target compounds and DMC**s at** the following concentrations **in 10 mL of reagent water**:

7.5.1.1 All non-ketone target compounds and DMC**s** are at 5, 10, 50, 100 and 200 µg/L; all ketones and their DMC**s** are at 10, 20, 100, 200, and 400 µg/L; 1, 4-dioxane and its DMC are at 100, 200, 1250, 2000, and 4000 µg/L. The concentrations of the m, p-xylene isomers must total 5.0, 10, 50, 100, and 200 µg/L.

7.**5**.2 The opening and closing continuing calibration standards are prepared at or near the mid-point of the calibration range. **Prepare at the following concentrations in 10 mL of reagent water:**

7.**5**.2.1 50 µg/L for non-ketones **and DMCs**, 100 µg/L for ketones, **and** 1250 µg/L for 1,4-dioxane and 1,4-dioxane-d_8.

7.**5**.**3** **Prepare intermediate standards in volumetric flasks. Prepare working standards in volumetric flasks or gastight syringes, depending on the volume needed.**

7.**5**.**4** Prepare a fresh calibration standard solution monthly, or sooner if the solution has degraded or evaporated.

7.**6** Internal Standard Solution

7.**6**.1 The internal standard solution consists of 1,4-difluorobenzene, chlorobenzene-d_5, and 1,4-dichlorobenzene-d_4.

7.**6**.2 Add a sufficient amount of internal standard to each calibration standard, blank, and sample including duplicate matrix spikes to result in 0.25 µg of each internal standard.

7.**6**.3 Prepare a fresh internal standard solution monthly, or sooner if the solution has degraded or evaporated.

7.**7** DMC Standard solution

7.**7**.1 **Prepare a** DMC standard solution **consisting of** vinyl chloride-d_3, chloroethane-d_5, 1,1-dichloroethene-d_2, chloroform-d, 1,2-dichloroethane-d_4, benzene-d_6, 1,2-dichloropropane-d_6, toluene-d_8, trans-1,3-dichloropropene-d_4, **1,1,2,2-tetrachlorothane-d_2,** and 1,2-dichlorobenzene-d_4, **at 1000 µg/mL; 2-hexanone-d_5, 2-butanone-d_5 at 5000 µg/mL; and 1,4-dioxane-d_8 at 12,000 µg/mL.**

7.**7**.2 Add a sufficient amount of DMC to each calibration standard, blank and sample including duplicate matrix spikes to result in 0.25 µg of each non-ketone DMC, 0.50 µg for each ketone DMC, and 6.25 µg for 1,4-dioxane-d_8.

7.**7**.3 Prepare a fresh DMC standard solution monthly, or sooner if the solution has degraded or evaporated.

7.**8** Matrix Spiking Solution

7.**8**.1 **Prepare a** matrix spiking solution consist**ing** of 1,1-dichloroethene, trichloroethene, chlorobenzene, toluene, and benzene at 5**0** µg/mL.

7.**8**.2 Prepare a fresh matrix spiking solution monthly, or sooner if the solution has degraded or evaporated.

7.9 Storage of standards

7.9.1 Store the stock standards in Teflon® sealed, screw-cap bottles with zero headspace at –10° C to –20° C. Protect the standards from light.

7.10 Standard Storage Records

7.10.1 All temperature records must be recorded daily following the procedures in QC SOP 13.15, "Documenting Refrigerator and Freezer Temperatures".

7.10.2 Corrective action SOPs **are** posted on the refrigerators/freezers.

8.0 Sample Preservation, Storage, and Holding Time

8.1 Samples are preserved and stored according to the tables in Sample Control SOP 4.1, "Receiving Samples" and 4.6, "Storing Samples." Sample holding times are also listed.

8.2 Analysis of soil sediment samples must be must be completed within 10 days of validated time of sample receipt (VTSR). Analysis of unpreserved, unfrozen soil sediment samples must be completed within 24 hours of VTSR. These holding time requirements do not apply to performance evaluation (PE) samples.

8.3 Sodium bisulfate preserved low-level soil samples and aqueous storage blanks must be protected from light and stored at 4° C (± 2° C) in a VOA only storage unit.

8.4 Unpreserved low-level soil samples and inert sand storage blanks must be protected from light and stored at less than -7 ° C in a VOA only storage unit.

8.5 Soil samples received in pre-prepared closed-system purge-and-trap sample vials or pre-weighed VOA vials are stored on their side at less than -7 ° C.

9.0 Quality Control

9.1 DMC

9.1.1 All samples, blanks and standards are fortified with DMC that are used to monitor performance of the entire purge and trap/GC/MS system.

9.1.2 The table below contains DMC recovery criteria for low-level soil analyses.

DMC	Percent Recovery for Soil Samples
Vinyl chloride-d_3	68-122
Chloroethane-d_5	61-130
1,1-Dichloroethene-d_2	45-132
2-Butanone-d_5	20-182
Chloroform-d	72-123
1,2-Dichloroethane-d_4	79-122
Benzene-d_6	80-121
1,2-Dichloropropane-d_6	74-124
Toluene-d_8	78-121
Trans –1,3-Dichloropropene-d_4	72-130
2-Hexanone-d_5	17-184
1,4-Dioxane-d_8	50-150
1,1,2,2-Tetrachloroethane-d_2	56-161
1,2-Dichlorobenzene-d_4	70-131

9.2 Internal Standards

9.2.1 **Add internal** standard compounds to every standard, blank and sample at a known concentration prior to analysis. Internal standards are used as the basis for quantitation of the DMC and target compounds.

9.2.2.1 The EICP area of each of the internal standards in the blanks and samples (including duplicate matrix spikes) must be in the range of 50% to 200% of its response in the most recent opening continuing calibration verification (CCV) standard.

9.2.2.2 The retention time (RT) shift of each internal standard in the blanks and samples (including duplicate matrix spikes) must be within ± 0.50 minutes (30 seconds) of its RT in the most recent opening CCV standard.

9.2.2.3 If internal standard area response and retention time shift criteria are not met, corrective action **is** taken. **A**ctions such as checking calculations and checking solutions for degradation **are** performed. Sample analyses not meeting internal standard criteria must be reanalyzed.

9.3 Blanks

All blanks must be analyzed on a GC/MS system meeting the BFB, initial calibration, and opening CCV acceptance criteria.

9.3.1 Method blank

9.3.1.1 Before any samples are analyzed, it must be demonstrated that a laboratory method blank is free from contamination that would prevent the determination of any analyte of concern. Background contamination must be reduced to an acceptable level before proceeding with the next analysis.

9.3.1.**2 Prepare t**he method blank using **Ottawa** sand and **carry it** through the entire analytical process.

9.3.1.2.1 Prepare the sand for use by pouring it into a beaker and baking it for 3 hours at 120° C. Store prepared sand in a dissecator until needed.

9.3.1.3 Analyze the method blank immediately after the opening CCV and before any field samples (including duplicate matrix spikes).

9.3.1.4 The percent recovery of each of the DMC in the blank must meet the criteria listed in 9.1.2. The recovery for 1,4-dioxane is advisory.

9.3.1.5 The method blank must meet the internal standard acceptance criteria listed in 9.2.1.

9.3.1.6 The concentration of each target compound found in the method blank must be less than the CRQL listed in Attachment 1, except methylene chloride, acetone, and 2-butanone which must be less than 2 times the CRQL.

9.3.2 Storage blanks

9.3.2.1 **Two vials of reagent water are stored with preserved water** samples **at 4° C ± 2°C** an**d** two vials **containing** clean **Ottawa** sand are stored with **soil** samples **being stored at < - 7° C**.

9.3.2.**2** The storage blank indicates whether contamination may have occurred during storage of samples. The storage blank is analyzed once per SDG.

9.3.2.3 The storage blank is analyzed after all samples in a SDG have been analyzed.

9.3.2.4 The storage blank must meet all method blank acceptance criteria.

9.3.2.5 If the storage blank does not meet the blank contamination criteria, reanalyze the storage blank to determine whether contamination occurred during analysis or during storage. If the results of the reanalysis do not meet blank contamination acceptance criteria, contamination occurred during storage. These results must be noted so that they can be discussed in the SDG narrative.

9.3.3 Instrument blanks

9.3.3.**1** The results from the instrument blank analysis indicate whether there is contamination from a previous sample.

9.3.3.2 Analyze instrument blanks after a sample analysis containing target compounds at concentrations that exceed the instruments analytical range.

9.3.3.3 The concentration of each target analyte in the instrument blank must be less than CRQL in order to resume sample analysis.

9.4 Duplicate Matrix Spikes

9.4.1 **Analyze d**uplicate matrix spikes on a GC/MS system meeting the BFB, initial calibration, opening CCV, and method blank acceptance criteria.

9.4.2 **Analyze d**uplicate matrix spikes (if requested by the **client**) for each group of 20 field samples in a SDG or for each SDG, which ever is most frequent.

9.4.3 Duplicate matrix spikes must meet the internal standard acceptance criteria in 9.2.1.

9.4.4 The table below contains the spike recovery and relative percent difference (RPD) criteria for duplicate matrix spikes. These limits are advisory and no further action by the laboratory is required. However,

frequent recovery and RPD failures **must be investigated** by the laboratory.

Spike Compounds	Percent Recovery Soil	RPD Soil
1,1-Dichloroethene	59-172	0-22
Trichloroethene	62-137	0-24
Benzene	66-142	0-21
Toluene	59-139	0-21
Chlorobenzene	60-133	0-21

9.**5** Samples

9.**5**.1 **Analyze a**ll samples on a GC/MS system meeting the BFB, initial calibration, opening CCV, and method blank acceptance criteria.

9.**5**.2 **Analyze s**amples within the contractual holding time.

9.**5**.3 Three DMC may fail the criteria in 9.1.2, excluding 1,4-dioxane-d_8. The recovery for 1,4-dioxane-d_8 is advisory.

9.**5**.4 The area responses of the internal standards must be within 50 to 200% of their respective area responses in the opening CCV.

9.**5**.5 The RT shift of each of the internal standards in the sample the must be less than 30 seconds from the corresponding internal standard in the most recent opening CCV .

9.**5**.6 If target compound concentrations exceed the instrument's analytical range, the sample must be prepared **and analyzed by the medium-level method**.

9.6 Contingency

9.6.1 If, due to a lab accident or to QC failure, a re-preparation is required for the sample and insufficient volume remains, the Project Manager must be alerted and will contact the client for direction on how to proceed. For the CLP, the Sample Management Office must be contacted.

9.6.2 If persistent contamination occurs in the laboratory, analyses must be halted until the source can be identified and isolated. When the contamination issue is resolved, sample analyses may proceed.

9.6.3 Any other issues that potentially affect data quality should be addressed with the Project Manager.

10.0 Calibration & Standardization

10.1 BFB

10.1.1 **Tune the GC/MS system using** perfluoro-tri-n-butylamine (FC-43).

10.1.2 **Perform t**he analysis of the instrument performance check solution by injecting 50 ηg of BFB (2 µL of Std ID#7008) into the GC using a 10 µL Hamilton syringe.

10.1.3 **Acquire** BFB by averaging three scans. The scan immediately prior to the apex, the apex scan, and the scan immediately following the apex are averaged. Background subtraction is also required and must be accomplished by subtraction of a single scan no more than 20 scans prior to the elution of BFB. Do not subtract part of the BFB peak.

10.1.5 The analysis of the instrument performance check solution must meet the ion abundance criteria given in the table below.

BFB Key Ions and Ion Abundance Criteria

Key Ions	Ion Abundance Criteria
50	15.0 – 40.0% of **m**/**z** 95
75	30.0 – 80.0% of **m**/**z** 95
95	Base Peak; 100% relative abundance
96	5.0 – 9.0% of **m**/**z** 95
173	< 2.0% of **m**/**z** 174
174	50.0 – 120% of **m**/**z** 95
175	5.0 – 9.0% of **m**/**z** 174
176	95.0 – 101% of **m**/**z** 174
177	5.0 – 9.0% of **m**/**z** 176

Note: All ion abundances must be normalized to **m**/**z** 95, even though ion **m**/**z** 174 may be up to 120% of **m**/**z** 95.

10.1.6 If BFB technical acceptance criteria are not met, retune the GC/MS system. **If needed,** clean the ion source, clean the **quadrople** rods, or take other corrective action to achieve the technical acceptance criteria.

10.1.7 BFB technical acceptance criteria must be met before any standards, samples, or blanks are analyzed.

10.2 Initial calibration

10.2.1 Prior to the analysis of samples and blanks, and after the instrument performance check solution (BFB) criteria have been met, each GC/MS system must be calibrated at five concentrations (see 7.**5**.1.1) to demonstrate sensitivity and the linearity of the GC/MS response for the target compounds.

10.2.2 **Analyze a**ll initial calibration standards at the concentration**s stated in Section 7.5** on a GC/MS system meeting the BFB technical acceptance criteria.

10.2.2.1 If time remains in the 12-hour time period after meeting the technical acceptance criteria for the initial calibration, samples may be analyzed. It is not necessary to analyze an opening CCV.

10.2.2.2 A method blank is required. Quantify all blank and sample internal standard area response change and RT shift, against the med-level initial calibration standard.

10.2.3 **Perform a**n initial calibration when the continuing calibration criteria cannot be met or whenever a column is changed or an ion source **is** cleaned.

10.2.4 Excluding those ions in the solvent front, no ion may saturate the detector.

10.2.5 **Tabulate t**he area response of the characteristic ions in the EICP against the concentration for each compound and internal standard and **calculate the** relative response factors (RRF) for each compound.

10.2.6 The RRF at each calibration concentration for each DMC and target compound must be greater than o**r** equal to the compounds minimum RRF listed in Attachment 2.

10.2.7 The percent relative standard deviation (%RSD) for each DMC and target compound must be less than or equal to that listed in Attachment 2.

10.2.9 Up to two compounds may fail to meet minimum RRF criteria and up to two compounds may fail maximum %RSD criteria. However, none may fail with more than 40.0% RSD and none may have an RRF less than 0.010.

10.2.9.1 The exceptions are 1,4-dioxane and 1,4-dioxane-d_8, which must have a minimum RRF of ≥ 0.005 and a maximum % RSD of ≤ 50.0.

10.2.10 If the initial calibration technical acceptance criteria are not met, inspect the system for problems. **If required,** clean the ion source, perform column maintenance, change the column, service the purge and trap device, or take other corrective action**s** to achieve the technical acceptance criteria.

10.2.11 Initial calibration technical acceptance criteria must be met before any samples or blanks are analyzed.

10.3 Opening and Closing Continuing Calibration Verification (CCV)

10.3.1 The CCV standards are at a concentration at or near the mid point of the initial calibration.

10.3.2 A check of the calibration of the GC/MC system must be performed once every 12 hours by the injection of BFB and the opening CCV standard.

10.3.2.1 The RRF percent difference (%D) for each DMC and target compound must be less than or equal to the maximum %D listed in Attachment 2.

10.3.2.2 The RRF for each DMC and target compound must be greater than or equal to the minimum RRF listed in Attachment 2.

10.3.2.3 Up to two compounds may fail the criteria in 10.3.2.1 and 10.3.2.2, however, these compounds must meet a minimum RRF of ≥ 0.01 and a maximum %D of ± 40.0. The exceptions are 1,4-dioxane and 1,4-dioxane-d8, which must have a minimum RRF of ≥ 0.005 and a maximum %D of ± 50.0.

10.3.3 Opening CCV acceptance criteria must be met before any samples, including duplicate matrix spikes, or blanks are analyzed. If the acceptance criteria are not met, recalibrate the GC/MS by performing another initial calibration. This may require some corrective action first.

10.3.4 After all the samples are analyzed, and before the end of the twelve-hour time period, the closing CCV standard must be analyzed.

10.3.4.1 The RRF %D for each target compound must be ± 50.

10.3.4.2 The RRF for each DMC and target compound must be ≥ 0.01, except 1,4-dioxane and 1,4-dioxane-d_8, which must meet a minimum RRF of .0050.

10.3.4.3 If the closing CCV meets the acceptance criteria for the opening CCV, sample analysis may continue without the analysis of BFB. The twelve hour time period begins at the injection time of the closing CCV.

10.3.5 Closing CCV acceptance criteria must be met or all samples analyzed within the twelve hour time period must be reanalyzed.

11.0 Procedure

Documentation must follow the requirements in QC SOP: Proper Documentation Procedures. Record all instrument information in the GC/MS VOA Run Log (Attachment 3).

11.1 Instrument Performance Check

11.1.1 Perform an instrument performance check by analyzing 50 ηg of BFB. The BFB may be directly injected onto the GC column or purged in reagent water or a calibration standard.

11.1.2 If BFB acceptance criteria are met, print the BFB mass spectrum, mass listing, and reconstructed ion chromatograph (RIC).

11.2 Initial Calibration Analysis

11.2.1 Prepare the five low-level soil initial calibration standards **(See Section 7.5)** by adding calibration standard, DMC, and internal standard solutions to 10 mL of reagent water in a **40 mL** VOA vial and place vial on the purge-and-trap autosampler. **P**urge at approximately 40° C.

11.2.2 Analyze the initial calibration standards at the concentration listed in 7.**5**.1.1.

11.2.3 Process and review each standard analysis using the Target3 data system insuring that each DMC and target compound is present in each standard.

11.2.4 Check that the initial calibration met acceptance criteria by reviewing the initial calibration summary form on the Target3 data system.

11.2.5 If acceptance criteria are met, print the initial calibration summary form. Also print the RIC, quantitation report, and EICP for each calibration standard used.

11.2.6 If time remains in the twelve hour period after the initial calibration has been analyzed, samples may be analyzed without the analysis of an opening CCV.

11.2.7 If no samples are analyzed, complete the GC/MS run log. (Attachment 3) "Z" out any unused portion of the run log and have a supervisor or designee to review and sign it. Make a photocopy of the run log and attach it to the hard copy data for the BFB and initial calibration analysis.

11.3 Opening CCV

11.3.1 After the BFB and the initial calibration have met acceptance criteria**. Check** the calibration by analyzing the opening CCV standard.

11.3.2 Process and review the opening CCV using Target3 processing software insuring that each target compound is present in the analysis

11.3.3 Check that the CCV met acceptance criteria, by reviewing the continuing calibration summary form on the Target3 data system.

11.3.4 If opening CCV acceptance criteria are met print the continuing calibration summary form, RIC, quantitation report and EICP.

11.4 Method Blank Analysis

11.4.1 After BFB, initial calibration, and opening CCV acceptance criteria are met, **analyze** the method blank.

11.4.2 **Analyze t**he method blank before any samples.

11.4.3 Prepare the low-level soil method blank is by adding 10 mL of reagent water to 5 g **Ottawa** sand in a 40 mL VOA vial. Add internal standard and DMC solutions prior to purging.

11.4.4 Process and review the method blank. **Analyze samples a**fter the method blank meets acceptance criteria samples.

11.5 Instrument Blank Analysis

11.5.1 **Prepare i**nstrument blanks by adding internal standard and DMC solutions to 10 mL of reagent water in a 40 mL VOA vial.

11.5.2 **Analyze i**nstrument blanks after samples containing target analytes that exceed the initial calibration range.

11.5.3 Process and review each instrument blank. **Resume s**ample analysis when no target compound detected is > CRQL.

11.6 Storage Blank Analysis

11.6.1 Prepare storage blanks in the same manner as an instrument blank for preserved soil samples stored at 4° C (± 2° C). For soil samples stored at less than -7° C, prepare storage blanks consisting of clean Ottawa sand.

11.6.**2** Storage blanks are analyzed after all samples in the SDG have been analyzed.

11.7 Sample Preparation

11.7.1 **Transfer l**ow-level soil samples that are provided to the laboratory in core sampling/storage containers (EnCore™ or equivalent) upon receipt to pre-weighed VOA vials. **Analyze t**hese samples within 24 hours of receipt or store at less than -7 ^{o}C until time of analysis.

11.7.1.1 Allow frozen samples to equilibrate to ambient temperature. Prepare the sample for analysis by adding 10 mL of reagent water, internal and DMC solutions through the septum seal of the VOA vial. Use a small gauge needle to pierce the seal.

11.7.2 **For samples received preserved, in pre-weighed VOA vials, weigh and store at less than -7° C. Use these samples for medium level analysis, if necessary.**

11.7.3 For duplicate matrix spikes, **add** the matrix spiking solution, along with the DMC and internal standard solutions, to each sample aliquot prior to analysis.

11.8 Purge and Trap Analysis

Recommended purge and trap analyses

11.8.1 After sample preparation, **load** the purge vessel **into** the closed-system autosampler that is interfaced with the purge and trap apparatus.

11.8.2 **Heat t**he sample to approximately 40° C and purge for 11.0 (± 0.1) minutes.

11.8.3 After purging, **heat** the trap to 180° C and **back flush** its contents onto the GC column with helium for 4.0 (± 0.1) minutes (desorb).

11.8.4 After desorbing, **recondition** the trap by baking at 180° C for at least 7 minutes. When the trap has finished baking and is cool, it is ready for the next sample to be purged.

11.9 GC Analysis

Recommended GC analysis conditions.

11.9.1 After desorbing, hold the GC temperature at 10° C for 1 to 5 minutes. Ramp the GC temperature at 6° C per minute to 160° C and hold until 3 minutes after the last target compound has eluted.

11.10 Mass Spectrometer Analysis conditions

The following are the required mass spectrometer conditions:

11.10.1 Election energy: 70 volts (nominal)

11.10.2 Mass Range: 35-300 amu

11.10.3 Ionization Mode Election ionization (EI)

11.10.4 Scan Time: To give at least 5 scans per peak, not to exceed 2 seconds per scan for capillary column.

11.11 Sample Dilutions

11.11.1 If a sample concentration exceeds the concentration of the high level initial calibration standard, **prepare** a new sample and analyze by the medium-level method.

11.11.2 **Analyze t**he sample and medium-level analysis**, if required,** within the required holding time.

11.11.3 If more than one sample dilution (and the original analysis) is necessary to have all target analytes within the calibration range, contact **the client**.

11.12 Sample **Processing**

11.12.1 Process each sample.

11.12.2 Check that each sample meets internal standard response and RT criteria.

11.12.3 Check that each sample meets DMC recovery criteria.

11.12.4 Check that all target compound concentrations are with**in the** analytical range.

11.13 Closing CCV

11.13.1 **Analyze the closing CCV a**fter all samples have been analyzed and before the end of the twelve-hour period**.**

11.13.2 Process and review the closing CCV using Target3 processing software insuring that each target compound is present.

11.13.3 Check that the closing CCV met acceptance criteria, by reviewing the continuing calibration summary form on the Target3 data system.

11.13.4 If the closing CCV acceptance criteria are met, print the continuing calibration summary form, RIC, quantitation report and EICP**, and take corrective action if the CCV fails**.

11.13.5 Complete the GC/MS run log. "Z" out any unused portion of the run log and have a supervisor of designee review and sign it. Make a photocopy of the run log page and attach it to the hard copy data for the BFB and initial or continuing calibration analysis.

11.14 Qualitative Identification of Target Compounds

11.14.1 An analyst/data reviewer competent in the interpretation of mass spectra must identify the compounds listed in Attachment 1 by comparing the sample mass spectra to the standard mass spectra.

11.14.2 Identify each target compound by verifying that the compound in the sample eluted at the same GC Relative Retention Time (RRT) as the compound in the standard and that the compound's mass spectrum in the sample is comparable to the compound's mass spectrum in the standard.

11.14.2.1 The RRT of the compound in the sample must be within ± 0.06 RRT units of the RRT of the compound in the corresponding opening CCV. For samples analyzed in the same 12-hour period as the initial calibration, the sample RRT is compared to that of the 50 µg/L standard.

11.14.2.1.1 If co-elution of interfering compounds prohibits accurate assignment of the RRT of a compound in the sample from the total ion chromatograph, assign the RRT using the EICP or ions unique to the compound of interest.

11.14.2.2 Compare the mass spectra of the target compounds in the sample to those in the standard used in section 11.14.2.1.

11.14.2.2.1 All ions present in the standard mass spectrum at a relative intensity of >10% (most abundant ion in the spectrum equals 100%) must be present in the sample mass spectrum.

11.14.2.2.2 The relative intensities of the ions in the sample mass spectrum must agree within ±20% of the ions in the standard mass spectrum (e.g., for an ion with an abundance

of 50% in the standard spectrum the corresponding abundance of the ion in the sample must be between 30 and 70 %.)

11.14.2.2.3 Ions with an abundance >10% in the sample spectrum but not present in the standard spectrum must be considered and accounted for by the analyst/data reviewer making the comparison. The verification process should favor false positives. All compounds meeting the identification criteria must be reported with their spectra. Compounds meeting the identification criteria, but at concentration below the adjusted CRQL are reported as estimated concentrations (flagged with a "J").

11.14.3 If a compound cannot be verified by all of the identification criteria in section 11.14.2.2, but in the technical judgment of the analyst/data reviewer that the identification is correct, the compound is reported.

11.15 Qualitative Analysis of Non-Target Compounds

11.15.1 Tentatively identify all compounds in the sample that have not already been identified as target compounds, DMC, or internal standard compounds by performing a computer-generated library search using the NIST 129K.1 mass spectral library. The library search must not be normalized.

11.15.2 Do not report carbon dioxide, compounds with area responses <10% of the area response of the nearest internal standard, or semivolatile TCL analytes.

11.15.3 Report up to 30 tentatively identified compounds (TICs), excluding alkanes, having the greatest concentrations for each sample.

11.15.4 TICs identified as alkanes are not counted among the TICs in section 11.15.3. Alkane concentrations are summed as a single result and reported as "total alkanes".

11.15.5 Rules for making tentative identification:

11.15.5.1 TICs receiving a library search match of 85% or higher are considered a "probable match". Report the compound identified.

11.15.5.2 For TICs receiving two or more library search matches of 85% or higher, report the compound with the highest percent match.

11.15.5.3 For TICs receiving two or more library search matches of 85% or higher with the same percent match, report the first compound.

11.15.5.4 For TICs that are isomers receiving library search matches of 85% or higher, report the compound with the highest percent match.

Note: If in the opinion the experienced analyst/data reviewer there is sound technical evidence not to identify the compound as specified in sections 11.15.5.1 to 11.15.5.4 the justification must be documented in the narrative.

11.15.5.5 TICs receiving a library search match of < 85% are given a tentative identification by the analyst/data reviewer, if possible. If no identification can be made the TIC is reported as "unknown". If possible, the unknown is further identified as part of a class of compounds (for example "unknown aromatic").

11.15 Sample Quantitation

11.15.1 The concentration of each target and non-target compound is calculated using the equations is section 12.0. Concentrations are based on the dry weight of the sample which is determined using SOP 2.8.1 "Undecanted Percent Moisture Determination in Soil/Sediment/Sludge by CLP and SW-846".

12.0 Data Analysis & Calculations

Calculations must be consistent with the Q**uality** C**ontrol** SOP **13.4 "**Numerical Data Reduction**"**.

12.1 Calculation of the mean or average of a set of values:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where:

n = total number of values
x_i = each individual value used to calculate the mean
x = the mean of n

12.2 Calculation of the standard deviation of a set of values:

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n}\left(X_n - \overline{X}\right)^2}{n-1}}$$

12.3 Calculation of percent recovery:

12.3.1 Surrogates:

$$\%R = \frac{Amount\ found}{Amount\ spiked}\ x\,100$$

12.3.2 Matrix spikes:

$$\%\,R = \frac{Amount\ in\ spiked\ sample - Amount\ in\ unspiked\ (native)\ sample}{Amount\ spiked}\ x\,100$$

12.4 Calculation of % RSD

$$\%RSD = \left(\frac{Standard\ deviation}{\overline{X}}\right) \times 100$$

12.5 Calculation of RPD

$$RPD = \frac{|Value\ 1 - Value\ 2|}{(Value\ 1 + Value\ 2)/2}\ x100$$

12.6 Calculation of %Difference (%D)

$$\%Diff = \frac{Value - \overline{Reference\ \ value}}{\overline{Reference\ \ value}} \times 100$$

12.7 Calculation of Relative Response Factor (RRF)

$$RRF = \frac{Ax}{Ais} \times \frac{Cis}{Cx}$$

where:

Ax = area of the characteristic ion from the EICP for the compound to be measured
Ais = area of the characteristic ion for the EICP for the internal standard
Cis = concentration of the internal standard
Cx = concentration of the compound to be measured

12.8 Concentration of soil samples (dry weight basis) by GC/MS analysis using relative response factor:

$$\mu g / kg = \frac{(As)(Cis)(Df)}{(Ais)(\overline{RRF})(Ws)(D)}$$

where:

As = area of the characteristic ion from the EICP for the compound to be measured
Ais = area of the characteristic ion for the EICP for the internal standard
Cis = amount of internal standard injected (ng)
$\overline{RRF}$ = mean relative response factor from the initial calibration
Ws = weight of sample purged, in grams
Df = dilution factor
D = $dry\ weight = \frac{100 - \%\ moisture}{100}$

12.9 Non- target compounds are quantified by comparing the MS response from the reconstructed ion chromatogram (RIC) for the non-target compound peaks to the MS response for a peak produced by the nearest internal standard compound. A response factor of 1 is assumed.

$$TIC\ amount = \frac{[\ A(tic)\ ][\ Amt(std)\ ](\ Df\ )}{[\ A(IS)\ ][\ 1(RRF)\ ](\ Ws\ )(\ D\ )}$$

where:

A(tic) = area response from RIC for non-target compound
Amt(std) = amount of internal standard added to the sample
A(I.S.) = area response of the nearest internal standard
1(RRF) = assumed relative response factor of 1
Df = dilution factor
D = $dry\ weight = \frac{100 - \%\ moisture}{100}$

13.0 Method Performance

This method was validated through in-house laboratory studies of method detection limits and precision and accuracy for single analyst. The data are retained by the QA department.

14.0 Pollution Prevention

The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 thing. **See SOP 12.1 Hazardous Waste Disposal for procedures on pollution prevention.**

15.0 Waste Management

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Samples preserved with HCl are hazardous and must be handled as hazardous waste.

Refer to the Hazardous Waste Management and Safety SOPs located in the lab.

16.0 References

16.1 U.S. EPA CLP SOW for Organic Analysis, Multi-Media, Multi-Concentration, SOM01.**1** (**May 2005**)

16.2 "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods", SW-846, 3rd Edition, Update III, 12/96

16.3 Methods for Chemical Analysis of Water and Wastes, March 1983

16.4 Standard Methods for the Examination of Water and Wastewater, 20th (1998) Edition, Method 1080

16.5 Code of Federal Register, 40 CFR, Part 136, "Guidelines for Establishing Test Procedures for Priority Pollutants"

16.6 Q**uality** C**ontrol** SOP **13.6 "**Proper Documentation Procedures**"**

16.7 Q**uality** C**ontrol** SOP **13.4 "**Numerical Data Reduction**"**

16.8 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477.

16.9 Hazardous Waste Management & Safety SOPs: "Hazardous Waste Disposal" and "Spill Control & Cleanup."

16.10 NELAC Standards, **June 2003**, plus revisions

16.11 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995

16.**12** CompuChem Quality Manual, Revision **7**, **Update 1, 12/13/05**

16.**13** Sample Control SOP 4.1, "Receiving Samples"

16.**14** Sample Control SOP 4.6, "Storing Samples"

16.**15** QC SOP 13.15, "Documenting Refrigerator and Freezer Temperatures"

16.18 Sample Preparation Procedure –223, "Methanol Extraction of Soil/Sediment Samples for the Analysis of Medium Level Volatile Organics by EPA CLP and NYSASP".

16.**17** Organic Standard Preparation Procedure, "Instrument Performance Check (Tuning) Solution, ID # 7008, VOA, Water & Soil"

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.1 Attachment 1– Target Compound List (TCL) and CRQLs

17.2 Attachment 2 – Relative Response Factor Criteria for Initial and Continuing Calibration Verification of Volatile Organic Compounds.

17.3 Attachment 3 – Characteristic Ions for Trace Volatile Target Compounds

17.4 Attachment 4 – Target Compounds and DMCs with Corresponding Internal Standards for Quantitation

17.5 Attachment 5 – GC/MS Volatile Run Log Example

Attachment 1

Volatiles Target Compound List (TCL) and
Contract Required Quantitation Limits (CQRLs)

Target Compound	Quantitation Limits		
	Low Water µg/L	Low Soil µg/Kg	Medium Soil µg/Kg
Dichlorodifluoromethane	5.0	5.0	250
Chloromethane	5.0	5.0	250
Vinyl chloride	5.0	5.0	250
Bromomethane	5.0	5.0	250
Chloroethane	5.0	5.0	250
Trichlorofluoromethane	5.0	5.0	250
1,1-Dichloroethene	5.0	5.0	250
1,1,2-Trichloro-1,2,2-trifluoroethane	5.0	5.0	250
Acetone	10	10	500
Carbon disulfide	5.0	5.0	250
Methyl acetate	5.0	5.0	250
Methylene chloride	5.0	5.0	250
trans-1,2-Dichloroethene	5.0	5.0	250
Methyl tert-butyl ether	5.0	5.0	250
1,1-Dichloroethane	5.0	5.0	250
cis-1,2-Dichloroethene	5.0	5.0	250
2-Butanone	10	10	500
Bromochloromethane	5.0	5.0	250
Chloroform	5.0	5.0	250
1,1,1-Trichloroethane	5.0	5.0	250
Cyclohexane	5.0	5.0	250
Carbon tetrachloride	5.0	5.0	250
Benzene	5.0	5.0	250
1,2-Dichloroethane	5.0	5.0	250
1,4-Dioxane	100	100	5000
Trichloroethene	5.0	5.0	250
Methylcyclohexane	5.0	5.0	250
1,2-Dichloropropane	5.0	5.0	250
Bromodichloromethane	5.0	5.0	250
cis-1,3-Dichloropropene	5.0	5.0	250
4-Methyl-2-pentanone	10	10	250
Toluene	5.0	5.0	250

Attachment 1 (Continued)

Volatiles Target Compound List (TCL) and
Contract Required Quantitation Limits (CQRLs)

Target Compound	Quantitation Limits		
	Low Water µg/L	Low Soil µg/Kg	Medium Soil µg/Kg
trans-1,3-Dichloropropene	5.0	5.0	250
1,1,2-Trichloroethane	5.0	5.0	250
Tetrachloroethene	5.0	5.0	250
2-Hexanone	10	10	500
Dibromochloromethane	5.0	5.0	500
1,2-Dibromoethane	5.0	5.0	250
Chlorobenzene	5.0	5.0	250
Ethylbenzene	5.0	5.0	250
o-Xylene	5.0	5.0	250
m-, and p-Xylene	5.0	5.0	250
Styrene	5.0	5.0	250
Bromoform	5.0	5.0	250
Isopropylbenzene	5.0	5.0	250
1,1,2,2-Tetrachloroethane	5.0	5.0	250
1,3-Dichlorobenzene	5.0	5.0	250
1,4-Dichlorobenzene	5.0	5.0	250
1,2-Dichlorobenzene	5.0	5.0	250
1,2-Dibromo-3-chloropropane	5.0	5.0	250
1,2,4-Trichlorobenzene	5.0	5.0	250
1,2,3-Trichlorobenzene	5.0	5.0	250

Attachment 2

Technical Acceptance Criteria for Initial and Opening Continuing Calibration Verification for Volatile Organic Compounds

Volatile Compounds	Minimum RRF	Maximum % RSD[1]	Maximum % Diff[1]
Dichlorodifluoromethane	0.010	40.0	± 40.0
Chloromethane	0.010	40.0	± 40.0
Vinyl chloride	0.100	20.0	± 25.0
Bromomethane	0.100	20.0	± 25.0
Chloroethane	0.010	40.0	± 40.0
Trichlorofluoromethane	0.010	40.0	± 40.0
1,1-Dichloroethene	0.100	20.0	± 25.0
1,1,2-Trichloro-1,2,2-trifluoroethane	0.010	40.0	± 40.0
Acetone	0.010	40.0	± 40.0
Carbon disulfide	0.010	40.0	± 40.0
Methyl acetate	0.010	40.0	± 40.0
Methylene chloride	0.010	40.0	± 40.0
trans-1,2-Dichloroethene	0.010	40.0	± 40.0
Methyl tert-butyl ether	0.010	40.0	± 40.0
1,1-Dichloroethane	0.200	20.0	± 25.0
cis-1,2-Dichloroethene	0.010	40.0	± 40.0
2-Butanone	0.010	40.0	± 40.0
Bromochloromethane	0.050	20.0	± 25.0
Chloroform	0.200	20.0	± 25.0
1,1,1-Trichloroethane	0.100	20.0	± 25.0
Cyclohexane	0.010	40.0	± 40.0
Carbon tetrachloride	0.100	20.0	± 25.0
Benzene	0.400	20.0	± 25.0
1,2-Dichloroethane	0.100	20.0	± 25.0
1,4-Dioxane	0.0050	50.0	± 50.0
Trichloroethene	0.300	20.0	± 25.0
Methylcyclohexane	0.010	40.0	± 40.0

[1]For a closing CCV, all target compounds and DMCs must meet a minimum RRF of 0.010 and a maximum percent difference of ±50.0 , except for 1,4-dioxane and 1,4-dioxane-d_8, which must meet a minimum RRF of 0.0050 and a maximum percent difference of ±50.0.

Attachment 2 (Continued)

Technical Acceptance Criteria for Initial and Opening Continuing Calibration Verification for Volatile Organic Compounds

Volatile Compounds	Minimum RRF	Maximum % RSD[1]	Maximum % Diff[1]
1,2-Dichloropropane	0.010	40.0	± 40.0
Bromodichloromethane	0.200	20.0	± 25.0
cis-1,3-Dichloropropene	0.200	20.0	± 25.0
4-Methyl-2-pentanone	0.010	40.0	± 40.0
Toluene	0.400	20.0	± 25.0
trans-1,3-Dichloropropene	0.100	20.0	± 25.0
1,1,2-Trichloroethane	0.100	20.0	± 25.0
Tetrachloroethene	0.100	20.0	± 25.0
2-Hexanone	0.010	40.0	± 40.0
Dibromochloromethane	0.100	20.0	± 25.0
1,2-Dibromoethane	0.010	40.0	± 40.0
Chlorobenzene	0.500	20.0	± 25.0
Ethylbenzene	0.100	20.0	± 25.0
o-Xylene	0.300	20.0	± 25.0
m-, and p-Xylene	0.300	20.0	± 25.0
Styrene	0.300	20.0	± 25.0
Bromoform	0.050	20.0	± 25.0
Isopropylbenzene	0.010	40.0	± 40.0
1,1,2,2-Tetrachloroethane	0.300	20.0	± 25.0
1,3-Dichlorobenzene	0.600	20.0	± 25.0
1,4-Dichlorobenzene	0.500	20.0	± 25.0
1,2-Dichlorobenzene	0.400	20.0	± 25.0
1,2-Dibromo-3-chloropropane	0.010	40.0	± 40.0
1,2,4-Trichlorobenzene	0.200	20.0	± 25.0
1,2,3-Trichlorobenzene	0.200	20.0	± 25.0

[1]For a closing CCV, all target compounds and DMCs must meet a minimum RRF of 0.010 and a maximum percent difference of ±50.0, except for 1,4-dioxane and 1,4-dioxane-d_8, which must meet a minimum RRF of 0.0050 and a maximum percent difference of ±50.0.

Attachment 2 (Continued)

Technical Acceptance Criteria for Initial and Opening Continuing Calibration Verification for Volatile Organic Compounds

Deuterated Monitoring Compounds	**Minimum RRF**	**Maximum % RSD[1]**	**Maximum % Diff[1]**
Vinyl chloride-d_3	0.010	20.0	± 25.0
Chloroethane-d_5	0.010	40.0	± 40.0
1,1-Dichloroethene-d_2	0.010	20.0	± 25.0
2-Butanone-d_5	0.010	40.0	± 40.0
Chloroform-d	0.010	20.0	± 25.0
1,2-Dichloroethane-d_4	0.010	20.0	± 25.0
Benzene-d_6	0.010	20.0	± 25.0
1,2-Dichloropropane-d_6	0.010	40.0	± 40.0
Toluene-d_8	0.010	20.0	± 25.0
trans-1,3-Dichloropropene-d_4	0.010	20.0	± 25.0
2-Hexanone-d_5	0.010	40.0	± 40.0
1,4-Dioxane-d_8	0.0050	50.0	± 50.0
1,1,2,2-Tetrachloroethane-d_2	0.010	20.0	± 25.0
1,2-Dichlorobenzene-d_4	0.010	20.0	± 25.0

[1]For a closing CCV, all target compounds and DMCs must meet a minimum RRF of 0.010 and a maximum percent difference of ±50.0, except for 1,4-dioxane and 1,4-dioxane-d_8, which must meet a minimum RRF of 0.0050 and a maximum percent difference of ±50.0.

Attachment 3

Target Compounds and Deuterated Monitioring Compounds Quantitation and Secondary Ions

Target Compound	Quantitation Ion	Secondary Ion(s)
Dichlorodifluoromethane	85	87
Chloromethane	50	52
Vinyl chloride	62	64
Bromomethane	94	96
Chloroethane	64	66
Trichlorofluoromethane	101	103
1,1-Dichloroethene	96	61, 63
1,1,2-Trichloro-1,2,2-trifluoroethane	101	85, 151
Acetone	43	58
Carbon disulfide	76	78
Methyl acetate	43	74
Methylene chloride	84	49, 86
trans-1,2-Dichloroethene	96	61, 98
Methyl tert-butyl ether	73	43, 57
1,1-Dichloroethane	63	65, 83
cis-1,2-Dichloroethene	96	61, 98
2-Butanone	43*	72
Chloroform	83	85
Bromochloromethane	128	49, 130, 51
1,1,1-Trichloroethane	97	99, 61
Cyclohexane	56	69, 84
Carbon tetrachloride	117	119
Benzene	78	-
1,2-Dichloroethane	62	98
1,4-Dioxane	88	43, 58
Trichloroethene	95	97, 132, 130
Methylcyclohexane	83	55, 98
1,2-Dichloropropane	63	112
Bromodichloromethane	83	85, 127
cis-1,3-Dichloropropene	75	77
4-Methyl-2-pentanone	43	58, 100
Toluene	91	92
trans-1,3-Dichloropropene	75	77
1,1,2-Trichloroethane	97	83, 85, 99, 132, 134
Tetrachloroethene	164	129, 131, 166
2-Hexanone	43	58, 57, 100
Dibromochloromethane	129	127

* m/z 43 is used for quantitation of 2-Butanone, but m/z 72 must be present for positive identification

Attachment 3 (Continued)

Target Compounds and Deuterated Monitioring Compounds Quantitation and Secondary Ions

Target Compound	Quantitation Ion	Secondary Ion(s)
1,2-Dibromoethane	107	109, 188
Chlorobenzene	112	77, 114
Ethylbenzene	91	106
o-, m-, p-xylene	106	91
Styrene	104	78
Bromoform	173	175, 254
Isopropylbenzene	105	120, 77
1,1,2,2-Tetrachloroethane	83	85, 131
1,3-Dichlorobenzene	146	111, 148
1,4-Dichlorobenzene	146	111, 148
1,2-Dichlorobenzene	146	111, 148
1,2-Dibromo-3-chloropropane	75	157, 155
1,2,4-Trichlorobenzene	180	182, 145
1,2,3-Trichlorobenzene	180	182, 145
Deuterated Monitoring Compounds	**Quantitation Ion**	**Secondary Ion(s)**
Vinyl chloride-d_3	65	67
Chloroethane-d_5	69	71, 51
1,1-Dichloroethene-d_2	63	98, 65
2-Butanone-d_5	46	77
Chloroform-d	84	86, 47, 49
1,2-Dichloroethane-d_4	65	67, 51
Benzene-d_6	84	82, 54, 52
1,2-Dichloropropane-d_6	67	65, 46, 42
Toluene-d_8	98	100, 42
trans-1,3-Dichloropropene-d_4	79	81, 42
2-Hexanone-d_5	63	46
1,4-Dioxane-d_8	96	51, 66
1,1,2,2-Tetrachloroethane-d_2	84	86
1,2-Dichlorobenzene-d_5	152	150
Internal Standards	**Quantitation Ion**	**Secondary Ion(s)**
1,4-Dichlorobenzene-d_4	152	115, 150
1,4-Difluorobenzene	114	63, 88
Chlorobenzene-d_{-5}	117	82, 119

Attachment 4

Target Compounds and Deuterated Monitioring Compounds (DMCs) with Corresponding Internal Standards for Quantitation

1,4-Difluorobenzene (IS)	**Chlorobenzene-d_5 (IS)**	**1,4-Dichlorobenzene-d_4 (IS)**
Dichlorodifluoromethane	1,1,1-Trichloroethane	Bromoform
Chloromethane	Cyclohexane	1,3-Dichlorobenzene
Vinyl Chloride	Carbon Tetrachloride	1,4-Dichlorobenzene
Bromomethane	Benzene	1,2-Dichlorobenzene
Chloroethane	Trichloroethene	1,2-Dibromo-3-chloropropane
Trichlorofluoromethane	Methylcyclohexane	1,2,4-Trichlorobenzene
1,1-Dichloroethene	1,2-Dichloropropane	1,2,3-Trichlorobenzene
1,1,2-Trichloro-1,2,2-trifluoroethane	Bromodichloromethane	1,2-Dichlorobenzene-d_4 (DMC)
Acetone	cis-1,3-Dichloropropene	
Carbon Disulfide	4-Methyl-2-pentanone	
Methyl Acetate	Toluene	
Bromochloromethane	trans-1,3-Dichloropropene	
Methylene Chloride	1,1,2-Trichloroethane	
trans-1,2-Dichloroethene	Tetrachloroethene	
Methyl tert-Butyl Ether	2-Hexanone	
1,1-Dichloroethane	Dibromochloromethane	
cis-1,2-Dichloroethene	1,2-Dibromoethane	
2-Butanone	Chlorobenzene	
Chloroform	Ethylbenzene	
1,2-Dichloroethane	m- and p- Xylenes	
1,4-Dioxane	o-Xylene	
Vinyl chloride-d_3 (DMC)	Styrene	
Chloroethane-d_2 (DMC)	Isopropylbenzene	
1,1-Dichloroethene-d_2 (DMC)	1,1,2,2-Tetrachloroethane	
2-Butanone-d_5 (DMC)	Benzene-d_6 (DMC)	
Chloroform-d	1,2-Dichloropropane-d_6 (DMC)	
1,2-Dichloroethane-d_4 (DMC)	trans-1,3-Dichloropropene-d_4 (DMC)	
1,4-Dioxane-d_8 (DMC)	Toluene-d_8 (DMC)	
	2-Hexanone-d_5 (DMC)	
	1,1,2,2-Tetrachloroethane-d_2 (DMC)	

Attachment 5

COMPUCHEM a division of Liberty Analytical Corp DATE ____/____/____INITIAL TIME OF TUNE_____ SHIFT/S(A)_____(B)_____(C)____
GC/MS VOLATILE RUN LOG TIME TUNE EXPIRES_____ LINKER /METHOD_____
COMPUCHEM LOGBOOK 11 X 17 (F50052)
PREVENTIVE MAINTENANCE_____

	REJECTED	FILE NAME	REPORTED	DATE	TIME	CLIENT ID#	CASE/SDG#	SAMPLE VOLUME	CHEMIST	COMMENTS(ETC.)/DISPOSITION
1				/ /						
2				/ /						
3				/ /						
4				/ /						
5				/ /						
6				/ /						
7				/ /						
8				/ /						
9				/ /						
10				/ /						
11				/ /						
12				/ /						
13				/ /						
14				/ /						
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21				/ /						
22				/ /						
23				/ /						
24				/ /						

SUPERVISOR APPROVAL_____ Date_____

Tune (ID #7008) Lot No. _____

Calibration Group Code / Lot No. _____

The presence of the Chemist's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist together with the chemist's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

5/30/02:dce

CompuChem
a division of Liberty Analytical Corporation
501 Madison Avenue
Cary, NC 27513

NELAP accredited

SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire block below (except effective date).

This is a new procedure _____ revised procedure _____ outdated procedure (archive) _____

- Procedure Code: IP1401 SOP Section #: 1.2.4.2 Revision #: 1

SOP Title: GC/MS Analysis of Trace Level Volatiles in Water Scan and Selected Ions for Monitoring using EPA CLP SOW SOM01.1 Effective 6/19/06

Effective date: (QA fills in) 6/21/06

- Procedure prepared by: Weapass Date: 6/20/06
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) Bob McEwen Date: 6-20-06
- Reason for change: Revisions requested by NT DEP
- This procedure meets the requirements of the following approved method references: "US EPA CLP SOW for Organic Analysis, Multi-Media, Multi-Concentration" SOM01.1

Procedure approved by Quality Assurance Representative: Date:
(Not needed if signed above)

_____ _____

Effective 1-1-96, on an annual basis: Lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary, indicate by your signature that the SOP has been reviewed.

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Instrument Procedure 1401: GC/MS Analysis of Trace Level Volatiles in Water Scan and Selected Ion Monitoring using EPA CLP SOW SOM01.**1**

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Instrument Procedure 1401: GC/MS Analysis of Trace Level Volatiles in Water Scan and Selected Ion Monitoring using EPA CLP SOW SOM01.**1**.

1.0 Scope and Application

This method is used for the gas chromatograph mass spectrometer (GC/MS) analysis of water samples for trace concentrations of volatile organic compounds. When requested, an additional analysis by selected ion monitoring (SIM) is performed for 1,4-dioxane, 1,2-dibromoethane, and 1,2-dibromo-3-chloropropane. The target compound list (TCL) for this method and the Contract Required Quantitation Limits (CRQL) are listed in Attachment 1.

Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

2.0 Summary of Method

A 25 mL sample is sparged with an inert gas at ambient temperature transferring purgeable compounds from the aqueous phase to the vapor phase. The vapor is then swept onto a sorbent column where the purgeable compounds are trapped. The sorbent column is heated and back flushed with the inert gas to desorb the purgeables compounds onto a gas chromatograph (GC) wide-bore capillary column. The gas chromatograph is temperature programmed to separate the purgeable compounds, which are then detected with a mass spectrometer (MS).

3.0 Definitions

3.1 Method detection limit (MDL) – The minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR, Part 136, Appendix B.)

3.2 Reporting Limit – The laboratory reporting limit is based on the lowest multipoint calibration standard concentration. Values detected below the reporting limit and above the MDL may be reported and qualified as an estimated concentration.

For CLP methods, the MDL is required to be lower than the reporting limit.

For CLP the reporting limit is the Contract Required Quantitation Limit (CRQL).

3.3 Reporting Units – µg/L

3.4 An SDG is defined by the following, whichever is more frequent:

- each Case of field samples received, or
- each 20 field samples (excluding PE samples) received within a case, or
- each 7 calendar day period (3 calendar day period for 7 day turn around) during which field samples in a case are received beginning with the receipt of the first sample.

3.5 Analytical range – The analytical range is defined by the concentrations of the standards in the initial calibration. Samples containing target analytes at concentrations above the level of the highest calibration standard must be diluted, or a lesser amount of sample analyzed, in order to bring the concentration to within the upper half of the calibration range. For CLP the upper half is defined as the concentration between the midpoint standard and the high standard. For non-CLP the limit is between one-half the concentration of the high standard and the low standard.

3.6 DMC – Deuterated Monitoring Compounds

3.7 IS – Internal Standard

3.8 BFB – Bromofluorobenzene

3.9 EICP – Extracted Ion Current Profile

3.10 VTSR – Validated Time of Receipt of Sample Receipt

4.0 Interferences

4.1 Impurities in the purge gas or methanol, organic compounds out-gassing from the plumbing ahead of the trap, and solvent vapors in the laboratory account for the majority of contamination problems. Gas lines from the gas tanks to the instrument **are to be made of** copper tubing. Non- polytetrafluoroethylene (PTFE) thread sealants, or flow controllers with rubber components are not used.

When potential interfering peaks are noted in laboratory method blanks, it may be necessary to reduce solvent contamination in the laboratory, purge the methanol used to prepare standard solutions, purge the reagent water with helium or nitrogen, change the purge gas source, or regenerate the molecular sieve purge gas filter.

4.2 Samples can be contaminated by diffusion of purgeable organics (particularly methylene chloride, fluorocarbons, and other common laboratory solvents) through the septum seal into the sample during storage and handling. Therefore, **store** samples in **the** GC/MS volatiles laboratory refrigerator separate from laboratory standards**.** **A**nalyze **samples** in a room whose atmosphere is demonstrated to be free of all potential contaminants that will interfere with the analysis.

4.3 Laboratory clothing worn by analysts must be **devoid** of solvents because clothing previously exposed to methylene chloride and other laboratory solvent fumes during common liquid/liquid extraction procedures can contribute to sample contamination.

4.4 The method blank is analyzed to determine the level of contamination present in the lab environment, in the reagents used and in the GC/MS system. Contamination by carryover can occur whenever a sample is analyzed after a sample that contains high levels of organic compounds. When an unusually concentrated sample is analyzed, it is followed by the analysis of an instrument blank to confirm that the instrument is free of contamination. If the samples are set up on an autosampler, the next sample analyzed after the high concentration sample is checked for contamination.

4.5 Method interferences caused by contaminants in solvents, reagents, glassware, purge gas, sorbents, laboratory air, and other sample storage and processing hardware that lead to discrete artifacts and/or elevated baselines in gas chromatograms must be eliminated. **Inspect t**he chromatographic system for malfunctions and **make** corrections as required before **analyzing additional** samples.

4.6 The following are problems associated with certain compounds analyzed by this method:

- Chloromethane , vinyl chloride, bromomethane, and chloroethane may display peak broading.

- Acetone, hexanone, 2-butanone, 4-methyl-2-pentanone, and 1,4-dioxane have poor purge efficiencies.

- 1,1,1-trichloroethane and all of the dichloroethanes maybe degraded by contaminated transfer lines in purge-and-trap systems and/or active sites in the trapping materials.

- Chloromethane may be lost if the purge flow is too fast.

- Bromoform is adversely effected by cold spots and/or active sites in the transferlines. Bromoform's quantitation (m/z 173) is directly effected by the tuning of the Bromofluorobenzene (BFB) at m/z 174/176.

4.7 Instrument problems/preventative maintenance

4.7.1 If a low response is observed for the early eluting compounds such as the gases, replacement of the trap or septum may be necessary. In addition, adjustments to the purge flow may be necessary to achieve a desired response for these compounds. If such adjustments do not help, it may be necessary to check the fittings on the purge and trap device and on the column for leaks. This is done with a helium leak detector and certain software utility programs.

4.7.2 Column maintenance or replacement may be necessary if peak tailing or broad chromatographic peaks are observed.

5.0 Safety

5.1 Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous. During sample preparation, glasses, gloves and lab coats are a minimum requirement. The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

5.2 Laboratory staff **must** review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets (MSDS) for solvents and reagents used in the laboratory. The MSDS are located in the Quality Assurance department.

5.3 The toxicity and carcinogenicity of many chemicals used in this method have not been precisely determined: each chemical should be treated as a potential health hazard. Exposure to these chemicals should be minimized.

5.4 The following method analytes have been tentatively classified as known or suspected human or mammalian carcinogens: benzene, carbon tetrachloride, chloroform, vinyl chloride and 1,4-dioxane.

6.0 Equipment & Supplies

6.1 **Hamilton** micro syringes

6.1.1 10 µL

6.1.2 25 µL

6.1.3 50 µL

6.1.4 100 µL

6.2 SGE International gastight syringes

6.2.1 1 mL

6.2.2 5 mL

6.2.3 10 mL

6.2.4 25 mL

6.**3** pH paper-wide range, capable of measuring pH 0-14.

6.**4** Analytical column

6.**4.1** Restek RTX-624, 60 M, 0.32 mm ID, 1.8 µm film thickness**, used in instrument 90 (HP5973MSD)**

6.**4.2** Supelco SPB-624, 60 M, 0.32 mm ID, 1.4 µm film thickness**, used in instruments 71 (HP6890MSD) and 73 (HP5972MSD)**

6.**5** Purge and trap

6.5.1 Archon Model 5100, 4552 purge and trap autosampler, interfaced with a Tekmar 3000 sample concentrator, with a Supelco K trap or equivalent.

6.5.1.1 The K (VOCARB 3000) trap consists of the following:

- **carbopack B, 10 cm**
- **carboxen - 1000, 6 cm**
- **carboxen – 1001, 1 cm**

6.5.2 Tekmar/Dohrmann Solatek 72 Multi-Matrix Vial Autosampler interfaced with a Tekmar/Dohrmann 3100 Sample Concentrator

6.**6** Gas Chromatograph

6.6.1 Varian 3400

6.6.2 Hewlett Packard 5890 Series

6.6.3 Hewlett Packard 6890 Series

6.**7** Mass spectrometer

6.**7.1** Hewlett Packard 5972 Mass Selective Detector (MSD)

6.**7.2** Hewlett Packard 5973 MSD

6.7.3 Hewlett Packard 6890MSD

6.**8** Interface (GC to mass spectrometer)

6.8.1 Direct capillary interface **at** 225° C **is used for Hewlett Packard MSDs**

6.**9** Data system

6.9.1 For data acquisition, the INCOS500 GC/MS systems use the ProLab Resources system, with EnviroLink software. The Hewlett Packard GC/MS systems utilize ChemServer software, for data acquisition.

6.9.2 For data processing, CompuChem uses the Hewlett Packard HP 9000 series 735 Unix Workstation employing Target3 and Envision software by Thru-Put Systems.

6.9.3 The reference library used is the NBS129K.1 version.

6.10 Data storage

Data are stored on the Target3 Unix Workstation. The Workstation is backed up incrementally on a daily basis.

7.0 Reagents and standards

Reference standards used in this procedure are prepared by analysts in the volatiles laboratory. Standards are stored separately from samples at -10° C to -20° C in the laboratory when not in use.

7.1 Reagent water – All water used in this procedure must be equivalent to ASTM Type I **, with regard to resistivity of > 10 megohm-cm (19th and 20th Editions of Standard Methods, Method 1080),** which is subsequently purged with the inert gas, nitrogen, and demonstrated to meet the blank contamination acceptance criteria contained in this Standard Operating Procedure (SOP). It is referred to throughout the remained of this SOP as reagent water.

7.2 Methanol – purge and trap grade

7.3 Tuning standard

7.3.1 Bromofluorobenzene (BFB)

7.3.1.1 Standard ID# 7008, at **a concentration of** 25µg/mL in methanol.

7.3.1.2 Prepare fresh BFB solution every six months or sooner if degradation or evaporation occurs.

7.4 Internal Standards

7.4.1 Prepare the internal standard spiking solution at 125 µg/mL containing 1,4-dichlorobenzene-d_4, chlorobenzend-d_5, and 1,4-difluorobenzene in methanol.

7.4.2 Prepare monthly or as needed.

7.5 DMC

7.5.1 Prepare the DMC spiking solution at 25 µg/mL for non-ketones, 250 µg/mL for ketones, and 1250 µg/mL for 1,4-dioxane-d_8.

7.5.2 Prepare monthly or as needed.

7.**6** Initial Calibration Standards

7.6.1 **Prepare a**ll non-ketones and their associated deuterated monitoring compounds (DMC) (listed in Attachment 1), except 1,4-dioxane, at 0.50 1.0, 5.0, 10, and 20 µg/L. **Prepare a**ll ketones and their associated DMC at 5.0, 10, 50, 100 and 200 µg/L. **Prepare** 1,4-dioxane and its associated DMC at 20, 40, 250, 400 and 800 µg/L. The concentration of m and p-xylene must total 0.50 1.0, 5.0, 10, and 20 µg/L.

7.6.2 **Prepare t**he initial calibration **standards** for SIM analysis at 0.05, 0.10, 0.50, 1,0, and 2.0 µg/L for all compounds of interest and their associated DMC, except 1,4-dioxane. Prepare 1,4-dioxane and its DMC at 2.0 4.0, 25, 40 and 80 µg/L.

7.6.3 **Perform i**nitial calibrations whenever corrective actions are taken which may affect, the initial calibration criteria (i.e., ion source cleaning/repair, column replacement, etc.).

7.**6**.4 Calibration standards **are** prepared in volumetric flask**s** or **gastight** syringe**s**.

7.**7** Storage of Standards

7.**7**.1 Stock standards are purchased from a commercial provider and stored in the freezer until needed. After the ampoule is opened, the solution is stored in a min-inert vial in the freezer at -10° C to -20° C.

7.**7**.2 **Working standards are prepared monthly or sooner and are stored in a freezer.**

7.**8** Standard Storage Records

7.8.1 All temperature records must be recorded daily following the procedures in QC SOP 13.15, “Documenting Refrigerator and Freezer Temperatures”.

7.8.2 Corrective action SOPs must be posted on the refrigerators.

8.0 Sample Storage and Holding Times

8.1 Samples are preserved, and stored according to the tables in Sample Control SOP 4.1, “Receiving Samples” and 4.6, “Storing Samples.” Sample holding times are also listed.

8.2 **Complete analysis of a**ll water samples, except performance evaluation samples (PE), within 10 days of Validated Time of Sample Receipt (VTSR).

8.3 Prior to analysis, **store** all samples under refrigeration at 4° C (± 2° C) in a volatiles only storage unit. **Store all** samples in the same sample delivery group (SDG) together in the same refrigerator.

9.0 Quality Control

9.1 Deuterated Monitoring Compounds (DMC)

9.1.1 Add an amount of DMC solution to each blank and sample (including matrix spikes) to result in a concentration of 5 µg/L **for** each non-ketone DMC, 50 µg/L for each ketone DMC, and 250 µg/L for 1,4-dioxane-d_8**, for scan analysis**.

9.1.1.1 Add 2.5 µL of non-ketone DMC standard, 5µL of ketone DMC standard, and 1.25µL of 1,4-dioxane DMC standard.

9.1.2 Add a sufficient amount of DMC solution to each blank and sample to result in a concentration of 0.50 µg/L for each non-ketone DMC and 25 µg/L for 1,4-dioxane-d8, for SIM analyses.

9.1.2.1 Add 2.5 µL of non-ketone DMC standard and 5 µL of 1,4-dioxane DMC standard.

9.1.**3** DMCs must meet the recovery criteria listed in the table below:

Deuterated Monitoring Compound Recovery Limits

Compound	Percent Recovery Limits
Vinyl Chloride-d_3	65-131
Chloroethane-d_5	71-131
1,1-Dichloroethene-d_2	55-104
2-Butanone-d_5	49-155
Chloroform-d	78-121
1,2-Dichloroethane-d_4	78-129

Compound	Percent Recovery Limits
Benzene-d_6	77-124
1,2-Dichloropropane-d_6	79-124
Toluene-d_8	77-121
trans-1,3-Dichloropropene-d_4	73-121
2-Hexanone-d_5	28-135
1,4-Dioxane-d_8	50-150
1,1,2,2-Tetrachloroethane-d_2	73-125
1,2-Dichlorobenzene-d_4	80-131

Note: The recovery limits for 1,4-dioxane-d_8 are advisory.

9.2 Internal Standards

9.2.1 **Add 5 µL of i**nternal standard **solution** to every standard, blank, and sample prior to **scan or SIM** analysis. **Use i**nternal standards as the basis for quantitation of the target and DCM compounds. Attachment 2 summarizes target and DMC compounds with corresponding internal standards for quantitation.

9.2.2 **Evaluate t**he EICP area response for each of the internal standard compounds during or immediately after data acquisition. **Compare t**he EICP area response of each of the internal standards in the blanks, matrix spikes and field samples to the most recent opening continuing calibration verification (CCV) standard**. The response** must be within the range of 60% - 140%.

9.2.3 **Compare the** retention time shift for each internal standard in the blanks, matrix spikes and field samples, to the most recent opening CCV, during or immediately after data acquisition. If the retention time for any internal standard changes by more than ± 0.33 minutes (20 seconds), corrective action must be taken.

9.2.4 **Take corrective action, i**f the acceptance criteria for any internal standard are not met. Corrective action may require instrument maintenance**, replacement of internal standard solution,** and/or recalibration. Once corrective action are completed, samples having internal standard retention time shifts outside the limits must be reanalyzed to verify whether the initial failure was due to the sample matrix or whether it was due to a laboratory problem.

9.2.5 The RRT of each of the DMCs must be within ± 0.06 RRT units of its relative retention time in the most recent continuing calibration standard analysis.

9.3 Blanks

9.3.1 Method blank

The method blank measures reagent and system contamination and consists of 25 mL reagent water.

9.3.1.1 Analyze **a** method blank immediately after the initial calibration sequence if samples are analyzed before the **12-**hour time period expires. **Analyze a** method blank immediately after the continuing calibration standard and before any samples are analyzed.

9.3.1.2 Method blanks must meet all internal standard and DMC acceptance criteria in 9.1.2. and 9.2. The concentration of all compounds listed in Attachment 1 (with the exception of methylene chloride, acetone, and 2-butanone) must be less than the CRQL, and all tentatively identified compounds (TICs) less than 2µg/L. For methylene chloride, acetone, and 2-butanone the concentration levels in the method blank must be less than 2 times the CRQL.

9.3.2 Storage blank

The storage blank indicates whether cross-contamination may have occurred during storage of samples. Acceptance criteria are the same as the method blank.

9.3.2.1 Upon receipt of the first samples from a SDG, **fill** two 40 mL screw cap vials with a PTFE-faced silicon septum with reagent water (80 mL total).

9.3.2.2 **Store t**he vials with the SDG under the same conditions. **Analyze a** 25 mL aliquot of the storage blank after all samples in the SDG have been analyzed.

9.3.3 Instrument blank

The results from the instrument blank analysis indicate whether there is carryover from a previous sample. Instrument blank criteria are the same as those of the method blank.

9.3.3.1 **Analyze an i**nstrument blanks after a sample/dilution, containing a target compound at a concentration greater than the initial calibration range.

9.3.4 Corrective Action for Blank Analysis

9.3.4.1 **Re-analyze a**ny method blank or instrument blank that fails to meet the technical acceptance criteria. **Re-analyze a**ll samples processed within the same 12-hour time period with a method blank that does not meet the blank technical acceptance criteria.

9.3.4.2 Until an instrument blank meets the blank technical acceptance criteria or a sample meets the maximum carryover criteria, **re-analyze** any samples analyzed since the original contaminated **sample**.

9.3.4.3 If the storage blank does not meet technical acceptance criteria for blank analysis, correct any system problem and reanalyze the storage blank. If the storage blank does not meet contamination criteria, the problem should be addressed in the narrative along with the corrective action taken.

Note: The storage blank is a deliverable and it must also be made available for review during an on-site audit.

9.4 Duplicate Matrix Spikes

9.4.1 **Analyze d**uplicate matrix spike analyses at the frequency of once per twenty samples in an SDG or once per SDG, if requested by the submitting **client**. **SIM and PE sample analyses do not require d**uplicate matrix spike analyses**.**

9.4.2 **Prepare the m**atrix spike solution at a concentration of 12.5 µg/mL**, containing** the compounds listed in the table in 9.4.4.

9.4.3 If the **client** designates a sample to be used for duplicate spike analyses, that sample must be used. If there is insufficient volume of the designated sample to perform duplicate matrix spike analyses, another sample is

chosen. **N**otif**y the client** that an alternate sample was chosen and the reason for the change. **Note t**his information in the SDG narrative.

9.4.4 The duplicate matrix samples must meet the following criteria.

Spike Compounds	Percent Recovery	Relative Percent Difference
1,1-Dichloroethene	61-145	14
Benzene	76-127	11
Trichloroethene	71-120	14
Toluene	76-125	13
Chlorobenzene	75-130	13

9.4.5 **Record t**he lot numbers of the matrix spike solution in the comment section of the log sheet.

9.4.6 **Analyze d**uplicate matrix spikes on a GC/MS system meeting the BFB, initial calibration, continuing calibration, and blank technical acceptance criteria, and within the contract-required holding time.

9.4.7 Internal standard retention time shift must be within ± 0.33 minutes (20 seconds) compared to the most recent opening CCV standard. The internal standard area response must be within 60.0% to 140% of the corresponding internal standard response in the most recent opening CCV.

Note: The limits for the matrix spike recovery and RPD are advisory and no further action by the laboratory is required. However, frequent failures to meet the limits should be investigated by the laboratory and may warrant questions by the Agency.

9.5 Samples

9.5.1 **Analyze a**ll samples on a GC/MS system meeting the BFB, initial calibration, opening CCV, and method blank criteria.

9.5.2 **Analyze t**he sample within the contractual holding time.

9.5.3 DMC recovery must meet the acceptance criteria presented in Section 9.1.2. Up to three DMCs per sample may fail to meet the recovery limits.

9.5.4 The area responses of the internal standards must be within 60.0% to 140% of their respective area responses in the opening CCV standard.

9.5.5 The internal standard retention time shift between the sample and the most recent opening CCV must be ± 0.33 minutes (20 seconds).

9.5.6 If target compound concentrations are outside the upper limit of the instrument's analytical range, **re–prepare** the sample and reanalyze at a dilution such that the compound concentrations in question will be within the upper half of the analytical range for this method.

9.6 Contingency

9.6.1 If due to a lab accident or to QC failures, a re-preparation and analysis are required for the sample and insufficient sample volume remains, the Project Manager must be alerted and will contact the client for direction on how to proceed.

9.6.2 If persistent contamination occurs in the laboratory, analysis must be halted until the source of the contamination can be identified and isolated. When the contamination issue is resolved, samples analysis may proceed.

9.6.3 Refer to the corresponding Data Review SOP (number will vary among sections) for information on how to handle reporting of data that are unacceptable or out-of-control.

9.6.4 Any other issues that potentially effect data quality should also be addressed with the Project Manager.

10.0 Calibration & Standardization

10.1 BFB

10.1.1 **Tune the GC/MS with** perfluoro-tri-n-butylamine (FC-43).

10.1.2 **Analyze the** instrument performance check solution by injecting 50 **η**g of BFB (2 µL STD ID# 7008) into the GC using a 10 µL Hamilton syringe.

10.1.3 All **performance** criteria must be met**.** GC/MS tuning and Mass Calibration forms must be printed and attached to the instrument run log page for each tune. **Report r**elative abundances to the number of significant figures presented in the table in Section 10.1.5.

10.1.4 **Base t**he criteria for BFB analysis on averaging from one scan prior to the apex of the BFB peak to one scan after the apex, subtracting a single background scan prior to the peak, but no more than 20 scans prior to the elution of BFB. **D**o not subtract part of the BFB peak.

10.1.5 Analysis of the instrument performance check solution must meet the ion abundance criteria given in the following table.

BFB Key Ions and Ion Abundance Criteria

Mass	Ion Abundance Criteria
50	15.0 – 40.0 % of m/z 95
75	30.0 – 80.0 % of m/z 95
95	Base Peak; 100 % relative abundance
96	5.0 – 9.0 % of m/z 95
173	<2.0 % of m/z 174
174	50.0 – 120 % of m/z 95
175	5.0 – 9.0 % of m/z 174
176	95.0 – 101 % of m/z 174
177	5.0 – 9.0 % of m/z 176

Note: All ion abundances must be normalized to m/z 95, even though the ion abundance of m/z 174 may be up to 120% of m/z 95.

10.1.6 If BFB technical acceptance criteria are not met, retune the GC/MS system. **If required,** clean the ion source, clean the **quadrapole** rods, or take other corrective action to achieve the technical acceptance criteria.

10.1.7 BFB technical acceptance criteria must be met before **the analysis of** any standards, samples, or required blanks.

10.2 Initial calibration

10.2.1 Prior to the analysis of samples and required blanks, and after the instrument performance check solution (BFB) criteria have been met, **perform a 5-point calibration of** each GC/MS system (See 7.4.1 and 7.4.2) to demonstrate instrument sensitivity and the linearity of the GC/MS response for the purgeable target compounds and DMC.

10.2.2 **Analyze a**ll initial calibration standards at the concentration and at the frequency levels required on a GC/MS system meeting the BFB technical acceptance criteria.

10.2.2.1 If time remains in the **12-**hour time period after meeting the technical acceptance criteria for the initial calibration, **analyze** samples. It is not necessary to analyze a CCV standard. A method blank is required.

10.2.2.2 Quantitate all samples and blank results using the mean relative response factor ($\overline{RRF}$) from the initial calibration. Compare quality control criteria, such as, internal standard area response change and retention time (RT) shift, against the initial calibration standard that is the same concentration as the continuing calibration standard.

10.2.3 **Perform a**n initial calibration if the CCV acceptance criteria has not been met, or whenever a corrective action might effect the initial calibration (i.e., a column is changed or an ion source cleaned).

10.2.4 Excluding those ions in the solvent front, no quantitation ion may saturate the detector.

10.2.5 **Tabulate t**he area response of the characteristic ions in the extracted ion current profile (EICP) against the concentration for each compound and internal standard**. Calculate** relative response factors (RRF) for each compound. **Calculate t**he mean RRF for all compounds.

10.2.6 The RRF at each calibration concentration for each target and DMC must be greater than or equal to the compounds minimum RRF listed in Attachment 4

10.2.7 The percent relative standard deviation (%RSD) for each target and DMC must be less than or equal to that listed in Attachment 4.

10.2.7.1 Up to two compounds may fail to meet minimum RRF criteria or maximum %RSD criteria, however these compounds must have a minimum RRF of greater than or equal to 0.01 and a maximum %RSD of 40. The exceptions are 1,4-dioxane and 1,4-dioxane d_8, which must have a minimum RRF of 0.005 and a maximum %RSD of 50.

10.2.7.2 For SIM analysis, each target compound and DMC must meet a minimum RRF of 0.01 and a maximum %RSD of less than or equal to 50.

10.2.8 If the initial calibration technical acceptance criteria are not met, inspect the system for problems. **If required,** clean the ion source, perform column maintenance, change the column, service the purge and trap device, or take other corrective action to achieve the technical acceptance criteria

10.2.9 Initial calibration technical acceptance criteria must be met before any samples or required blanks are analyzed.

10.3 Opening and Closing Continuing Calibration Verification

10.3.1 **Analyze an opening CCV b**efore the analysis of samples and required blanks and after BFB and initial calibration acceptance criteria have been met, to ensure that the instrument meets the sensitivity and linearity requirements of the method. **Analyze a closing CCV a**fter all the blanks and samples, and before the end of the twelve-hour time period.

10.3.2 **Perform t**he opening and closing CCV standards at the mid-level concentration of the initial calibration; 5.0 µg/L for non-ketones, 25 µg/L for ketones, 250 µg/L for 1,4-dioxane, 25 µg/L for 1,4-dioxane by SIM, and 0.50 µg/L for all other compounds by SIM.

10.3.3 **Perform a** check of the calibration curve every 12 hours, beginning with the injection of BFB. **Calculate** percent difference (%D) of the opening CCV relative response factor compared to the average relative response factor from the initial curve. The opening CCV must meet the minimum RRF and maximum %D acceptance criteria listed in Attachment 4.

10.3.3.1 For the opening CCV up to two compounds may fail to meet minimum RRF criteria and up to two compounds may fail maximum %RSD criteria in the opening CCV; however these compounds must have a minimum RRF of greater than or equal to 0.01 and a maximum %RSD of 40. The exceptions are 1,4-dioxane and 1,4-dioxane d_8, which must have a minimum RRF of 0.005 and a maximum %RSD of 50.

10.3.4 The closing CCV must meet a minimum RRF of 0.01 for all target and DMC, except 1,4-dioxane and 1,4-dioxane-d_8. (1,4-dioxane and 1,4-

dioxane-d_8 must meet a minimum RRF of 0.005). The closing CCV must meet a maximum %D of 50

10.3.5 Opening CCV acceptance criteria must be met before any samples, spikes, or blanks are analyzed. If the acceptance criteria are not met, recalibrate the GC/MS by performing another initial calibration. This may require some corrective action first.

10.3.6 If closing CCV acceptance criteria are not met, all sample analyzed within the twelve hour time period must be reanalyzed.

11.0 Procedure

Documentation must follow the requirements in QC SOP: Proper Documentation Procedures. Record all instrument information in the GC/MS VOA Run Log (Attachment 5).

11.1 Instrument Performance Check

Analyze an instrument performance check sample and **ensure it** meets acceptance criteria, before any calibration standards, blanks, or samples are analyzed.

11.1.**1** **Inject** 2 µL, of 25 µL/mL BFB solution (50 ηg), into the GC column.

11.1.2 If BFB acceptance criteria are met, print the BFB mass spectrum, mass listing, and reconstructed ion chromatogram (RIC)

11.2 Initial Calibration

11.2.1 **Perform an** initial calibration after all BFB tuning criteria are met. The initial calibration consists of 5 standards at the concentrations listed in 7.4.1 and 7.4.2.

11.2.2 Prepare each standard in a 25 mL gastight syringe by adding calibration standard, DMC, and internal standard solutions to 25 mL of reagent water. Inject the contents of the syringe into a 40mL vial and place it on the autosampler. **Purge t**he standards at ambient temperature.

11.2.3 Prepare each standard in a volumetric flask, by adding calibration standard, DMC, and internal standard solutions to reagent water and brining the flask to the appropriate volume. Measure a 25 mL volume

using a 25 mL gastight syringe. Inject the contents of the syringe into a 40mL vial and place it on the autosampler.

11.2.4 Process and review each calibration standard using the **Target3** data system insuring that each DMC and target compound is present in each analysis.

11.2.5 Check that the **initial calibration** met acceptance criteria by reviewing the initial calibration summary form on the Target3 data system.

11.2.6 If acceptance criteria are met, print the initial calibration summary form. Also print the RIC, quantitation report, and EICP for each standard used.

11.2.7 **Analyze samples i**f time remains in the twelve hour period after the initial calibration has been analyzed, without the analysis of an opening CCV.

11.2.8 If no samples are analyzed, complete the GC/MS run log (Attachment 5). "Z" out any unused portion of the run log and have a supervisor or designee to review and sign it. Make a photocopy of the run log an attach it to the hard copy data for BFB and the initial calibration.

11.3 Opening CCV

11.3.1 After the BFB and initial calibration have met acceptance criteria, **check** the GC/MS system by analyzing the opening CCV.

11.3.2 Process and review the opening CCV using Target 3 processing software insuring that each target compound is present in the analysis.

11.3.3 Check that the opening CCV met acceptance criteria, by reviewing the continuing calibration summary form on the Target3 data system.

11.3.4 If the opening CCV acceptance criteria are met, print the continuing calibration summary form, RIC, quantitation report, and EICP.

11.4 Method Blank

11.4.1 **Analyze a** method blank after all BFB and initial calibration or opening CCV criteria are met.

11.4.2 **Prepare t**he method blank by adding internal standard and DMC solutions to 25 mL of reagent water in a gastight syringe. **Add t**he contents of the syringe to a 40 **mL** vial and place on the autosampler for analysis.

11.4.3 Process and review the method blank. If the method blank meets acceptance criteria, sample**s** may be analyzed. **If the method blank fails, re-analyze.**

11.5 Sample Preparation and Analysis

11.5.1 **Permit sample to obtain ambient temperature.**

11.5.2 **P**repare liquid samples for analysis, **by** pour**ing** the sample into a 25 mL Hamilton gastight syringe, replace the plunger, adjust the volume to 25 mL, and add internal standard and DMC solutions. Inject the contents of the syringe into a 40 mL vial and place on the autosampler for analysis.

11.5.2.1 **Determine t**he pH of **the** water samples**.** Test the pH by placing one or two drips on the pH paper (do not add pH paper to the vial). Record the pH of each sample. **Do not adjust the pH.**

11.5.2.2 **Prepare d**uplicate matrix spike samples **cited** in 11.5.2, with the addition of matrix spike solution.

11.6 Instrument Blank

11.6.1 Perform an instrument blank analysis after a sample analysis containing a target compound(s) **exceeding** the instrument's calibration range.

Note: The results of the instrument blank analysis indicate if there is contamination from a previous sample.

11.6.2 **Prepare t**he instrument blank by adding internal standard and DMC solutions to 25 mL of reagent water.

11.6.3 **Do not conduct s**ample analysis until the instrument blank meets method blank acceptance criteria.

11.7 Storage Blank

11.7.1 Analyze the storage blank after all samples in the SDG have been analyzed.

Note: The results of the storage blank indicate whether the samples were contaminated during storage.

11.7.2 Prepare the storage blank by adding internal standard and DMC solutions to a 25 mL aliquot.

11.7.3 Storage blank analysis **must** meet all method blank acceptance criteria. If these criteria are not met, analyze a second aliquot and document the results in the SDG narrative.

11.8 Purge and Trap Analysis

11.8.1 After preparation, **load** each standard, blank, and sample onto the closed-system autosampler interfaced with the purge-and-trap apparatus.

11.8.2 Purge for 11 minutes at ambient temperature.

11.8.3 Heat the trap to 180° C and desorb the trapped contents onto the GC column by back flushing the trap with inert gas for 4.0 (± 0.1) minutes.

11.8.4 Bake the trap for 7.0 (± 0.1) minutes **at 220 to 260°C.**

11.9 GC/MS Analysis

11.9.1 Hold the GC column temperature at 10° C for 1 to 5 minutes, then ramp at 6° C per minute to 160° C and hold until 3 minutes after the last volatile compounds have eluted.

11.9.2 The following are the required MS analytical conditions:

Parameter	
Electron Energy	70 Volts (nominal)
Mass Range	35 - 300 amu
Ionization Mode	Electron Ionization (EI)
Scan Time	At least 5 scans per peak, not to exceed

	2 seconds per scan for capillary column

11.10 Sample Quantitation

11.10.1 Process each sample data file. Review file(s) to ensure that internal standards, DMC, and dilution acceptance criteria are met.

11.11 Closing CCV

11.11.1 **Analyze a closing CCV a**fter all samples and before the end of the twelve-hour period.

11.11.2 Process and review the closing CCV using the Target3 data system insuring that each DMC and target compound is present in the analysis.

11.11.3 Check that the closing CCV met acceptance criteria by reviewing the continuing calibration summary form on the Target3 data system.

11.11.4 If the closing CCV meets the acceptance criteria for the opening CCV, sample analysis may continue for another twelve hour period without analyzing BFB.

11.11.5 If the closing CCV acceptance criteria are met, print the continuing calibration summary form, RIC, quantitation report and EICP.

11.11.6 After the analysis and acceptance of the closing CCV, make all entries on the appropriate logbook page(s). Have the logbook page(s) reviewed and signed by the supervisor or designee and make a copy. This copy will accompany the data. Attach the **BFB** and calibration data to the logbook copy.

11.12 Sample Dilutions

11.12.1 **Dilute s**amples if target compounds concentrations in the sample analyses are outside of the instrument's calibration range, as defined by the highest level to the initial calibration standard.

11.12.2 An acceptable dilution is one that brings the concentration of the diluted compound within the upper half of the instruments calibration range. Dilutions must be analyzed within the required holding time.

11.12.3 A dilution **is** prepared in a gastight syringe of volumetric flask.

11.12.3.1 To prepare a 25 times dilution, fill a 25 mL gastight syringe (Luer-Lok) with 24 mL of reagent water. Adjust plunger to 25 mL. Fill a 1 mL gastight syringe with 1 mL of sample and add it to the other 25 mL syringe.

11.12.3.2 To prepare a 100 times dilution, add an aliquot of reagent water to a 100 mL volumetric flask. Using a gastight syringe, aliquot 1 mL of sample and add to flask. Adjust to mark with reagent water and invert to mix.

11.12.4 If more than two sample analyses (i.e., the undiluted analysis and more than one dilution) are necessary to have all target analytes within the calibration range, contact **client** for guidance.

12.0 Data Analysis & Calculations

Calculations must be consistent with the QC SOP: Numerical Data Reduction.

12.1 Calculation of the mean or average of a set of values:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where:

n = total number of values
x = each individual value used to calculate the mean
$\overline{x}$ = the mean of n

12.2 Calculation of the standard deviation of a set of values:

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n} \left(X_n - \overline{X}\right)^2}{n-1}}$$

12.3 Calculation of percent recovery:

12.3.1 DMCs:

$$\%R = \frac{Amount\ found}{Amount\ spiked}\ x\ 100$$

12.3.2 Matrix spikes:

$$\%\ R = \frac{Amount\ in\ spiked\ sample - Amount\ in\ unspiked\ (native)\ sample}{Amount\ spiked}\ x\ 100$$

12.4 Calculation of % RSD

$$\%RSD = \left(\frac{Standard\ deviation}{\overline{X}}\right)\ \times\ 100$$

12.5 Calculation of RPD

$$RPD\ = \frac{\left|Value\ \ 1 - Value\ \ 2\right|}{(Value\ \ 1 + Value\ \ 2)/2}\ x100$$

12.6 Calculation of %Difference (%D)

$$\%Diff\ \ = \frac{Value\ \ - \overline{Reference\ \ value}}{\overline{Reference\ \ value}}\ x\ 100$$

12.7 Calculation of Relative Response Factor (RRF)

$$RRF = \frac{Ax}{Ais}\ x\ \frac{Cis}{Cx}$$

where:

Ax = area of the characteristic ion from the EICP for the compound to be measured
Ais = area of the characteristic ion for the EICP for the internal standard
Cis = concentration of the internal standard
Cx = concentration of the compound to be measured

12.8 Concentration of aqueous samples by GC/MS analysis

$$\mu g / L = \frac{(Ax)(Is)(Df)}{(Ais)(\overline{RRF})(Vo)}$$

where:

Ax = area of the characteristic ion from the EICP of the compound to be measured
Ais = area of the characteristic ion for the EICP of the internal standard
Is = amount of internal standard added (ng)
$\overline{RRF}$ = mean relative response factor from continuing calibration standard
Vo = volume of water purged (mL)
Df = dilution factor. If no dilution, Df = 1.0

12.9 **Quantify n**on- target compounds by comparing the MS response from the reconstructed ion chromatogram (RIC) for the non-target compound peaks to the MS response for a peak produced by the nearest internal standard compound. A**ssume a** response factor of 1.

$$TIC\ amount = \frac{A(tic)\ x\ Amt(std)xDf}{A(IS)\ x\ 1(RRF)xVo}$$

where:

Df, Vo are defined in 12.8
A(tic) = area response from RIC for non-target compound
Amt(std) = 50ug/L (amount of internal standard added to the sample
A(I.S.) = area response of the nearest internal standard
1(RRF) = assumed response factor of 1

12.11 Calculating Dilutions

If a sample concentration exceeds the high level standard, a dilution must be performed. Determine a level of dilution that will result in a value within the upper half of the initial calibration range. This is an acceptable dilution. **Determine the sample volume needed for the diluted analysis to bring the analyte concentration within the upper half of the initial calibration range.**

12.1.1 $(C_1)(V_1) = (C_2)(V_2)$

where: C_1 = desired concentration within upper half of calibration range
V_1 = total purge volume
C_2 = concentration of analyte to be diluted in the sample

V_2 = sample volume needed for diluted analysis

12.1.2 Calculate the dilution factor by dividing the total volume purged by the volume of sample purged.

13.0 Method Performance

This method was validated through in-house laboratory studies of method detection limits and precision and accuracy for single analyst. The data are retained by the QA department.

14.0 Pollution Prevention

The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 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 thing. **See SOP 12.1, Hazardous Waste Disposal, regarding laboratory procedures for recycling solvent waste streams.**

15.0 Waste Management

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. **The laboratory also complies** with all sewage discharge permits and regulations.

Samples preserved with HCl are hazardous and **are** handled as hazardous waste. Refer to the Hazardous Waste Management and Safety SOPs located in the lab.

16.0 References

16.1 U.S. EPA CLP SOW for Organic Analysis, Multi-Media, Multi-Conc**en**tration SOM01.**1** (**May, 2005**)

16.2 "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods", SW-846, 3rd Edition, Update III, 12/96

16.3 Methods for Chemical Analysis of Water and Wastes, March 1983

16.4 Standard Methods for the Examination of Water and Wastewater, 20th (1998) Edition, Method 1080

16.5 Code of Federal Register, 40 CFR, Part 136, "Guidelines for Establishing Test Procedures for Priority Pollutants"

16.6 New York State Analytical Services Protocol (NYSASP), 6/2000, plus revisions

16.7 Q**uality** C**ontrol** SOP **13.6"**Proper Documentation Procedures**"**

16.8 Q**uality** C**ontrol** SOP **13.4"**Numerical Data Reduction**"**

16.9 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477.

16.10 Hazardous Waste Management & Safety SOPs: "Hazardous Waste Disposal" and "Spill Control & Cleanup."

16.11 NELAC Standards, Ju**ne 2003**, plus revisions

16.12 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995.

16.13 New York State Environmental Laboratory Approval Program, Certification Manual, **December 2005**, plus revisions.

16.14 CompuChem Quality Manual, Revision **7**, **Update 1, 12/13/05,** plus revisions

16.15 Sample Control SOP 4.1, "Receiving Samples"

16.16 Sample Control SOP 4.6, "Storing Samples"

16.17 QC SOP 13.15, "Documenting Refrigerator and Freezer Temperatures"

16.18 Sample Preparation Procedure –223, "Methanol Extraction of Soil/Sediment Samples for the Analysis of Medium Level Volatile Organics by EPA CLP and NYSASP".

16.19 Organic Standard Preparation Procedure, "Instrument Performance Check (Tuning) Solution, ID # 7008, VOA, Water & Soil"

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.1 Attachment 1 – Target Compound List (TCL) and CRQLs

17.2 Attachment 2 – TCL and DMC with corresponding IS for quantitation

17.3 Attachment 3 – TCL and DMC Quantitation and Secondary Ions

17.4 Attachment 4 – Technical Acceptance Criteria for Initial and Opening Continuing Calibration Verification for Trace Volatile Organic Compounds

17.5 Attachment 5 – GC/MS Volatile Run Log Example

Attachment 1

Target Compound List (TCL) and Contract
Required Quantitation Limits (CRQL)

Target Compound	Trace	Trace by SIM
Dichlorodifluoromethane	0.50	
Chloromethane	0.50	
Vinyl chloride	0.50	
Bromomethane	0.50	
Chloroethane	0.50	
Trichlorofluoromethane	0.50	
1,1-Dichloroethene	0.50	
1,1,2-Trichloro-1,2,2-trifluoroethane	0.50	
Acetone	5.00	
Carbon disulfide	0.50	
Methyl acetate	0.50	
Methylene chloride	0.50	
trans-1,2-Dichloroethene	0.50	
Methyl tert-butyl ether	0.50	
1,1-Dichloroethane	0.50	
cis-1,2-Dichloroethene	0.50	
2-Butanone	5.00	
Bromochloromethane	0.50	
Chloroform	0.50	
1,1,1-Trichloroethane	0.50	
Cyclohexane	0.50	
Carbon tetrachloride	0.50	
Benzene	0.50	
1,2-Dichloroethane	0.50	
1,4-Dioxane	20.00	2.0
Trichloroethene	0.50	
Methylcyclohexane	0.50	
1,2-Dichloropropane	0.50	
Bromodichloromethane	0.50	
cis-1,3-Dichloropropene	0.50	
4-Methyl-2-pentanone	5.00	
Toluene	0.50	

Attachment 1 (Continued)

Target Compound List (TCL) and Contract
Required Quantitation Limits (CRQL)

Target Compound	Trace	Trace by SIM
trans-1,3-Dichloropropene	0.50	
1,1,2-Trichloroethane	0.50	
Toluene	0.50	
trans-1,3-Dichloropropene	0.50	
1,1,2-Trichloroethane	0.50	
tetrachloroethene	0.50	
2-Hexanone	5.00	
Dibromochloromethane	0.50	
1,2-Dibromoethane	0.50	0.05
Chlorobenzene	0.50	
Ethylbenzene	0.50	
Xylenes (total)	0.50	
Styrene	0.50	
Bromoform	0.50	
Isopropylbenzene	0.50	
1,1,2,2-Tetrachloroethane	0.50	
1,3-Dichlorobenzene	0.50	
1,4-Dichlorobenzene	0.50	
1,2-Dichlorobenzene	0.50	
1,2-Dibromo-3-chloropropane	0.50	0.05
1,2,4-Trichlorobenzene	0.50	
1,2,3-Trichlorobenzene	0.50	

Attachment 2

Target Compounds and Deuterated Monitioring Compounds (DMCs) with Corresponding Internal Standards for Quantitation

1,4-Difluorobenzene	**Chlorobenzene-d_5**	**1,4-Dichlorobenzene-d_4**
Dichlorodifluoromethane	1,1,1-Trichloroethane	Bromoform
Chloromethane	Cyclohexane	1,3-Dichlorobenzene
Vinyl Chloride	Carbon Tetrachloride	1,4-Dichlorobenzene
Bromomethane	Benzene	1,2-Dichlorobenzene
Chloroethane	Trichloroethene	1,2-Dibromo-3-chloropropane
Trichlorofluoromethane	Methylcyclohexane	1,2,4-Trichlorobenzene
1,1-Dichloroethene	1,2-Dichloropropane	1,2,3-Trichlorobenzene
1,1,2-Trichloro-1,2,2-trifluoroethane	Bromodichloromethane	1,2-Dichlorobenzene-d_4 (DMC)
Acetone	cis-1,3-Dichloropropene	
Carbon Disulfide	4-Methyl-2-pentanone	
Methyl Acetate	Toluene	
Bromochloromethane	trans-1,3-Dichloropropene	
Methylene Chloride	1,1,2-Trichloroethane	
trans-1,2-Dichloroethene	Tetrachloroethene	
Methyl tert-Butyl Ether	2-Hexanone	
1,1-Dichloroethane	Dibromochloromethane	
cis-1,2-Dichloroethene	1,2-Dibromoethane	
2-Butanone	Chlorobenzene	
Chloroform	Ethylbenzene	
1,2-Dichloroethane	o-Xylene	
1,2-Dichloroethane-d_4 (DMC)	m- and p- Xylenes	
1,4-Dioxane-d_8 (DMC)	Trans-1,3-Dichloropropene-d_4 (DMC)	
Vinyl Chloride-d_3 (DMC)	Toluene-d_8 (DMC)	
Chloroethane-d_5 (DMC)	2-Hexanone-d_5 (DMC)	
1,1-Dichloroethene-d_2 (DMC)	1,1,2,2-Tetrachloroethane-d_2 (DMC)	
2-Butanone-d_5 (DMC)	Styrene	
Chloroform-d (DMC)	Isopropylbenzene	
1,4-Dioxane	1,1,2,2-Tetrachloroethane	
	Benzene-d_6 (DMC)	
	1,2-Dichloropropane-d_6 (DMC)	

Attachment 3

Target Compounds and Deuterated Monitioring Compounds Quantitation and Secondary Ions

Target Compound	Quantitation Ion	Secondary Ion(s)
Dichlorodifluoromethane	85	87
Chloromethane	50	52
Vinyl chloride	62	64
Bromomethane	94	96
Chloroethane	64	66
Trichlorofluoromethane	101	103
1,1-Dichloroethene	96	61, 63
1,1,2-Trichloro-1,2,2-trifluoroethane	101	85, 151
Acetone	43	58
Carbon disulfide	76	78
Methyl acetate	43	74
Methylene chloride	84	49, 86
trans-1,2-Dichloroethene	96	61, 98
Methyl tert-butyl ether	73	43, 57
1,1-Dichloroethane	63	65, 83
cis-1,2-Dichloroethene	96	61, 98
2-Butanone	43*	72
Chloroform	83	85
Bromochloromethane	128	49, 130, 51
1,1,1-Trichloroethane	97	99, 61
Cyclohexane	56	69, 84
Carbon tetrachloride	117	119
Benzene	78	None
1,2-Dichloroethane	62	98
1,4-Dioxane	88	43, 58
Trichloroethene	95	97, 132, 130
Methylcyclohexane	83	55, 98
1,2-Dichloropropane	63	112
Bromodichloromethane	83	85, 127
cis-1,3-Dichloropropene	75	77
4-Methyl-2-pentanone	43	58, 100
Toluene	91	92
trans-1,3-Dichloropropene	75	77
1,1,2-Trichloroethane	97	83, 85, 99, 132, 134
Tetrachloroethene	164	129, 131, 166
2-Hexanone	43	58, 57, 100
Dibromochloromethane	129	127

*m/z 43 is used for quantitation of 2-Butanone, but m/z 72 must be present for positive identification

Attachment 3 (Continued)

Target Compounds and Deuterated Monitioring Compounds Quantitation and Secondary Ions

Target Compound	**Quantitation Ion**	**Secondary Ion(s)**
1,2-Dibromoethane	107	109, 188
Chlorobenzene	112	77, 114
Ethylbenzene	91	106
o-, m-, p-xylene	106	91
Styrene	104	78
Bromoform	173	175, 254
Isopropylbenzene	105	120, 77
1,1,2,2-Tetrachloroethane	83	85, 131
1,3-Dichlorobenzene	146	111, 148
1,4-Dichlorobenzene	146	111, 148
1,2-Dichlorobenzene	146	111, 148
1,2-Dibromo-3-chloropropane	75	157, 155
1,2,4-Trichlorobenzene	180	182, 145
1,2,3-Trichlorobenzene	180	182, 145
Deuterated Monitoring Compounds	**Quantitation Ion**	**Secondary Ion(s)**
Vinyl chloride-d_3	65	67
Chloroethane-d_5	69	71, 51
1,1-Dichloroethene-d_2	63	98, 65
2-Butanone-d_5	46	77
Chloroform-d	84	86, 47, 49
1,2-Dichloroethane-d_4	65	67, 51
Benzene-d_6	84	82, 54, 52
1,2-Dichloropropane-d_6	67	65, 46, 42
Toluene-d_8	98	100, 42
trans-1,3-Dichloropropene-d_4	79	81, 42
2-Hexanone-d_5	63	46
1,4-Dioxane-d_4	96	51, 66
1,1,2,2-Tetrachloroethane-d_2	84	86
Internal Standards	**Quantitation Ion**	**Secondary Ion(s)**
1,4-Dichlorobenzene-d_4	152	115, 150
1,4-Difluorobenzene	114	63, 88
Chlorobenzene-d_{-11}	117	82, 119

Attachment 4

Technical Acceptance Criteria for Initial and Opening Continuing Calibration Verification for Trace Volatile Organic Compounds

Volatile Compounds	Minimum RRF	Maximum % RSD[1]	Maximum % Diff[1]
Dichlorodifluoromethane	0.010	40.0	± 40.0
Chloromethane	0.010	40.0	± 40.0
Vinyl chloride	0.100	30.0	± 30.0
Bromomethane	0.100	30.0	± 30.0
Chloroethane	0.010	40.0	± 40.0
Trichlorofluoromethane	0.010	40.0	± 40.0
1,1-Dichloroethene	0.100	30.0	± 30.0
1,1,2-Trichloro-1,2,2-trifluoroethane	0.010	40.0	± 40.0
Acetone	0.010	40.0	± 40.0
Carbon disulfide	0.010	40.0	± 40.0
Methyl acetate	0.010	40.0	± 40.0
Methylene chloride	0.010	40.0	± 40.0
trans-1,2-Dichloroethene	0.010	40.0	± 40.0
Methyl tert-butyl ether	0.010	40.0	± 40.0
1,1-Dichloroethane	0.200	30.0	± 30.0
cis-1,2-Dichloroethene	0.010	40.0	± 40.0
2-Butanone	0.010	40.0	± 40.0
Bromochloromethane	0.050	30.0	± 30.0
Chloroform	0.200	30.0	± 30.0
1,1,1-Trichloroethane	0.100	30.0	± 30.0
Cyclohexane	0.010	40.0	± 40.0
Carbon tetrachloride	0.100	30.0	± 30.0
Benzene	0.400	30.0	± 30.0
1,2-Dichloroethane	0.100	30.0	± 30.0
1,4-Dioxane	0.0050	50.0	± 50.0
Trichloroethene	0.300	30.0	± 30.0
Methylcyclohexane	0.010	40.0	± 40.0

[1]For a closing CCV, all target compounds and DMCs must meet a minimum RRF of 0.010 and a maximum percent difference of ± 50.0 , except for 1,4-dioxane and 1,4-dioxane-d_8, which must meet a minimum RRF of 0.0050 and a maximum percent difference of ±50.0.

Attachment 4 (Continued)

Technical Acceptance Criteria for Initial and Opening Continuing Calibration Verification for Trace Volatile Organic Compounds

Volatile Compounds	Minimum RRF	Maximum % RSD[1]	Maximum % Diff[1]
1,2-Dichloropropane	0.010	40.0	± 40.0
Bromodichloromethane	0.200	30.0	± 30.0
cis-1,3-Dichloropropene	0.200	30.0	± 30.0
4-Methyl-2-pentanone	0.010	40.0	± 40.0
Toluene	0.400	30.0	± 30.0
trans-1,3-Dichloropropene	0.100	30.0	± 30.0
1,1,2-Trichloroethane	0.100	30.0	± 30.0
Tetrachloroethene	0.100	30.0	± 30.0
2-Hexanone	0.010	40.0	± 40.0
Dibromochloromethane	0.100	30.0	± 30.0
1,2-Dibromoethane	0.010	40.0	± 40.0
Chlorobenzene	0.500	30.0	± 30.0
Ethylbenzene	0.100	30.0	± 30.0
o-, m-, and p-xylene	0.300	30.0	± 30.0
Styrene	0.300	30.0	± 30.0
Bromoform	0.050	30.0	± 30.0
Isopropylbenzene	0.010	40.0	± 40.0
1,1,2,2-Tetrachloroethane	0.100	30.0	± 30.0
1,3-Dichlorobenzene	0.400	30.0	± 30.0
1,4-Dichlorobenzene	0.400	30.0	± 30.0
1,2-Dichlorobenzene	0.400	30.0	± 30.0
1,2-Dibromo-3-chloropropane	0.010	40.0	± 40.0
1,2,4-Trichlorobenzene	0.200	30.0	± 30.0
1,2,3-Trichlorobenzene	0.200	30.0	± 30.0

[1]For a closing CCV, all target compounds and DMCs must meet a minimum RRF of 0.010 and a maximum percent difference of ±50.0 , except for 1,4-dioxane and 1,4-dioxane-d_8, which must meet a minimum RRF of 0.0050 and a maximum percent difference of ±50.0.

Attachment 4 (Continued)

Technical Acceptance Criteria for Initial and Opening Continuing Calibration Verification for Trace Volatile Organic Compounds

Deuterated Monitoring Compounds	**Minimum RRF**	**Maximum % RSD[1]**	**Maximum % Diff[1]**
Vinyl chloride-d_3	0.010	30.0	± 30.0
Chloroethane-d_5	0.010	40.0	± 40.0
1,1-Dichloroethene-d_2	0.010	30.0	± 30.0
2-Butanone-d_5	0.010	40.0	± 40.0
Chloroform-d	0.010	30.0	± 30.0
1,2-Dichloroethane-d_4	0.010	30.0	± 30.0
Benzene-d_6	0.010	30.0	± 30.0
1,2-Dichloropropane-d_6	0.010	40.0	± 40.0
Toluene-d_8	0.010	30.0	± 30.0
trans-1,3-Dichloropropene-d_4	0.010	30.0	± 30.0
2-Hexanone-d_5	0.010	40.0	± 40.0
1,4-Dioxane-d_8	0.0050	50.0	± 50.0
1,1,2,2-Tetrachloroethane-d_2	0.010	30.0	± 30.0
1,2-Dichlorobenzene-d_4	0.010	30.0	± 30.0

[1]For a closing CCV, all target compounds and DMCs must meet a minimum RRF of 0.010 and a maximum percent difference of ±50.0 , except for 1,4-dioxane and 1,4-dioxane-d_8, which must meet a minimum RRF of 0.0050 and a maximum percent difference of ±50.0.

Attachment 5

COMPUCHEM a division of Liberty Analytical Corp DATE ____/____/____ INITIAL TIME OF TUNE_____ SHIFT/S(A)_____(B)_____(C)____
GC/MS VOLATILE RUN LOG TIME TUNE EXPIRES_____ LINKER /METHOD_____
COMPUCHEM LOGBOOK 11 X 23 (f50052)

PREVENTIVE MAINTENANCE_____

	REJECTED	FILE NAME	REPORTED	pH	Vial	DATE	TIME	Client ID	SDG#	INJ. VOL.*	DF+	CHEMIST	COMMENTS(ETC.)/ DISPOSITION
1						/ /							
2						/ /							
3						/ /							
4						/ /							
5						/ /							
6						/ /							
7						/ /							
8						/ /							
9						/ /							
10						/ /							
11						/ /							
12						/ /							
13						/ /							
14						/ /							
15						/ /							
16						/ /							
17						/ /							
18						/ /							
19						/ /							
20						/ /							
21						/ /							
22						/ /							
23						/ /							
24						/ /							

*On-column sample aliquot
+Not applicable to soil matrix

SUPERVISOR APPROVAL_____ Date_____

Tune (ID #7008) Lot No. _____

Calibration Group Code / Lot No. _____

The presence of the Chemist's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist together with the chemist's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

08/19/04:jad

CompuChem
a division of Liberty Analytical Corporation
501 Madison Avenue
Cary, NC 27513

NELAP accredited

SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire block below (except effective date).

This is a new procedure _____ revised procedure ✓ outdated procedure (archive) _____

- Procedure Code: IP 190 SOP Section #: 2.1.2.3 Revision #: 1

SOP Title: gc/ECD Analysis of Pesticides in Aqueous & Solid Sample Extracts by EPA CLP SOW SOM01.1 and NYSASP

Effective date: (QA fills in) 6/21/06

- Procedure prepared by: Weispass Date: 6/20/06
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) Bob Mann Date: 6-20-06
- Reason for change: Add Revisions for NJ DEP
- This procedure meets the requirements of the following approved method references: "US EPA CLP SOW for Organic Analysis Multi-Media, Multi-Concentration SOM01.1 and New York State Analytical Services Protocol (NYSASP) June 2000, plus revisions"

Procedure approved by Quality Assurance Representative: Date:
(Not needed if signed above)

Effective 1-1-96, on an annual basis: Lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary, indicate by your signature that the SOP has been reviewed.

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Instrument Procedure 190: GC/ECD Analysis of Pesticides in Aqueous and Solid Sample Extracts by EPA CLP SOW SOM01.**1** and NYSASP

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Instrument Procedure 190: GC/ECD Analysis of Pesticides in Aqueous and Solid Sample Extracts by EPA CLP SOW SOM01.**1** and NYSASP

1.0 Scope and Application

This analytical method is designed to analyze water, sediment, and soil from hazardous waste sites to determine the presence and concentration of the chlorinated pesticides found in the Target Compound List (TCL) found in Attachment 1. The method can be used for determining analyte concentrations in the range from the contract required quantitation limits (CRQL) to one million times the CRQL in these matrices when appropriate dilutions are made. The extract is analyzed using the dual column, megabore capillary Gas Chromatography/Electron Capture Detector (GC/ECD) technique.

This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

2.0 Summary of Method

Prior to analysis continuous liquid-liquid or separatory funnel extraction procedures are used for water samples following Sample Preparation Procedure -742 (-1090→-938), "Preparation of Water Samples for the Analysis of Pesticides/ PCBs by CLP and NYSASP". Sonication extraction is required for soil/sediment samples following Sample Preparation Procedure -743 (-251→-940→-938), "Preparation of Soil/Sediment/Sludge Samples for the Analysis of Pesticides/PCBs by EPA CLP SOW SOM01.**1** and NYSASP". Florisil adsorption column cleanup is also specified for both water and soil extracts followed by GC/ECD analysis.

An instrument blank and a Performance Evaluation Mixture (PEM) or an instrument blank and the midpoint concentration of Individual Standard Mixture **C** are analyzed no less than once in every 12-hour analytical sequence in order to monitor retention times, calibration factors, and column performance. Data can be collected only as long as the results for these standards and instrument blanks fall within the acceptable limits. If two consecutive unacceptable standards are run, all extracts run since the previous acceptable calibration verification must be re-analyzed. Therefore, it is desirable to run these standards and blanks more frequently.

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3.0 Definitions

3.1 Contract-Required Quantitation Limits (CRQL)-Reporting limits defined in the contract. GC/MS and GC results may be reported below the CRQL with positive qualitative identification and flagged or qualified as estimated concentration. **(See Attachment 1.)**

3.2 Contract Laboratory Program (CLP) – An analytical services program which provides a contractual framework for laboratories to apply EPA analytical methods for the isolation, detection, and quantitative measurement of volatile, semivolatile, and pesticide/Aroclor target compounds in water and soil/sediment environmental samples.

3.3 Statement of Work (SOW) – part of the documentation for a contract between EPA and a commercial laboratory to perform analyses in support of EPA Superfund programs.

3.4 VTSR – Validated time of sample receipt

3.5 Method detection limit (MDL) – The minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR, Part 136, Appendix B.)

3.6 Reporting Limit – The laboratory reporting limit is based on the lowest multipoint calibration standard concentration. For organic methods, values detected below the reporting limit and above the MDL may be reported and qualified as an estimated concentration.

If the low level standard concentration is not at least three times higher than the MDL value, the standard concentration is adjusted upward in order to achieve this minimal ratio. It may be adjusted higher than three times depending on the concentration range of the calibration curve and the ability to meet method linearity requirements. An exception to this is for CLP methods where the MDL is only required to be lower than the reporting limit.

For CLP the reporting limit is the Contract Required Quantitation Limit (CRQL) for organics.

3.7 Reporting Units – **µ**g/L for water and **µ**g/Kg for soil

3.8 An SDG is defined by the following, whichever is more frequent:

- each 20 field samples received within a case, or
- each 7 calendar day period (3 calendar day period for 7 day turn around) during which field samples in a case are received (14 calendar days if requested by the client) beginning with the receipt of the first sample.

3.9 RT – Retention time

3.10 **INDC** = Individual Standard Mixture **C**

4.0 Interferences

4.1 Contaminants may be present in solvents/reagents, glassware, and other materials used in processing samples. Discrete artifacts and/or elevated baselines may result from these interferences. Materials used in sample preparation and analysis are demonstrated to be free of interferences by processing method blanks. Interferences from phthalates can be minimized by not using plastics in the lab.

Depending on the source of the environmental samples, co-extracted contaminants may cause matrix interferences that may vary from sampling site to sampling site.

5.0 Safety

5.1 Each chemical used in the method should be treated as a potential health hazard since the toxicity or carcinogenicity of each chemical/reagent lab has not been thoroughly determined. Safe handling of chemicals used in this method **must** be practiced. Information concerning the chemicals is available in Material Safety Data Sheets (MSDS). When working with these chemicals/reagents use adequate safeguards (hoods, safety glasses, and lab coats) and if eye or skin contact occurs, flush with large volumes of water.

Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous. During sample preparation glasses, gloves and lab coats are a minimum requirement. The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

5.2 The following analytes in this method have been tentatively classified as known or suspect carcinogens: 4,4′-DDT, 4,4’-DDE, and BHCs.

5.3 Laboratory staff are **required** to review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets for reagents used in the laboratory.

6.0 Equipment and Supplies

6.1 Gas Chromatograph

6.1.1 ThermoQuest Trace 8000 GCs and Varian 3400 GCs equipped with **CTC A2000S/CTC HS500** autosamplers and dual Electron Capture Detectors are used.

6.1.2 Glass or other tee adapters will be used in 0.25 inch injector ports with glass adapters, allowing simultaneous injections onto both columns.

6.1.3 Helium is used as the carrier gas; P-5 (argon/methane) is used as the make-up gas.

6.2 Columns

6.2.1 **Restek Rtx® CLPesticide** (0.**32** mm ID **x 30 m, 0.5 µm film thickness**) fused silica

6.2.2 Restek **Rtx®** CLPesticide II **(0.32 mm ID x 30 m, 0.25 µm film thickness) fused silica**

6.2.3 **Restek universal Y presstight connectors**

6.3 Data system

6.3.1 EZ-Chrom data acquisition system

6.3.2 ThruPut's Quick Form generation software.

6.4 Pipets

6.4.1 Eppendorf adjustable pipet with disposable pipet tips**: 10 – 100 mL; 100 – 1000 µL**

6.4.2 Drummond adjustable pipet with disposable capillary tubes to deliver between 20-100 **µL** volumes

7.0 Reagents and Standards

All standards are prepared by the Organic Standards chemist. Details for the preparation are contained in the standard operating procedures (SOP) for that area (Section 7.0 of the SOP collection.).

7.1 Reagent water – All water used **in this procedure must be reagent-grade Type I with regard to resistivity of > 10 megohm-cm (19th and 20th Editions of Standard Methods, Method 1080), and is demonstrated to meet the blank criteria contained in this Standard Operating Procedure (SOP). It is referred throughout this SOP as DI water.**

7.2 Hexane **–** pesticide quality or equivalent

7.3 Working Standards

7.3.1 **Commercially available s**tandards **are purchased from Restek and are received with m**anufacturer's certificates of analysis**. The certificate documentation is retained for reference purposes**. **Working standards are prepared from the commercial standards in the organic standards preparation lab.**

Note: The concentration and composition of standards used during the sample preparation and cleanup are provided in the sample preparation SOPs. Standards must equilibrate to room temperature before use.

7.3.2 Resolution Check Mixture

7.3.2.1 Prepare in hexane every six months, or sooner, if the solution has degraded or concentrated.

Compounds	Concentration (ηg/mL)
alpha-BHC	10.0
beta-BHC	10.0
delta-BHC	10.0
gamma-BHC	10.0
Aldrin	10.0
Heptachlor	10.0
Heptachlor epoxide	10.0
alpha-Chlordane	10.0
gamma-Chlordane	10.0

Compounds	Concentration (ηg/mL)
Endosulfan I	10.0
Endosulfan II	20.0
4,4′-DDD	20.0
4,4′-DDE	20.0
4,4′-DDT	20.0
Dieldrin	20.0
Endrin	20.0
Endosulfan sulfate	20.0
Endrin ketone	20.0
Endrin aldehyde	20.0
Methoxychlor	100.0
Tetrachloro-m-xylene	10.0
Decachlorobiphenyl	20.0

7.3.3 Performance Evaluation Mixture (PEM)

7.3.3.1 Prepare in hexane every six months, or sooner, if the solution has degraded or concentrated.

Compounds	Concentration (ηg/mL)
gamma-BHC	10.0
alpha-BHC	10.0
4,4′-DDT	100.0
beta-BHC	10.0
Endrin	50.0
Methoxychlor	250.0
Tetrachloro-m-xylene	20.0
Decachlorobiphenyl	20.0

7.3.4 Individual Standard Mixture **C**

7.3.4.1 Prepare in hexane every six months or sooner, if the solution has degraded or concentrated.

7.3.4.2 The low calibration standard concentration corresponds to the CRQL, the midpoint concentration must be 4x the low point concentration and the high point concentration must be at least 16x

the low point concentration. The standard **is** prepared every six months, or sooner if the solutions have degraded or concentrated.

INDC (ηg/mL)					
Compound	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**
alpha-BHC	5.0	10	20	40	80
Heptachlor	5.0	10	20	40	80
gamma-BHC	5.0	10	20	40	80
Endosulfan I	5.0	10	20	40	80
Dieldrin	10	20	40	80	160
Endrin	10	20	40	80	160
4,4'-DDD	10	20	40	80	160
4,4'-DDT	10	20	40	80	160
Methoxychlor	50	100	200	400	800
beta-BHC	**5.0**	**10**	**20**	**40**	**80**
delta-BHC	**5.0**	**10**	**20**	**40**	**80**
Aldrin	**5.0**	**10**	**20**	**40**	**80**
Heptachlor Epoxide (exo-epoxy isomer)	**5.0**	**10**	**20**	**40**	**80**
alpha-Chlordane	**5.0**	**10**	**20**	**40**	**80**
gamma-Chlordane	**5.0**	**10**	**20**	**40**	**80**
4,4'-DDE	**10**	**20**	**40**	**80**	**160**
Endosulfan Sulfate	**10**	**20**	**40**	**80**	**160**
Endrin Aldehyde	**10**	**20**	**40**	**80**	**160**
Endrin ketone	**10**	**20**	**40**	**80**	**160**
Endosulfan II	**10**	**20**	**40**	**80**	**160**
Tetrachloro-m-xylene	5.0	10	20	40	80
Decachlorobiphenyl	10	20	40	80	160

NOTE: Only the exo-epoxy isomer (isomer B) of Heptachlor Epoxide is used as an analytical standard.

7.3.5 Toxaphene Standards

7.3.5.1 Prepare in hexane every six months or sooner, if the solution has degraded or concentrated.

7.3.5.2 The concentrations of the surrogates tetrachloro-m-xylene (TCX) and decachlorobiphenyl (DCB), in each of the five concentration levels is the same as the IND**C** standard.

7.3.5.3 The **concentrations** of Toxaphene in the five calibration standards are 500, 1000, 2000, 4000, and 8000 ηg/mL.

7.4 Standard Solution Storage

7.4.1 Stocks and secondary dilution standards are stored at 4°C (± 2°C) in Teflon®-lined, screw cap amber vials/bottles. Fresh standard should be prepared every six months or sooner if degradation/evaporation occurs.

7.4.2 All working standards are stored at 4°C (± 2°C) in amber glass bottles/vials with Teflon®-lined screw caps and replaced every six months or sooner if degradation/evaporation occurs.

7.4.3 Corrective action SOPs shall be posted on the refrigerators.

8.0 Sample Preservation **and** Storage

8.1 Water samples **are received from clients** collected in 1L (or 1 quart) amber glass containers, fitted with screw caps lined with Teflon. If amber containers are not available, the samples should be protected from light. Soil samples **are received from clients** collected in glass containers or closed-end tubes (e.g.**,** brass sleeves) in sufficient quantity to perform the analysis.

8.2 All samples must be iced or refrigerated at 4°C (± 2°C) from the time of collection until extraction.

8.3 Samples must be protected from light and refrigerated at 4°C (± 2°C) from the time of receipt until 60 days after delivery of a complete reconciled SDG.

8.4 Extracts must be stored at 4°C (± 2°C) until analysis and for 365 days after delivery of a complete reconciled SDG.

8.5 Samples and extracts must be stored in an atmosphere demonstrated to be free of contaminants.

8.6 Water samples must be extracted within 5 days of VTSR, and started within 5 days for continuous liquid/liquid extraction. Soil/sediment samples must be extracted within 10 days of VTSR.

8.7 Samples are preserved and stored according to the tables in Sample Control SOP 4.1, "Receiving Samples" and 4.6, "Storing Samples." Sample holding times are also listed.

8.8 All extracts must be analyzed within 40 days of extraction.

8.9 Prior to analysis, all extracts must be stored in the reach-in refrigerated storage units in the laboratory. After analysis, extracts are returned to Sample Control for long-term storage and disposal.

8.10 Samples are received into the GC Lab by GC chemists from the extractions lab with the appropriate extraction worksheet that also documents chain-of-custody transfers. All extracts are stored refrigerated at 4°C ± 2°C. CLP client extracts are stored in GC Refrigerator #3 or Refrigerator #8. The extraction sheet has the necessary information explaining the extraction procedure (i.e., sample identification number, final volume, sample weight/volume used, lab identification number, dates, whether or not GPC was performed, etc.).

9.0 Quality Control

9.1 Instrument Failure for GC analysis

9.1.1 When linearity is difficult to achieve, verify that the appropriate length of column is inserted in the detector. Examine all column ends and determine if the ends of the columns need to be trimmed.

9.1.2 When the instrument blanks fail, examine the chromatography to determine if there is contamination in the column that is causing the failure. If so, bake the column for 1 hour or less to see if this can be corrected. If the contamination is such that baking for 1 hour does not improve the baseline, it may be necessary to change the liner.

9.1.3 When calibration verifications fail recovery low, verify that the correct peaks are being named. Also verify that the syringe is not plugged and change the septa. If the calibration verification fails again, examine the chromatography to determine if there is a problem with the baseline that is causing the failure. If so, bake the column for 1 hour or less to see if this can be corrected. Also, if the calibration verification is failing on only one

column, the y-splitter may be plugged. If the calibration verification continues to fail, the instrument will need a new calibration curve.

9.1.4 When calibration verifications fail recovery high, verify that the correct peaks are being named. Examine the chromatography to determine if there is contamination on the column that is causing the failure. If so, bake the column for 1 hour or less to see if this can be corrected. If the calibration verification fails again, the instrument will need a new calibration curve.

9.1.5 When the calibration verification fails due to drift, change the septa and verify that all the column fittings are secure. Also, determine if there is contamination on the column that is causing the failure. If so, bake the column for 1 hour or less to see if this can be corrected. If it is not corrected, a new multipoint must be acquired.

9.1.6 All preventive and routine maintenance as mentioned above is recorded in the instrument run log. Major maintenance is recorded in the maintenance log.

9.2 Initial Calibration

9.2.1 Acceptance Criteria

9.2.1.1 The resolution between two adjacent peaks**, when using the single Individual Standard Mixture (C) has to** be $\geq$ **80**.0 % **for all analytes for the primary column**. **For the confirmation column, the resolution for all analytes has to be ≥ 50.0%.**

9.2.1.2 All single component pesticide and surrogate peaks in both runs of the PEM must be $\geq$ 90.0 % resolved on each column.

9.2.1.3 The absolute retention times (RT) of each of the single component pesticides and surrogates in both the PEMs must be within the retention time windows determined from the five-point initial calibration.

9.2.1.4 The percent difference (%D) of the calculated amount and the true amount for each of the single component pesticides AND surrogates in both of the PEMs on both columns must be $\geq$ -25.0 %, and $\leq$ 25.0 %

9.2.1.5 The breakdown of DDT and Endrin in both of the PEMs (bottle #2 and #**14**) must be ≤ 20.0 percent, and the combined breakdown of DDT and Endrin must be ≤ 30.0%.

9.2.1.6 The %RSD of the calibration factors for each single component pesticide is ≤ 20.0 % except alpha-BHC and delta-BHC, both of which must be ≤ 25.0 %.

- The %RSD of the calibration factors for the two surrogates must be ≤ 30.0 %.
- Other than surrogates, the calibration factors of up to two single-component analytes per column may exceed 20.0 % (25% for alpha-BHC and delta-BHC), but must be ≤ 30.0 %.
- The % RSD of the calibration factors for Toxaphene must be ≤ 30.0 %.

If the linearity requirements listed above are met, the calibration factor from the mid-point concentration standard is used for quantitation of each single component pesticide.

9.2.1.7 The resolution between any two adjacent peaks in the midpoint concentrations of Individual Standard Mixture **C** (CS3) in the initial calibration must be **at least** ≥ **80**.0 % **for the primary column and 50.0% for the secondary column**.

9.2.1.8 Instrument blanks must not contain any target analyte ≥ the CRQL.

9.3 Continuing Calibration **Verification**

9.3.1 **See Section 10.2 for frequency of Continuing Calibration Verification.**

9.3.**2** Acceptance Criteria

9.3.**2**.1 All single component pesticides and surrogates in the PEM used to demonstrate continuing calibration must be ≥ 90.0 % resolved. The resolution between any two adjacent peaks in the midpoint concentration of IND**C** (CS3) must be ≥ **80**.**0 for the primary column and 50.0% for the secondary column**.

9.3.**2**.2 All **absolute** RTs for single-component pesticides and surrogates in the PEMs and midpoint **INDC** must be within the RT windows determined from the five-point initial calibration.

9.3.**2**.3 The percent difference of the calculated amount and the amount added (nominal amount) for each of the single component pesticides and surrogates in the PEM**,** used to demonstrate continuing calibration**,** must be $\geq$ -25.0 % and $\leq$ 25.0 %.

9.3.**2**.4 Breakdown for endrin and DDT separately must be $\leq$ 20.0 % on each column. The combined breakdown of both DDT and endrin must be $\leq$ 30.0 % on each column.

9.3.2.5 The percent difference between the CF of each single component pesticide and surrogate in the INDC (CS3), used to demonstrate calibration verification, and the mean CF from the initial calibration must be ≥ -20.0% and ≤ 20.0%.

9.3.**2.6** Instrument blanks must not have any target analytes detected at $\geq$ the CRQL, and surrogates must be within the RT windows.

9.4 Acceptance Criteria for Chromatograms of Calibration Standards

9.4.1 Chromatograms for the Resolution Check Mixture, the Performance Evaluation Mixture, and Individual Standard Mixture **C** during the initial calibration sequence must display the single component analytes at greater than 10% of full scale but less than 100% of full scale.

9.4.2 The chromatograms, for at least one of the five analyses of Individual Standard Mixtures **C** from the initial calibration sequence, must display the single component analytes at greater than 50% and less than 100% of full scale.

9.4.3 The chromatogram for at least one of the five analyses of the Toxaphene standards analyzed during the initial calibration must display the peaks chosen for identification at greater than 25% and less than 100% of full scale.

9.4.4 For any standard containing alpha-BHC, the baseline of the chromatogram must return to below 50% of full scale before the elution time of alpha-

BHC, and return to below 25% of full scale after the elution time of alpha-BHC and before the elution time of decachlorobiphenyl.

9.4.5 If a chromatogram is replotted electronically to meet requirements, the scaling factor used must be displayed on the chromatogram.

Note: While the Target software does not provide a scaling factor, it does indicate intensity values.

9.4.6 If a chromatogram is replotted electronically to meet these requirements, both the initial chromatogram and the replotted chromatogram must be submitted in the data package.

9.5 Blanks

There are three types of blanks required by this method: method blanks, sulfur cleanup blanks, and instrument blanks.

9.5.1 Method Blanks. Method blanks**, extracted each time samples are extracted (up to 20 field samples excluding MS/MSDs, PE samples and LCSs),** are spiked with the surrogate solution, extracted, cleaned up, and analyzed by the same procedure as the samples. Water method blanks are one liter of reagent water treated as a water sample, while soils are 30 g of sodium sulfate treated as a soil sample.

Note: The following acceptance criteria apply independently to each column.

9.5.1.1 Method blanks must be analyzed on each GC/EC system used to analyze samples.

9.5.1.2 Method blanks cannot contain any target analytes at levels equal to or greater than the CRQL.

9.5.1.3 Surrogate acceptance criteria MUST be met.

9.5.1.4 Surrogate RTs must be within the RT windows from the initial calibration as described in section **10**.0.

9.5.1.5 All samples associated with an unacceptable method blank must be re-extracted and reanalyzed.

9.5.2 Sulfur Cleanup Blank. A modified form of the method blank, it is hexane spiked with the surrogates and passed through the sulfur cleanup procedure with samples. Refer to Sample Preparation Procedure –946, "Sulfur Cleanup of Pesticide and PCB Extracts by Copper or Tetrabutylammonium (TBA) Sulfite by CLP, SW-846 and NYSASP."

Note: The following acceptance criteria apply independently to each column.

9.5.2.1 The sulfur cleanup blank is prepared when only part of a set of samples extracted together requires sulfur cleanup, and is associated only with the part of the set that requires sulfur cleanup. If all samples in a given SDG require sulfur cleanup, then the method blank must be subjected to sulfur cleanup, and no sulfur cleanup blank is required.

9.5.2.2 The sulfur cleanup blank also cannot contain any target analytes equal to or above the CRQLs, and the RTs of both surrogates must be within the RT window calculated during the initial calibration.

9.5.2.3 All samples associated with an unacceptable sulfur cleanup blank must be re-extracted.

9.5.2.4 Surrogate acceptance criteria MUST be met.

9.5.3 Instrument Blank. An instrument blank**, the first analysis in a 12-hour long sequence,** is a hexane solution containing 20.0 ηg/mL of tetrachloro-m-xylene and 40.0 ηg/mL decachlorobiphenyl. **All groups of acceptable analyses must be preceded and followed by acceptable instrument blanks.**

Note: The following acceptance criteria apply independently to each column.

9.5.3.1 All acceptable sample analyses are to be bracketed by acceptable instrument blanks.

9.5.3.2 The instrument blank must demonstrate that no target analyte is detected at equal to or greater than the CRQL and that the surrogate RTs are within the established RT criteria.

9.5.3.3 If analytes are detected at greater than the CRQL or the surrogate RTs are outside the RT windows, all data collection must be stopped and an acceptable instrument blank run before samples can be analyzed. All samples run between the last acceptable instrument blank and one that fails must be re-analyzed.

9.6 Matrix Spikes/Matrix Spike Duplicate (MS/MSD)

9.6.1 An MS/MSD must be performed at least once every SDG, extracted and analyzed within holding times, and analyzed on an instrument meeting initial calibration verification and blank technical acceptance criteria.

9.6.2 The surrogate RTs must be within the RT windows.

9.6.3 Recovery limits and RPD are advisory, and the EPA dictates no action.

Compound	%Rec. Water	RPD Water	%Rec. Soil	RPD Soil
gamma-BHC	56-123	**0**-15	46-127	**0**-50
Heptachlor	40-131	**0**-20	35-130	**0**-31
Aldrin	40-120	**0**-22	34-132	**0**-43
Dieldrin	52-126	**0**-18	31-134	**0**-38
Endrin	56-121	**0**-21	42-139	**0**-45
4, 4'-DDT	38-127	**0**-27	23-134	**0**-50

9.7 Laboratory Control Sample (LCS)

9.7.1 A Laboratory Control Sample (LCS) is prepared and analyzed with each extraction batch.

9.7.2 The technical acceptance requirements apply independently to each GC column.

9.7.3 The LCS must be analyzed on a GC/ECD system meeting initial calibration, calibration verification, and blank technical acceptance criteria.

9.7.4 The surrogate RTs must be within the RT windows.

9.7.5 The percent recovery for each of the compounds in the LCS (water and soil/sediment) must be within the recovery limits presented below.

9.7.6 Surrogate recoveries must fall within the limits of 30-150% and the limits are not advisory.

Compounds	% Recovery
gamma-BHC	50-120
Heptachlor epoxide	50-120
Dieldrin	30-130
4,4′-DDE	50-150
Endrin	50-120
Endosulfin sulfate	50-120
gamma-Chlordane	30-130

9.7.7 If the acceptance criteria for the surrogates or the LCS compounds are not met, check calculations, spiking solutions, and instrument performance.

9.7.7.1 LCS technical acceptance criteria must be met before reporting any data.

9.7.7.2 LCS contamination or any LCS not meeting the technical acceptance criteria will require re-extraction and reanalysis of the LCS, along with all samples and required blanks (including MS/MSD and PE samples).

9.8 Sample Data Acceptance Criteria.

9.8.1 Requirements apply to both columns, and quantitations must be reported from both GC columns.

9.8.2 Surrogate acceptance limits are 30-150% for both tetrachloro-m-xylene and decachlorobiphenyl. Up to one surrogate may fail per column and the limits don't apply to dilutions.

9.8.3 The RT for both of the surrogates must be within the RT windows for both columns.

9.8.4 All samples must be analyzed as part of a valid analysis sequence, and must be bracketed by acceptable instrument blanks, Performance Evaluation Mixtures, and Individual Standard Mixture **C**, that were analyzed at the required frequency.

9.8.5 Reportable data for a sample must include a chromatogram with a baseline returning to < 50% of full scale before the elution of alpha-BHC, and to <25% of full scale after alpha-BHC but before the elution of decachlorobiphenyl.

9.8.6 For specifics regarding acceptable sample dilutions, see Section 11.0 below. **No target compound responses may exceed the upper limit responses of the initial calibration.**

9.8.7 The LCS associated with the samples must meet the technical acceptance criteria.

9.9 Surrogates

9.9.1 Two surrogates are used, 2,4,5,6-Tetrachloro-m-xylene (TCX) and Decachlorobiphenyl (DCB), and must be added to all samples, blanks, blank spikes (BS), MS, and MSDs prior to extraction. The RT of both surrogates must fall within the RT windows for an analysis to be acceptable. Surrogate recoveries are mandatory for blanks.

9.10 If Toxaphene is detected in a sample, a corresponding standard must be run within 72 hours of sample analysis. This standard is used for identification only. Quantitation is based on the mean calibration factor from the initial calibration.

9.11 Contingency

9.11.1 If, due to a lab accident or to QC failure, a re-preparation is required for the sample and insufficient volume remains, the Project Manager must be alerted and will contact the client for direction on how to proceed. For the CLP, the Sample Management Office must be contacted.

9.11.2 If persistent contamination occurs in the laboratory, analyses must be halted until the source can be identified and isolated. When the contamination issue is resolved, sample analyses may proceed.

9.11.3 Any other issues that potentially affect data quality should be addressed with the Project Manager.

10.0 Calibration and Standardization

10.1 Initial Calibration

10.1.1 Analysis begins with an initial demonstration of instrument performance and the calibration of all pesticides and Toxaphene. Initial calibration must be repeated whenever calibration verification fails, or when major instrument maintenance is performed (replacing a column, baking out the detector, etc.)

10.1.2 Analytical Sequence

10.1.2.1 Before any samples can be analyzed, an acceptable initial calibration sequence must be run.

10.1.2.2 For single component analytes and Toxaphene the initial calibration consists of five points.

10.1.2.**3** The initial calibration standards are analyzed in order in positions (or bottles) 1-**14** on the autoanalyzer as follows:

1. Resolution Check
2. Performance Evaluation Mixture (PEM)
3. Toxaphene CS1
4. Toxaphene CS2
5. Toxaphene CS3
6. Toxaphene CS4
7. Toxaphene CS5
8. CS1 Individual Standard Mix **C**
9. CS2 Individual Standard Mix **C**
1**0**. CS3 Individual Standard Mix **C**
1**1**. CS4 Individual Standard Mix **C**
1**2**. CS5 Individual Standard Mix **C**
13. Instrument Blank
14. Performance Evaluation Mixture

10.1.2.5 Calibration and analysis sequence specifications of the GC/ECD method apply independently to both GC columns.

10.1.2.6 After the initial calibration, the analytical sequence may continue as long as acceptable instrument blanks, Performance Evaluation Mixtures, and Individual Standard Mixture **C** are analyzed at the required frequency and meet acceptance criteria.

A full sequence is performed as follows:

Time	Bottle/Position	Standards/Samples
	1-**12**	Initial Calibration
0 hour	1**3**	Instrument Blank at the end of ICal
	14	PEM at the end of ICal
	15	First Sample
		Subsequent Samples
12 hours		Last Sample
	1st inj. past 12 hours	Instrument Blank
	2nd injection samples	Mid **INDC**
		Samples
12 hours		Last Sample
	1st inj. past 12 hours	Instrument Blank
	2nd injection	PEM
		Samples
12 hours		Last Sample

10.1.2.7 The first 12 hours begin with injection #**13** (the instrument blank at the end of the initial calibration), and NOT from injection #1. Samples may be INJECTED until 12 hours have elapsed.

10.1.2.8 An analytical sequence must include all required QC: blanks, blank spikes, matrix spikes, and matrix spike duplicates.

10.2 Continuing Calibration Verification

10.2.1 Three types of analyses are used to verify the calibration and evaluate instrument performance. Instrument Blanks, PEM's, and the mid-point concentration of IND**C** (CS3) constitute the continuing calibration.

10.2.2 Each 12-hour period during which sample data are collected must be bracketed on one end by an Instrument Blank (IB) plus a PEM and on the other end by an IB plus the mid point concentration of IND**C**.

10.2.3 For the 12-hour period immediately following the initial calibration sequence, the IB and PEM that are the last two steps in the initial calibration sequence are considered to bracket the front end of that 12-hour period. The injection of the IB starts the beginning of the 12-hour period. Samples may be INJECTED for 12 hours from the injection of

the IB. The **two** injections immediately following that 12-hour period must be an IB and IND**C**. The IB must be analyzed first and **then** the IND**C**.

10.2.4 The analyses of the IB **and** IND**C** immediately following one 12-hour period may be used to begin the subsequent 12-hour period, provided they meet acceptance criteria. The subsequent 12-hour period must end with the acceptable analyses of an IB and a PEM, in that order. Those two analyses may in turn be used to bracket the front end of yet another 12-hour period. This progression may continue every 12 hours until such time as any of the IBs, PEMs, or IND**C** **standards** fail to meet acceptance criteria. Each 12-hour period begins with the injection of the IB.

10.2.5 If more than 12 hours have elapsed since the injection of an IB that bracketed a previous 12-hour period, an acceptable IB and PEM MUST be analyzed in order to start a new sequence. This applies even if no analyses were performed since that standard was injected.

10.2.6 After a break in sample analyses, sample analysis may proceed, using the current initial calibration for quantitation, by first analyzing an acceptable IB and PEM.

10.2.7 If sample analyses are completed and there is time remaining in the 12 hour tune, the shortened sequence MUST be ended with either the IB/PEM combination or the IB/IND**C** combination, whichever was due to be performed at the end of the 12-hour period.

10.2.8 If the PEM or Individual Standard Mixture **C** do not meet acceptance criteria they must be immediately re-injected and if they then meet acceptance criteria, analyses may continue. If the second injection doesn't meet criteria, all analyses must be stopped and corrective action taken. If the corrective action involves changing the septa, changing the liner, or baking, re-inject the standard. If any other corrective action is taken, then a new initial calibration performed.

10.2.9 Carryover of late eluting peaks into the next injection is not acceptable. Instrument blanks and standards may have to be run at a greater frequency to avoid discarding data.

10.2.10 No more than 14 hours are allowed to lapse from the injection beginning the opening CCV and the injection ending the closing CCV (PEM or Individual Standard Mixture **C**).

10.3 Linearity

10.3.1 The high point concentration defines the upper end of the concentration, or linear range.

10.3.2 The linearity of the instrument is determined by calculating a percent relative standard deviation (%RSD) of the calibration factors from a five-point calibration curve for each single component pesticide, Toxaphene and surrogates. **P**eak area **is** used to calculate calibration factors used in the %RSD equation.

10.3.3 If the linearity requirements listed above are met, the mean calibration factor from the initial calibration standards are used for quantitation of each single-component pesticide and Toxaphene.

10.4 Determination of Absolute Retention Times

10.4.1 During the initial calibration sequence, absolute RTs are determined for all single response pesticides, Toxaphene, and the surrogates.

10.4.2 For single component pesticides an RT is measured in each of **the** five **Individual Standard Mixture C** calibration standards. The mean RT is calculated as the average of the five values. For surrogates, an RT is measured from each of the **five** analyses of Individual Mixture **C**, and the mean RT is calculated as the average of the five values.

10.4.3 For Toxaphene, an RT is measured in each of the five calibration standards for 3, 4, or 5 of the major peaks.

10.4.4 An RT window is calculated for each single component analyte and surrogate by using the following list. Windows are centered around the mean absolute retention time for the analyte established during the initial calibrations. Retention time windows are set as follows:

Compound	RT window(min)
alpha-BHC	± 0.05
beta-BHC	± 0.05
gamma-BHC	± 0.05
delta-BHC	± 0.05
Heptachlor	± 0.05
Aldrin	± 0.05

Compound	RT window(min)
alpha-Chlordane	± 0.07
gamma-Chlordane	± 0.07
Heptachlor epoxide	± 0.07
Dieldrin	± 0.07
Endrin	± 0.07
Endrin Aldehyde	± 0.07
Endrin Ketone	± 0.07
DDD	± 0.07
DDE	± 0.07
DDT	± 0.07
Endosulfan I	± 0.07
Endosulfan II	± 0.07
Endosulfan sulfate	± 0.07
Methoxychlor	± 0.07
Toxaphene	± 0.07
TCX	± 0.05
DCB	± 0.10

10.4.5 Analytes are identified when peaks are observed in the RT window for the compound on both GC columns.

11.0 Procedure

Documentation must follow the requirements in Q**uality** C**ontrol** SOP **13.6 "**Proper Documentation Procedures**"**. The analyst must complete all information fields in the run log (Attachment **2**.)

11.1 Analysis of a sample on BOTH GC columns is required for ALL samples, blanks, matrix spikes, matrix spike duplicates and LCSs, whether pesticides are detected on the primary column or not.

11.2 Sample analysis may not begin until a satisfactory calibration has been demonstrated.

11.3 GC Operating Conditions. The following are the GC analytical conditions:

11.3.1 Carrier gas

11.3.1.1 Helium

11.3.1.2 Flow rate: 10 mL/minute

11.3.2 Make-up gas

11.3.2.1 Argon/methane (P - 5)

11.3.3 Injector temperature**:** 225° C

11.3.4 Detector (ECD) temperature**:** 330° C

11.3.5 Injection volume**:** 1 **µL** per column

11.3.6 Initial oven temperature**:** 150° C

11.3.7 Initial hold time**:** 1.0 minute

11.3.8 Temperature ramp**:** 6° C/minute

11.3.9 Final temperature**:** 275° C

11.3.10 Final hold time**:** 1.0 minute

11.4 Sample Analysis and Acceptance Criteria

11.4.1 A single component pesticide is identified if a peak is detected within the target retention time window on each of two columns. Toxaphene is identified primarily by pattern recognition, but RTs of 3 to 5 major peaks must also be taken into consideration. The absolute RT window is calculated during initial calibration from the mean RT of the standards.

11.4.2 The ECD response for all analytes must be within the five-point calibration range. If not, the extracts must be diluted.

11.4.3 Quantitation must be performed and reported for both GC columns.

11.4.4 If sample chromatograms have interfering or off-scale peaks or a high baseline, then those samples must be diluted, subjected to sulfur cleanup, or re-extracted. Samples that still do not meet acceptance criteria after one re-extraction with the three-step cleanup (GPC, Florisil, and sulfur) can be reported without further analysis as long as they are discussed in the SDG narrative. Failures based on method blanks, however, must include additional extractions.

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If words above are not highlighted, this is an uncontrolled copy of this document.

11.4.5 A standard for Toxaphene must be analyzed on the same instrument and column within 72 hours of its detection in a sample, with a valid 12-hour sequence.

11.4.6 Sample Dilutions

11.4.6.1 The sample must be analyzed at the most concentrated level while still achieving satisfactory chromatography.

11.4.6.2 If an acceptable chromatogram is achieved with the diluted extract, an additional analysis 10 times the concentration of the diluted sample must be performed and reported with the sample data.

11.4.6.3 If the dilution factor is less than or equal to 10, an undiluted sample extract must be injected and reported. If the most concentrated extract doesn't meet dilution requirements of having no target analytes exceeding the upper limit of the initial calibration, then the analysis is at no additional cost to the laboratory.

11.4.6.4 If the response of any single component pesticide is greater than the response of the high standard (CS5) of the initial calibration on both columns, then the extract must be diluted and the response of the pesticide compounds(s) in the diluted extract must be between the initial calibration low and high point standards.

11.4.6.5 For Toxaphene, if the response of the largest peak is greater than the response of the corresponding Toxaphene peak in the high level standard from the initial calibration on both columns, then the sample must be diluted. The response of the largest peak in the dilution of the Toxaphene must be between the responses of the low and high level single component standards from the initial calibration.

11.4.6.6 Do not dilute the MS/MSD solely to get non-spike analytes within the calibration range.

11.4.6.7 If more than two analyses are required to get all target compounds within the calibration range, contact the **client** for guidance.

11.4.7 Sample Chromatograms

11.4.7.1 If no analytes are identified in a sample, the chromatogram of the sample must use the same scaling factor as the low point standard of the initial calibration.

11.4.7.2 Chromatograms must display single component pesticides detected in the sample at less than full scale.

11.4.7.3 Chromatograms must display the largest peak of any Toxaphene detected in the sample at less than full scale.

11.4.7.4 If an extract is diluted, chromatograms must display single component pesticides between 10 and 100 percent of full scale.

11.4.7.5 If an extract is diluted, chromatograms must display the peaks chosen for quantitation of Toxaphene between 25 and 100 percent of full scale.

11.4.7.6 For any sample, the baseline of the chromatogram must return to below 50% of full scale before the elution time of alpha-BHC, and return to below 25% of full scale after the elution time of alpha-BHC and before decachlorobiphenyl.

11.5 GC/MS Confirmation of Pesticides and Aroclors

11.5.1 Any pesticide or Aroclor analyte for which a concentration is reported from a GC/EC analysis must have the identification confirmed by GC/MS if the concentration is sufficient for that purpose.

GC/MS confirmation take place if pesticide concentrations are $\geq$ 5 ηg/µL for both columns for single components and 125 ηg/µL for both columns for Toxaphene. A GC/MS confirmation analysis also takes place if a pesticide is detected as a TIC in the semivolatile analysis and is also detected by GC/ECD. The GC/MS confirmation may be accomplished by one of the following:

11.5.1.1 examination of the semivolatile GC/MS library search results (TICs),

11.5.1.2 a second analysis of the semivolatile extract, or

11.5.1.3 analysis of the pesticide/Aroclor extract following solvent exchange.

11.5.2 If an analyte cannot be confirmed by either of the first two procedures listed above, then the pesticide/Aroclor extract must be analyzed by GC/MS following solvent exchange.

11.5.2.1 In order to confirm the identification of the target pesticide/Toxaphene, the GC/MS laboratory must also analyze a reference standard for the analyte at a concentration no greater than 10 ηg / 2 µL for single component pesticides and 125 ηg/µL for Toxaphene. This reference standard for single component pesticides may be included in the semivolatile continuing calibration standard or analyzed separately.

11.5.3 Regardless of which of the three approaches above is used for GC/MS confirmation, the appropriate blank must also be analyzed by GC/MS.

11.5.3.1 If the confirmation is based on the analysis of the semivolatile extract, the semivolatile method blank must be injected.

11.5.3.2 If the confirmation is based on the analysis of the pesticide extract, the pesticide method blank must be injected on the GC/MS instrument.

11.5.4 If the identification of the analyte cannot be confirmed by GC/MS, the analyte is then reported as undetected and the sample quantitation limit is adjusted to an equivalent concentration of the GC/MS reference standard. Unconfirmed analytes are qualified with a laboratory-defined footnote on the Form 1, and this is explained in the SDG narrative.

11.5.5 Pesticide results that are confirmed by GC/MS are flagged with a "C" on Form 1.

11.5.6 For single component analytes, the required deliverables are copies of the library search results (three best TIC matches) or analyte spectrum and the spectrum of the reference standard. For Toxaphene, spectra of three characteristic peaks are required for both the sample component and the reference standard.

12.0 Data Analysis & Calculations

12.1 Quantitation of Analytes

Calculations must be consistent with the QC SOP: Numerical Data Reduction.

12.1.1 If analytes are detected below the CRQL, they are reported and flagged with a "J" to indicate the value is estimated.

12.1.2 If target analytes are detected at a level greater than the high calibration point, the sample must be diluted either to a maximum of 1:100,000 or until the response is within the upper half of the linear range. If response is still out of range after a 1:100,000 dilution, **the client** should be contacted.

12.1.3 If a dilution is done solely to bring a peak within the calibration range or to get the Toxaphene pattern on scale, the results for both the more and the less concentrated extract must be reported. The changes in quantitation limits and surrogate recovery are affected by sample dilutions.

12.1.4 The quantitation of Toxaphene is done by comparing areas of each of three to five major peaks of the sample with the mean calibration factor for the same peaks established in the initial calibration. The concentration of each peak is determined in this way, and then an average concentration for three to five major peaks is determined and reported on Form I.

12.2 Calculation of the mean or average of a set of values (also used for Mean Calibration Factor, $\overline{CF}$)

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where: n = total number of values
x_i = each individual value used to calculate the mean
x = the mean of n

12.3 Calculation of the standard deviation of a set of values:

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n}\left(X_n - \overline{X}\right)^2}{n-1}}$$

12.4 Calculation of percent recovery:
12.4.1 LCS and surrogates:

$$\%R = \frac{Amount\ found}{Amount\ spiked}\ x\ 100$$

12.4.2 Matrix spikes:

$$\%\ R = \frac{Amount\ in\ spiked\ sample - Amount\ in\ unspiked\ (native)\ sample}{Amount\ spiked}\ x\ 100$$

12.5 Calculation of % RSD

$$\%RSD = \left(\frac{Standard\ deviation}{\bar{X}}\right) \times 100$$

12.6 Calculation of RPD

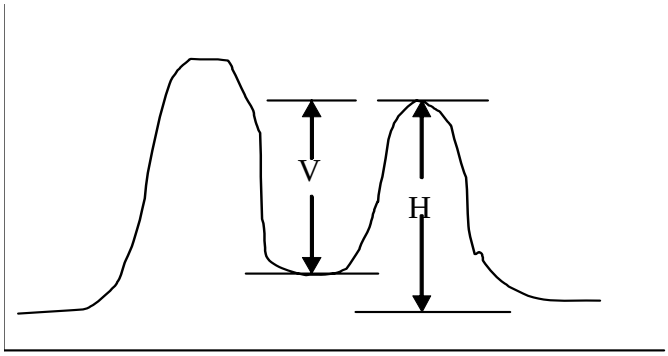
$$RPD = \frac{|Value\ 1 - Value\ 2|}{(Value\ 1 + Value\ 2)/2} x100$$

12.7 Calculation of %Difference (%D)

$$\%Diff = \frac{Value - \overline{Reference\ value}}{\overline{Reference\ value}}\ x\ 100$$

12.8 Calculation of Resolution

The calculation of resolution between the analyte in the Resolution Check Mixture, the Performance Evaluation Mixture, and the midpoint concentration of Individual Standard Mixtures A and B is performed as follows:



where: x axis = time
y axis = peak area or height
V = depth of the valley between two adjacent peaks. The depth of the valley is measured along a vertical line from the level of the apex of the shorter peak to the floor of the valley between the two peaks.
H = height of the shorter of the two adjacent peaks

$$\%\ Resolution = \frac{V}{H}\ x\,100$$

12.9 Breakdown in PEMs

$$\%\,breakdown\,DDT = \frac{Amount\,(\eta g)\,DDD + DDE\ \ found}{Amount\,(\eta g)\,DDT\ injected}\ x\,100$$

$$\%\,breakdown\,endrin = \frac{Amount\,(\eta g)\,endrin\,aldehyde + endrin\,ketone\ \ found}{Amount\,endrin\,injected}$$

$$Combined\ \%\,breakdown = \%\,breakdown\,DDT + \%\,breakdown\,endrin$$

12.10 Calibration Factor (See 12.2 for calculation of Mean Calibration Factor $\overline{CF}$)

$$CF = \frac{peak\ area\,(or\ height)}{mass\,injected\,(\eta g)}$$

12.11 Concentration

12.11.1 Quantitative analysis of pesticides and Toxaphene must be accomplished by the external standard method. Five-point calibration curves for single component analytes, Toxaphene and the surrogates must be generated during the initial calibration. A linear response range must be demonstrated from the Contract Required Quantitation Limits (CRQL) to a high point at least 16 times greater than the CRQL.

12.11.2 Concentration in aqueous samples

$$\mu g / L = \frac{(Ax)(Vt)(DF)(GPC)}{(\overline{CF})(Vo)(Vi)}$$

where:

Ax = area of the peak for the compound to be measured
$\overline{CF}$ = Mean calibration factor from the initial calibration
Vo = volume of water extracted (mL)
Vi = volume of extract injected (μ**L**)
Vt = volume of the concentrated extract (**μL**)
Df = dilution factor. If no dilution, Df = 1.0
GPC = GPC factor (If no GPC is performed, GPC = 1.0; if GPC is performed, then GPC = 2.0)

12.11.3 Concentration in soil samples (dry weight basis)

$$\mu g / kg = \frac{(Ax)(Vt)(Df)(GPC)}{(\overline{CF})(Vi)(Ws)(D)}$$

where:

Ax and $\overline{CF}$ = same as for water
Vt = Volume of concentrated extract in μl (5000 μL)
Vi = Volume of extract injected in μl
Ws = weight of sample extracted, in grams
Df = Dilution factor
GPC = GPC factor = 2
D = Dry weight factor (% moisture) = $\frac{100 - \%\ \text{moisture}}{100}$

12.12 Calculating Dilutions

If a sample concentration exceeds the high level standard a dilution must be performed. Determine a level of dilution that will result in a value within the

calibration range. This is an acceptable dilution. A 10x dilution is performed using 1 mL sample plus 9 mL diluent for a total volume of 10 mL. It should be recorded on the run log as "10x (1 mL in 10 mL)."

12.12.1 Dilution factor

$$Dilution\ factor = \frac{\mu L\ most\ conc.\ extract\ used\ to\ make\ dilution + \mu L\ clean\ solvent}{\mu L\ most\ conc.\ extract\ used\ to\ make\ dilution}$$

13.0 Method Performance

This method was validated through in-house laboratory studies of method detection limits and precision and accuracy for single analyst**.** The data are retained by the QA department.

14.0 Pollution Prevention

The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 thing. **See SOP 12.1, Hazardous Waste Disposal, regarding laboratory procedures for recycling solvent waste streams.**

15.0 Waste Management

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Samples preserved with HCl or H_2SO_4 to pH <2 are hazardous and must be handled as hazardous waste.

Refer to the Hazardous Waste Management and Safety SOPs located in the lab.

16.0 References

16.1 USEPA CLP SOW for Organic Analysis, Multi-media, Multi Concentration SOM01.**1** (**May 2005**)

16.2 Standard Methods for the Examination of Water and Wastewater, 20th **Edition** (1998), Method 1080

16.3 New York State Analytical Services Protocol (NYSASP), June 2000 plus revisions

16.4 Q**uality** C**ontrol** SOP **13.6 "**Proper Documentation Procedures**"**

16.5 Q**uality** C**ontrol** SOP **13.4 "**Numerical Data Reduction**"**

16.6 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477.

16.7 Hazardous Waste Management & Safety SOPs: "Hazardous Waste Disposal" and "Spill Control & Cleanup."

16.8 NELAC Standards, July **2003**, plus revisions

16.9 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995.

16.10 New York State Environmental Laboratory Approval Program, Certification Manual, **December 2005**, plus revisions.

16.11 CompuChem Quality Manual, Revision **7**, **Update 1, 12/13/05**

16.12 Sample Control SOP 4.1, "Receiving Samples"

16.13 Sample Control SOP 4.6, "Storing Samples"

16.14 Sample Preparation Procedure –946, "Sulfur Cleanup of Pesticide and PCB Extracts by Copper or Tetrabutylammonium (TBA) Sulfite by CLP, SW-846 and NYSASP."

16.15 Sample Preparation Procedure -742 (-1090-->-938), "Preparation of Water Samples for the Analysis of Pesticides/ PCBs by CLP and NYSASP"

16.16 Sample Preparation Procedure -743 (-251→-940→-938), "Preparation of Soil/Sediment/Sludge Samples for the Analysis of Pesticides/PCBs by EPA CLP and NYSASP"

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.1 Attachment 1 - Target Compound List and CRQLs

17.2 Attachment 2 - **GC Run Log**

Attachment 1

The Target Compound List (TCL) of analytes, together with their Contract Required Quantitation Limits (CRQL), in the proper reporting units.

Target Compound	CAS No.	CRQLs	
		Water µg/L	Soil µg/Kg
alpha-BHC	319-84-6	0.050	1.7
beta-BHC	319-85-7	0.050	1.7
delta-BHC	319-86-8	0.050	1.7
gamma-BHC (Lindane)	58-89-9	0.050	1.7
Heptachlor	76-44-8	0.050	1.7
Aldrin	309-00-2	0.050	1.7
Heptachlor epoxide	1024-57-3	0.050	1.7
Endosulfan I	959-98-8	0.050	1.7
Dieldrin	60-57-1	0.10	3.3
4,4′-DDE	72-55-9	0.10	3.3
Endrin	72-20-8	0.10	3.3
Endosulfan II	33213-65-9	0.10	3.3
4,4′-DDD	72-54-8	0.10	3.3
Endosulfan sulfate	1031-07-8	0.10	3.3
4,4′-DDT	50-29-3	0.10	3.3
Methoxychlor	72-43-5	0.50	17
Endrin ketone	53494-70-5	0.10	3.3
Endrin aldehyde	7421-93-4	0.10	3.3
alpha-Chlordane	5103-71-9	0.050	1.7
gamma-Chlordane	5103-74-2	0.050	1.7
Toxaphene	8001-35-2	5.0	170

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Attachment 2

COMPUCHEM a division of Liberty Analytical Corp Instrument ID 82 / 83 DATE ___/___/___

GC EXTRACTABLES RUN LOG Sequence ID: _____ SHIFT/S(A) ____ (B)

COMPUCHEM LOGBOOK 4 M(4) 20 Amt. Inj. 2 ul (1 ul on column)

Method : 8081A 8082 8151A CLP Other _____

	FILE NAME	DATE	CompuChem #	CASE/SDG#	CHEMIST	COMMENTS(ETC.)/DISPOSITION
1		/ /				
2		/ /				
3		/ /				
4		/ /				
5		/ /				
6		/ /				
7		/ /				
8		/ /				
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21		/ /				
22		/ /				
23		/ /				
24		/ /				

The presence of the Chemist's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist together with the chemist's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

12/08/04:jad

SUPERVISOR APPROVAL _____

DATE _____ Hexane Lot No _____

CompuChem
a division of Liberty Analytical Corporation
501 Madison Avenue
Cary, NC 27513

NELAP accredited

SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire block below (except effective date).

This is a new procedure _____ revised procedure ✓ outdated procedure (archive) _____

- Procedure Code: IP 1500 SOP Section #: 2.1.2.4 Revision #: 1

SOP Title: GC/ECD Analysis of Polychlorinated Biphenyls (PCBs) as Aroclors in Water & Soil Extracts by CLP SOW SOM01.1

Effective date: (QA fills in) 6/21/06

- Procedure prepared by: Keepass Date: 6/20/06
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) Bob Miller Date: 6-20-06
- Reason for change: Revisions requested by NJ DEP
- This procedure meets the requirements of the following approved method references: US EPA CLP SOW for "Organic Analysis, Multi-Media, Multi-Concentration" SOM01.1

Procedure approved by Quality Assurance Representative: ORIGINAL Date:
(Not needed if signed above)

Effective 1-1-96, on an annual basis: Lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary, indicate by your signature that the SOP has been reviewed.

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Instrument Procedure 1500: GC/ECD Analysis of Polychlorinated Biphenyls (PCBs) as Aroclors in Water and Soil Extracts by CLP SOW SOM01.**1**

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Instrument Procedure 1500: GC/ECD Analysis of Polychlorinated Biphenyls (PCBs) as Aroclors in Water and Soil Extracts by CLP SOW SOM01.**1**

1.0 Scope and Application

This procedure is used to determine the concentration of various polychlorinated biphenyls (PCBs) as Aroclors in extracts from solid and liquid matrices. Open-tubular, capillary columns are employed with electron capture detectors (ECD). The following are amenable to analysis using this method:

Compound Name	CAS Registry No.
Aroclor-1016	12674-11-2
Aroclor-1221	11104-28-2
Aroclor-1232	11141-16-5
Aroclor-1242	53469-21-9
Aroclor-1248	12672-29-6
Aroclor-1254	11097-69-1
Aroclor-1260	11096-82-5
Aroclor-1262	37324-23-5
Aroclor-1268	11100-14-4

Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

2.0 Summary of Method

Aqueous and solid sample extracts are analyzed using a gas chromatograph equipped with an electron capture detector (GC/ECD).

The analysis is performed using the dual column option where a Y-splitter joins a single injection port with two dissimilar analytical columns. In this manner, confirmation may be performed simultaneously with the primary analysis. **T**he extract is analyzed by

injecting 2 μL (1 μL per column) into a GC with dual wide-bore, fused silica, capillary columns.

3.0 Definitions

3.1 Method detection limit (MDL) – The minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR, Part 136, Appendix B.)

3.2 Reporting Limit – The laboratory reporting limit is based on the lowest multipoint calibration standard concentration. For organic methods, values detected below the reporting limit and above the MDL may be reported and qualified as an estimated concentration.

If the low level standard concentration is not at least three times higher than the MDL value, the standard concentration is adjusted upward in order to achieve this minimal ratio. It may be adjusted higher than three times depending on the concentration range of the calibration curve and the ability to meet method linearity requirements. An exception to this is for CLP methods where the MDL is only required to be lower than the reporting limit.

For CLP the reporting limit is the Contract Required Quantitation Limit (CRQL) for organics.

3.3 An SDG is defined by the following, whichever is more frequent:

- each 20 field samples received within a case, or
- each 7 calendar day period (3 calendar day period for 7 day turn around) during which field samples in a case are received (14 calendar days if requested by the client) beginning with the receipt of the first sample.

3.4 VTSR – Validated Time of Sample Receipt

3.5 Aroclor 1660 – **A** mixture of **single component** Aroclor**s** 1016 and 1260

4.0 Interferences

4.1 Interferences in this method can be grouped into three broad categories: contaminated solvents, reagents, or glassware; contaminated GC carrier gas, parts, column surfaces, detector surfaces; and the presence of co-eluting

compounds in the sample matrix that also are detected by the ECD. Specific cleanups may be necessary for samples, depending on the compounds of interest.

4.2 Interferences by phthalate esters introduced during the sample preparation procedures can be a major problem. Common flexible plastics found in certain gloves and other objects contain varying amounts of phthalates which may be introduced during lab operations. Cross-contamination of clean glassware routinely occurs when plastics are handled during extraction steps, especially when solvent wetted surfaces are handled. These interferences can be minimized by cleanup of solvents, reagents, and glassware.

4.3 Glassware must be scrupulously cleaned as soon as possible after use by rinsing with the last solvent used. This should be followed by detergent washing with hot water, and rinses with tap water and organic-free reagent water. Drain the glassware and dry in an oven at 130° C for several hours or rinse with methanol and drain.

4.4 The presence of elemental sulfur will result in broad peaks that interfere with early eluting pesticides, and can be removed by cleaning the extract with tetrabutylammonium (TBA) sulfite reagent**.**

4.5 Waxes, lipids, and other high molecular weight compounds are also removed using GPC.

5.0 Safety

Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous. During sample preparation glasses, gloves and lab coats are a minimum requirement. The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

Laboratory staff **must** review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets for reagents used in the laboratory.

6.0 Equipment & Supplies

6.1 G**C/ECD –** Varian 3400 and Trace 2000

6.2 **10 µL syringes – Hamilton**

6.3 Autosampler – CTC A2000S

6.4 GC Columns

6.4.1 Restek, Rtx® - CLPesticides, 30 m, 0.53 mm ID, 0.5 µm film thickness

6.4.2 Restek, Rtx® - CLPesticides II, 30 m, 0.53 mm ID, 0.42 µm film thickness

6.4.3 Restek universal Y presstight connectors

6.5 Screw top amber vials – 2 mL, Microliter Analytical Supplies, Inc.

6.6 Data system

6.6.1 EZ-Chrom data acquisition system

6.6.2 ThruPut's Quick Form generation software.

6.7 Pipets

6.7.1 Eppendorf adjustable pipet with disposable pipet tips: 10 – 100 mL; 100 – 1000 µL

6.7.2 Drummond adjustable pipet with disposable capillary tubes to deliver between 20-100 µL volumes

7.0 Reagents & Standards

Refer to the Standards Preparation Logbook 22 F for details on preparation of standards used in this procedure.

7.1 Reagent water – All water used **in this procedure must be reagent-grade Type I with regard to resistivity of > 10 megohm-cm (19th and 20th Editions of Standard Methods, Method 1080), and is demonstrated to meet the blank criteria contained in this Standard Operating Procedure (SOP). It is referred throughout this SOP as DI water.**

7.2 **Hexane – pesticide grade**

7.3 **Tetrabutylammonium sulfite reagent**

7.3.1 Tetrabutylammonium hydrogen sulfate – 97%, Sigma-Aldrich

7.3.2 Sodium sulfite – ACS grade, 98% EM Science

7.4 Stock standard solutions (1 mg/mL) are purchased from Restek Corporation, for example, as certified solutions.

7.5 Calibration standards are prepared at **100, 200, 400, 800, and 1600 ηg/mL** by diluting the stock standards solutions with hexane.

7.6 Separate calibration standards are used for each multi-component analyte, with the exception of Aroclors 1016 and 1260, which can be run as a mixture. The mixture is referred to as Aroclor 1660.

7.7 Surrogate standard s**olution – Tetrachloro-m-xylene (TCX) at 0.6 µg/mL and Decachlorobiphenyl (DCB) at 1.2 µg/mL**.

7.7.1 Decachlorobiphenyl (DCB) and tetrachloro-m-xylene (TCX) are the surrogates used. Corrective action is taken when the recoveries of both surrogates fall outside acceptance limits on both columns.

7.8 Store all reagents in a flammables cabinet or in a fume hood. Store all standard solutions at 4° C (± 2° C) in Teflon®-sealed amber containers. Replace all standard solutions (intermediate and working) after six months or sooner, if degradation occurs.

8.0 Sample Preservation **and** Storage

8.1 Samples are preserved and stored according to the tables in Sample Control SOP 4.1, "Receiving Samples" and 4.6, "Storing Samples."

8.2 Extraction of water samples by separatory funnel must be completed within 5 days of the VTSR. Extraction of water samples by continuous liquid-liquid extraction must be started within 5 days of VTSR. Extraction of soil/sediment samples must be completed within 10 days of VTSR.

8.3 All extracts must be analyzed within 40 days of extraction.

8.4 Prior to analysis, **store** all extracts under refrigeration at 4° C (± 2° C) in the reach-in storage unit in the laboratory. After analysis, extracts are returned to Sample Control for long-term storage and disposal.

9.0 Quality Control

9.1 Initial Calibration

9.1.1 Calibrate the GC/ECD instrument as described in section 10.1 before the analysis of any blanks, field, or QC samples.

9.1.2 If, during sample analysis, one of the single point Aroclors is detected in a sample, calibrate with five levels of the Aroclor standard. (See Section 10.1.1.2).

9.1.3 Perform an initial calibration if the calibration verification criteria are not met or after major instrument maintenance (e.g., column replacement, cleaning or replacement of the ECD).

9.1.4 Initial calibration acceptance criteria

9.1.4.1 The peaks chosen to identify the Aroclors in the calibration standards must be between 25 and 100 % of full scale in the chromatogram. The scaling factor must be displayed on the chromatogram.

9.1.4.2 The instrument blank must meet the acceptance criteria in section 9.2.4.

9.1.4.3 The percent Relative Standard Deviation (%RSD) of the calibration factors for each selected Aroclor component and surrogate in the initial calibration must be less than or equal to 20%. The % RSD for Aroclors is calculated by determining the mean of the average of the five selected peaks in each standard level. Acceptance criteria must be met by the average of the five peaks, as opposed to each individual peak. See Sections 10.1.2.

9.2 Continuing Calibration Verification (CCV)

9.2.1 Analyze an instrument blank and the CS3 Aroclor 1660 standard at the beginning (opening CCV) and at the end (closing CCV) of each 12-hour period during which field and QC samples are analyzed.

9.2.2 Analyze an instrument blank, CS3 Aroclor 1660 standard, and the CS3 of any single Aroclor standard at the beginning (opening CCV) and at the end (closing CCV) of each 12-hour analysis period, if an

Aroclor other than 1016 or 1260 was detected in the samples. The analysis of the single Aroclor standard is not necessary, if the samples are analyzed in the same 12-hour period as the initial calibration of the single component Aroclor.

9.2.3 If the closing CCV meets the acceptance criteria for the opening CCV (see section 9.2.6), it may be used as the opening CCV for the next 12-hour sample analysis period.

9.2.4 If the 12-hour sample analysis period has elapsed since the injection of the previous closing CCV, an opening CCV must be analyzed.

9.2.5 No more that 14 hours may elapse between the injection of the instrument blank in the opening CCV and the injection of the CS3 Aroclor standard in the closing CCV.

9.2.6 CCV Acceptance Criteria

9.2.6.1 The calibration factors for each Aroclor and surrogate peak in the continuing calibration verification (CCV) standard must be within ± 15% difference (%D) when compared to the mean calibration factors from the initial calibration on both analytical columns. The % D is calculated by determining the average %D of the five selected peaks for each Aroclor. Acceptance criteria must be met by the average of the five peaks, as opposed to each individual peak.

9.2.6.2 If the %D exceeds ± 15%, then corrective action must be taken and the opening CCV re-injected. If the calibration still exceeds the criteria, a new initial calibration must be analyzed.

9.2.6.3 The calibration factors for each Aroclor and surrogate in the closing CCV must not exceed a %D of ± 50%, when compared to the calibration factors from the initial calibration.

9.2.6.4 If any of the continuing calibration Aroclor components fall outside their retention time windows, the system is out of control and corrective action must be taken to correct the problem. If, after re-injection of the standard following

corrective action, the retention times are still outside the windows, a new initial calibration must be analyzed.

9.3 Surrogates

9.3.1 Surrogate recoveries must be met for all samples, blanks, laboratory control samples, matrix spikes, and matrix spike duplicates. The required surrogates, decachlorobiphenyl (DCB) and tetrachloro-m-xylene (TCX) must be in the recovery range of 30-150% and within the retention time windows. One surrogate may fail recovery criteria on one column.

If both surrogates (tetrachloro-m-xylene and decachlorobiphenyl) are outside the control range on both columns, the sample must be re-extracted and re-analyzed. The surrogate recovery requirements do not apply to sample dilutions.

9.4 Instrument Blanks

9.4.1 Prepare an instrument blank by spiking hexane with TCX at 20 ηg/mL and DCB at 40 ηg/mL.

9.4.2 Analyze an instrument blank after the initial calibration before any samples are analyzed.

9.4.3 Analyze an instrument blank as the first injection of the opening and closing CCV. The analysis of the instrument blank begins the 12-hour sample analysis period.

9.4.4 Instrument Blank Acceptance Criteria

9.4.4.1 The concentration of any target compound detected must be < CRQL.

9.4.4.2 The surrogates must be within the retention time windows on both columns.

9.4.5 The instrument blank is used to assess instrument contamination from analyte carryover from calibration standards or high concentration samples.

9.5 Method blanks

9.5.1 Method blanks are extracted with each preparation batch of up to 20 samples**, excluding the LCS, duplicate matrix spikes and PE samples**. **The method blank is analyzed on the same instrument used to analyze the associated samples.**

9.5.2 The acceptance criteria for method blanks includes the following:

9.5.2.1 Surrogate recoveries must be within 30-150% and each surrogate must be within the retention time windows.

9.5.2.2 No target analytes may be present at or above the Contract Required Quantitation Limit (CQRL).

9.5.3 If the method blank **does not meet** acceptance criteria, the source of the problem (s) must be investigated and appropriate corrective action taken. All samples processed with a method blank that does not meet acceptance criteria must be re-extracted and reanalyzed.

9.5.4 The method blank is used to assess contamination in the extraction process.

9.6 Sulfur Cleanup Blanks

9.6.1 Prepare a sulfur cleanup blank when one or more of the samples in an extraction batch require sulfur removal. No separate sulfur cleanup blank is necessary, if all of the samples in an extraction batch require sulfur cleanup.

9.6.2 Prepare a sulfur cleanup blank by adding surrogates to an aliquot of hexane and subjecting it to cleanup using TBA. See SOP 2.1.1.5 "Sulfur Cleanup of Pesticide/PCB Extracts by Copper or TBA Sulfite by CLP, SW-846, and NYASP".

9.6.3 Sulfur blank acceptance criteria are the same as the method blank.

9.6.4 The sulfur blank is used to assess any contamination from the sulfur cleanup process.

9.**7** Laboratory Control Sample (LCS)

9.**7**.1 The LCS is prepared for **each preparation batch of up to 20 field samples**.

9.**7**.2 An LCS contains Aroclor 1016 and 1260. The recovery criteria for each Aroclor is 50-150%.

9.**7**.3 Surrogate **recovery must be within 30-150%. The retention time for each surrogate must be within the RT window.**

9.**7**.4 If the LCS fails to meet acceptance criteria, all samples in the associated batch must be re-extracted and reanalyzed.

9.**8** Matrix Spikes

9.**8**.1 A matrix spike and matrix spike duplicate (MS/MSD) must be performed for each sample delivery group of up to 20 field samples**, unless otherwise specified by the client**.

9.**8**.2 The percent recovery and relative percent difference (RPD) criteria for the MS/MSD are shown in the following table.

Analyte	% Recovery	RPD
Aroclor 1016	29-135	0-15
Aroclor 1260	29-135	0-20

9.8.3 Duplicate matrix spikes must be analyzed within the contract required holding time. .

9.8.4 The retention time for each surrogate in the duplicate matrix spikes must be within the retention time windows.

9.8.5 The spike recovery limits for the duplicate matrix spikes are advisory and require no further action by the laboratory. However, frequent failures **must** be addressed.

9.9 Samples

9.9.1 Analyze samples after all initial and continuing calibration criteria are met.

9.9.2 Analyze samples within a 12-hour analysis period, beginning with the analysis of an instrument blank and ending with the analysis a CS3 Aroclor standard.

9.9.3 Analyze samples within the required holding time.

9.9.4 Sample Dilutions

9.9.4.1 If the response of the largest peak for any Aroclor is greater than the response of the same peak in the high-level standard in the initial calibration for both columns, the sample must be diluted. Dilute the sample such that the response of the largest peak (lower response of the two columns) is within the calibration range.

9.9.4.2 If the concentration of the analytes detected is greater than that of the high calibration standard, dilute the sample until the concentration is within the calibration range. The maximum dilution is 1: 100,000.

9.9.4.3 Dilute all sample extracts with hexane.

9.9.5 Sample Acceptance Criteria

9.9.5.1 The associated method blank must meet acceptance criteria.

9.9.5.2 The associated LCS must meet acceptance criteria.

9.9.5.3 The retention times of the surrogates must be within the retention window on both columns.

9.9.5.4 The surrogate percent recoveries must be between 30 and 150 %. One surrogate may fail this criterion per column.

9.9.5.5 Choose 5 peaks (minimum of 3 peaks) for the identification of each Aroclor. Choose peaks that are at least 25% of the height of the largest Aroclor peak and 1 peak that is unique to each Aroclor.

9.10 Corrective actions for GC/ECD analysis

9.10.1 When linearity is difficult to achieve, verify that the appropriate length of column is inserted in the detector. Examine all column ends and determine if the ends of the columns need to be trimmed. The removal of 0.5 meters of the detector end of the column may be indicated when linearity is difficult to achieve.

9.10.2 When the instrument blanks fail, examine the chromatography to determine if there is contamination in the column that is causing the failure. If so, bake the column for 1 hour or less to see if this can be corrected. If the contamination is such that baking for 1 hour does not improve the baseline, it may be necessary to change the liner.

9.10.3 When calibration verifications fail recovery low, verify that the correct peaks are being named. Also verify that the syringe is not plugged and change the septa. If the calibration verification fails again, examine the chromatography to determine if there is a problem with the baseline that is causing the failure. If so, bake the column for 1 hour or less to see if this can be corrected. Also, if the calibration verification is failing on only one column, the y-splitter may be plugged. If the calibration verification continues to fail, the instrument will need a new calibration curve.

9.10.4 When calibration verifications fail recovery high, verify that the correct peaks are being named. Examine the chromatography to determine if there is contamination on the column that is causing the failure. If so, bake the column for 1 hour or less to see if this can be corrected. If the calibration verification fails again, the instrument will need a new calibration curve.

9.10.5 When the calibration verification fails due to drift, change the septa and verify that all the column fittings are secure. Also, determine if there is contamination on the column that is causing the failure. If so, bake the column for 1 hour or less to see if this can be corrected. If the calibration verification still fails, it is permissible to update retention times once per 24 hours period. Record in the instrument run log when the retention times are updated.

9.10.6 All preventive and routine maintenance as mentioned above is recorded in the instrument run log. Major maintenance is recorded in the maintenance log (Attachment 1).

9.11 Contingency

9.11.1 If, due to a lab accident or to QC failure, a re-preparation is required for the sample and insufficient volume remains, the Project Manager must be alerted and will contact the client for direction on how to proceed. For the CLP, the Sample Management Office must be contacted.

9.11.2 If persistent contamination occurs in the laboratory, analyses must be halted until the source can be identified and isolated. When the contamination issue is resolved, sample analyses may proceed.

9.11.3 Any other issues that potentially affect data quality should be addressed with the Project Manager.

10.0 Calibration & Standardization

10.1 Initial Calibration

10.1.1 For the initial calibration five concentration levels are prepared for Aroclors 1016/1260. Single standards for the remaining Aroclors are prepared at the mid-concentration (CS3). The CS3 level for Aroclors 1221, 1232, 1242, 1248, 1254, 1262, and 1268 are used for pattern recognition and to generate calibration factors for them.

10.1.1.1 Analyze a five-point initial calibration for Aroclors 1016 and 1260 at 100, 200, 400, 800, and 1600 ηg/mL; surrogate TCX at 5.0, 10, 20, 40, and 80 ηg/mL; surrogate DCB at 10, 20, 40, 80, and 160 ηg/mL. Analyze the single-points initial calibration containing Aroclors 1221, 1232, 1242, 1248, 1254, 1262, and 1268 at 400 ηg/mL and surrogates at 20 ηg/mL for TCX and 40 ηg/mL for DCB.

10.1.1.2 If a sample is analyzed and any of the Aroclors analyzed as a single **point** are detected, a five-point calibration must be analyzed for that Aroclor. The calibrations must be prepared at the following levels:

- Aroclors 1221, 1232, 1242, 1248, 1254, 1262, and 1268 at 100, 200, 400, 800, and 1600 ηg/mL

- Surrogates
  - TCX at 5.0, 10, 20, 40, and 80 ηg/mL

- DCB at 10, 20, 40, 80, and 160 ηg/mL

10.1.2 A minimum of five sets of calibration factors is generated for the Aroclor 1016/1260 standards. Each set consists of the calibration factor for each of the five peaks chosen. The single standard of the remaining Aroclors will each produce a minimum of three calibration factors, one for each selected peak. **See Section 9.1.4 for initial calibration acceptance criteria.**

10.1.3 The initial calibration standard sequence is as follows.

12 hour Sequence Injection Number	Initial Calibration Standard Sequence
1	AR1660-CS1
2	AR1660-CS2
3	AR1660-CS3
4	AR1660-CS4
5	AR1660-CS5
6	AR 1221 CS3
7	AR1232 CS3
8	AR1242 CS3
9	AR1248 CS3
10	AR1254 CS3
11	AR1262 CS3
12	AR1268 CS3
13	Instrument blank

Note: The single-point Aroclor standards may be analyzed before the analyses of the five levels of the Aroclor 1660. The steps pertaining to the instrument blank are used as a part of the calibration verification as well.

10.2 **Continuing** Calibration Verification (CCV)

10.2.1 The continuing calibration verification standards are used to evaluate retention time stability. The injection of an instrument blank and Aroclor 1660 constitute the calibration verification.

11.0 Procedure

Documentation must follow the requirements in Q**uality** C**ontrol** SOP **13.6, "**Proper Documentation Procedures**"**.

11.1 Dual Column Analysis and Confirmation

11.1.1 The dual column/dual detector approach involves the use of two 30 m x 0.53 mm ID fused silica open-tubular columns of different polarities (CLPesticides and CLPesticides2). Each has different selectivities towards the target compounds. The columns are connected to a "Y-splitter" and dual ECD detectors.

11.2 GC operating conditions are as follows:

11.2.1 Column 1

- Type: CLPesticides
- Dimensions: 30 m x 0.53 mm ID
- Film Thickness: 0.50 μm

11.2.2 Column 2

- Type: CLPesticides2
- Dimensions: 30 m x 0.53 mm ID
- Film Thickness: 0.42 μm

11.2.3 Carrier gas

- Helium
- Flow rate: 6 mL/minute

11.2.4 Makeup gas

- **Mixture of a**rgon **and** methane
- Flow rate 20 mL/minute

11.2.5 Temperature program

- Hold at 150° C for 1.0 minute
- Ramp to 275° C at 5 degrees/minute
- Hold for 2.0 minutes

11.2.6 Injector temperature: 250° C

11.2.7 Detector temperature: 300° C

11.2.8 Injection volume: 2 or 4 μL (1 or 2 μL per column)

11.2.9 Solvent

- Hexane

11.2.10 Detector: Dual ECD's

11.2.11 Range: 10

11.3 Analytical Sequence

11.3.1 Analytical Sequence

All acceptable samples must be analyzed within a valid analysis sequence as given in the following:

Time	Injection #	Material Injected
	1-12	First 12 steps of the initial calibration
0 hr.	13	Instrument blank
	14	Aroclor 1016/1260 Standard Sample
12 hr.		Last sample
	1st injection past 12 hr.	Instrument blank
	2nd injection past 12 hr.	Aroclor 1016/1260 standard subsequent samples
Another		Last sample

Time	Injection #	Material Injected
12 hrs.		
	1st injection past 12 hr.	Instrument blank
	2nd injection past 12 hr.	Aroclor 1016/1260 standard
	3rd injection past 12 hr.	Sample

11.3.2 The first 12 hours are counted from **injection** #13, not from injection #1. Samples may be injected until 12:00 hours have elapsed. All subsequent 12-hour periods are timed from the injection of the instrument blank that brackets the front end of the samples. If more than 12 hours elapse between the injections of two instrument blanks that bracket a 12-hour period in which samples or required blanks are analyzed, then the time between the injection of the instrument blank and the preceding sample may not exceed the length of one chromatographic run. No more than 14 hours may elapse from the injection beginning the opening CCV (Aroclor Standard).

11.3.3 After the initial calibration, the analysis sequence may continue as long as acceptable calibration verifications(s) are analyzed at the required frequency.

11.4 Gas chromatographic analysis:

11.4.1 The GC is set up according to the operating conditions detailed above. A final temperature of 240 - 275° C is necessary to elute decachlorobiphenyl.

11.4.2 The initial calibration is performed according to the discussion in Section 10.0.

11.4.3 An opening/closing CCV standard brackets each 12-hour **analysis** period. Since an analytical sequence may continue as long as **calibration verification** criteria are met, the end of one 12-hour sequence is considered to be the beginning of the next 12-hour sequence. The calibration factor must meet acceptance criteria when compared to the initial calibration curve. **See Section 9.2.6 for CCV criteria.**

When this criteria is exceeded, corrective action is required as described in Section 7.0 and may include re-injection of the calibration verification standard or analysis of a new initial calibration before more samples are analyzed.

11.5 Retention Time Windows

11.5.1 An RT window is calculated for the major peaks (a minimum of 3) of each Aroclor and for each surrogate using the RT window listed below. Analytes are identified when peaks are observed in the RT window for the compound on both GC columns.

Compounds	RT Windows (min.)
Aroclors	± 0.07
TMX	± 0.05
DCB	± 0.10

11.6 Identification and Quantitation

11.6.1 Compound identification is based on a second column confirmation, with the second column being of a dissimilar nature. Target analyte peaks must fall within the retention time windows on both columns.

11.6.2 Tentative identification of an analyte occurs when three to five of the chosen Aroclor component peaks from a sample extract fall within the retention time windows and the pattern matches that of the Aroclor standard.

11.6.3 Identification of Aroclors is based on the characteristic pattern and retention times of the indicator peaks.

11.6.4 Quantitation is based on the area under the characteristic peaks as compared to the area under the corresponding peaks in the calibration standard at the same retention times. The external calibration method is used for quantitation.

11.6.5 When samples contain more than one multi-component analyte, a more experienced analyst may be required to process or assess the data. Similar conditions exist when multicomponent analytes have been subjected to environmental degradation, resulting in weathered Aroclors that may have significant differences in peak patterns than the standards.

11.6.6 Use the external calibration procedure to establish mean response factors for each chosen Aroclor component by dividing peak area in the standard

by the mass injected. Peak areas from peaks within the chosen Aroclor component's retention time window are used to calculate the quantity of each target Aroclor while retention times are used to identify each component.

The concentration reported on the reporting form is the higher of the two values obtained from the dual column analysis. If the result is >40% different, the data reviewer should verify that there are not overlapping peaks causing this to occur. Also, the data reviewer will examine the baseline to verify that the baseline parameters are set properly.

11.6.7 The Aroclors are quantitated using responses of five major peaks (minimum of three) of the sample pattern compared to the calibration factors of the same peaks in initial calibration for the Aroclor. Those concentrations are averaged for both columns. The lower value of the two columns is reported.

12.0 Data Analysis & Calculations

Calculations must be consistent with the QC SOP: Numerical Data Reduction.

12.1 Calculation of the mean or average of a set of values (also used for Mean Calibration Factor, $\overline{CF}$):

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where: n = total number of values
x_i = each individual value used to calculate the mean
x = the mean of n

12.2 Calculation of the standard deviation of a set of values:

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n} \left(X_n - \overline{X}\right)^2}{n-1}}$$

12.3 Calculation of percent recovery:

12.3.1 LCS and surrogates:

$$\%R = \frac{Amount\ found}{Amount\ spiked}\ x\ 100$$

12.3.2 Matrix spikes:

$$\%\ R = \frac{Amount\ in\ spiked\ sample - Amount\ in\ unspiked\ (native)\ sample}{Amount\ spiked}\ x\ 100$$

12.4 Calculation of % RSD

$$\%RSD = \left(\frac{Standard\ deviation}{\overline{X}}\right) \times 100$$

12.5 Calculation of RPD

$$RPD = \frac{|Value\ 1 - Value\ 2|}{(Value\ 1 + Value\ 2)/2} x100$$

12.6 Calculation of %Difference (%D)

$$\%Diff = \frac{Value - \overline{Reference\ \ value}}{\overline{Reference\ \ value}}\ x\ 100$$

12.7 Calibration factors are calculated by dividing the total peak area for each chosen Aroclor component in the standard by the total mass injected (in nanograms).

$$Calibration\ Factor\ (CF) = \frac{Peak\ area}{Total\ mass\ injected}$$

12.8 Concentration

12.8.1 Concentration of aqueous samples

$$\mu g / L = \frac{(Ax)(Vt)(Df)}{(\overline{CF})(Vi)(Vo)}$$

where: Ax = area response for the analyte
Vt = volume of the concentrated extract (µl)
Df = dilution factor. If no dilution, Df = 1.0

$\overline{CF}$ = mean calibration factor from the initial calibration
Vo = volume of water sample extracted (ml)
Vi = volume of extract injected (µl)

12.8.2 Concentration of soil samples (dry weight basis)

$$\mu g / kg = \frac{(Ax)(Vt)(Df)(GPC)}{(\overline{CF})(Vi)(Ws)(D)}$$

where:

Ws = weight of sample extracted, in grams
D (dry weight)= $\frac{100 - \%\ \text{moisture}}{100}$
Ax, Vt, Df, $\overline{CF}$, Vi have the same definitions as for water.

GPC = GPC factor = $\frac{\text{Volume of extract load column to GPC column}}{\text{Volume of extract collected after GPC clean-up}}$

12.9 Calculating Dilutions

12.9.1 If the response of the majority of the chosen Aroclor components exceeds the on-column amount of the high level Aroclor 1660 standard, it must be diluted and re-analyzed. Comparing the on-column nanogram amount of the chosen Aroclor components with the nanogram amounts of the same chosen Aroclor components from the high level standard used in the initial calibration will allow you to determine an appropriate dilution.

12.9.2 If a sample concentration exceeds the high level standard a dilution must be performed. Determine a dilution **factor** that will result in a value within the calibration range **by dividing the concentration of the high analyte in the sample by the desired concentration**. **Dilute the extract with hexane and note the DF and preparation in the run log. (Ex. 10X dil = 100 µL of sample into 900 µL of hexane.)**

13.0 Method Performance

This method was validated through in-house laboratory studies of method detection limits and precision and accuracy for single analyst. The data are retained by the QA department.

14.0 Pollution Prevention

The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 thing. **See SOP 12.1, Hazardous Waste Disposal, regarding laboratory procedures for recycling solvent waste streams.**

15.0 Waste Management

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Samples preserved with HCl, HNO_3, or H_2SO_4 to pH <2 are hazardous must be handled as hazardous waste.

Refer to the Hazardous Waste Management and Safety SOPs located in the lab.

16.0 References

16.1 U.S. EPA CLP SOW for Organic Analysis, Multi-Media, Multi-Concentration, SOM01.**1** (**May**, **2005**)

16.2 "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods", SW-846, 3rd Edition, Update III, 12/96, Method 8082

16.3 Standard Methods for the Examination of Water and Wastewater, 20th (1998), Method 1080

16.4 New York State Analytical Services Protocol (NYSASP), 6/2000, plus revisions.

16.5 Q**uality** C**ontrol** SOP **13.6 "**Proper Documentation Procedures**"**

16.6 Q**uality** C**ontrol** SOP **13.4 "**Numerical Data Reduction**"**

16.7 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477.

16.8 Hazardous Waste Management & Safety SOPs: "Hazardous Waste Disposal" and "Spill Control & Cleanup."

16.9 NELAC Standards, approved Ju**ne 2003**, plus revisions

16.10 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995.

16.11 New York State Environmental Laboratory Approval Program, Certification Manual, **December 2005**, plus revisions.

16.12 CompuChem Quality Manual, Revision **7**, **Update 1, 12/13/05**, plus revisions

16.13 Sample Control SOP 4.1, "Receiving Samples"

16.14 Sample Control SOP 4.6, "Storing Samples"

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.1 Attachment 1 – Instrument Maintenance Log

17.2 Attachment 2 – Instrument Run Log

Attachment 1

CompuChem a division of Liberty Analytical Corp. Logbook 4 H(4) 1

GC Extractables Instrument Maintenance Log: 66/67

Date: _____ Time:_____

System: _____

Problem: _____

_____

_____

_____

_____

Action Taken: _____

_____

_____

_____

_____

_____

Parts used:

Part Number	Description	Quantity

File Name Indicating Instrument In Control: _____

Performed By: _____ Date: _____

Reviewed By: _____ Date: _____

2/11/00:mlj

Attachment 2

COMPUCHEM a division of Liberty Analytical Corp Instrument ID 80 / 81
GC EXTRACTABLES RUN LOG Sequence ID: _____
COMPUCHEM .LOGBOOK 4 TTT 10

DATE ___/___/___
SHIFT/S(A)_____(B)_____
Amt. Inj. 2 Π (1 ul per column)

Method : 8081A 8082 8151A CLP Other_____

	FILE NAME	DATE	CompuChem #	CASE/SDG#	CHEMIST	COMMENTS(ETC)/DISPOSITION
1		/ /				
2		/ /				
3		/ /				
4		/ /				
5		/ /				
6		/ /				
7		/ /				
8		/ /				
9		/ /				
10		/ /				
11		/ /				
12		/ /				
13		/ /				
14		/ /				
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16		/ /				
17		/ /				
18		/ /				
19		/ /				
20		/ /				
21		/ /				
22		/ /				
23		/ /				
24		/ /				

The presence of the Chemist's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist together with the chemist's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

SUPERVISOR APPROVAL_____

DATE _____

4/8/02:dce

CompuChem
a division of Liberty Analytical Corporation
501 Madison Avenue
Cary, NC 27513

NELAP accredited

SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire block below (except effective date).

This is a new procedure _____ revised procedure ✓ outdated procedure (archive) _____

- Procedure Code: IP 452 SOP Section #: 2.3.2.4 Revision #: 10

SOP Title: Analysis of Nitroaromatics and Nitramines in Water and Soil Samples by HPLC in SW-846 and NYSASP

Effective date: (QA fills in) 4/15/04

- Procedure prepared by: Linda Carter Date: 3/22/04
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) Diane Ellmore Date: 3/22/04
- Reason for change: SC DHEC compliance
- This procedure meets the requirements of the following approved method references: SW-846, Update III, 3rd Edition, Method 8330; New York State Analytical Services Protocol (NYSASP) June 2000, plus revisions

Procedure approved by Quality Assurance Representative: Date:
(Not needed if signed above)

JAN 2 1 2010

Effective 1-1-96, on an annual basis, lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary, indicate by your signature that the SOP has been reviewed.

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Instrument Procedure 452: Analysis of Nitroaromatics and Nitramines in Water and Soil Samples by HPLC in SW-846 and NYSASP

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Instrument Procedure 452: Analysis of Nitroaromatics and Nitramines in Water and Soil Samples by HPLC in SW-846 and NYSASP

1.0 Scope and Application

1.1 This procedure describes the trace analysis of explosives residues by high performance liquid chromatography (HPLC) using a UV detector **at 254 nm**. This procedure is based upon Method 8330, which is used to determine the concentration of the compounds listed in Table 1 in water, soil, or sediment matrices.

Table 1. Method 8330 Target Compound List

Compound	Abbreviation	CAS No.
1,4-Dinitrobenzene	1,4-DNB	100-25-4
hexahydro-1,3,5-trinitro-1,3,5-triazine	RDX	121-82-4
1,3,5-trinitrobenzene	1,3,5-TNB	99-35-4
1,3-dinitrobenzene	1,3-DNB	99-65-0
methyl-2,4,6-trinitrophenylnitramine	Tetryl	479-45-8
nitrobenzene	NB	98-95-3
2,4,6-trinitrotoluene	2,4,6-TNT	118-96-7
4-amino-2,6-dinitrotoluene	4-Am-DNT	1946-51-0
2-amino-4, 6-dinitrotoluene	2-Am-DNT	355-72-78-2
2,4-dinitrotoluene	2,4-DNT	121-14-2
2,6-dinitrotoluene	2,6-DNT	606-20-2
2-nitrotoluene	2-NT	88-72-2
3-nitrotoluene	3-NT	99-08-1
4-nitrotoluene	4-NT	9-99-0
HMX	HMX	2691-41-0

1.2 The laboratory's current statistically – determined method detection limits (MDLs) and reporting limits are shown in Attachment 1.

1.3 Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

1.4 This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have

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demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

2.0 Summary of Method

Method 8330 provides a salting-out extraction and a solid-phase extraction procedure for low concentration of explosives residues in surface or ground water. Before analysis aqueous samples are first subjected to the steps in Sample Preparation Procedure –1052, "Preparation of Water Samples for the Analysis of Nitroaromatics and Nitramines by HPLC in SW846 and NYSASP" or Sample Preparation Procedure –1082, "Solid Phase Extraction of Water Samples for Analysis of Nitroaromatics and Nitroamines by HPLC in SW846 and NYSASP." (Note that the high concentration procedure is not performed.) Soil and sediment samples are extracted using acetonitrile before analysis according to Sample Preparation Procedure –220, "Preparation of Soil/Sediment/Sludge Samples for the Analysis of Nitroaromatics and Nitramines by HPLC in SW846."

During analysis target analytes are separated on a Allure C18 reverse phase column, determined at a wavelength of 254 nm, and confirmed on a Pinnacle Cyano reverse phase column, or vice versa.

3.0 Definitions

Relevant terms are defined in the text of this SOP where they appear.

3.1 Method detection limit (MDL) – The minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR, Part 136, Appendix B.)

3.2 Reporting Limit – The laboratory reporting limit is based on the lowest multipoint calibration standard concentration. For organic methods, values detected below the reporting limit and above the MDL may be reported and qualified as an estimated concentration.

If the low level standard concentration is not at least three times higher than the MDL value, the standard concentration is adjusted upward in order to achieve this minimal ratio. It may be adjusted higher than three times depending on the concentration range of the calibration curve and the ability to meet method linearity requirements.

For CLP the reporting limit is the Contract Required Quantitation Limit (CRQL) for organics.

3.3 Reporting Units – ug/L and mg/Kg

3.4 An SDG is defined by the following, whichever is more frequent:

- each 20 field samples received within a case, or
- each 7 calendar day period during which field samples in a case are received (14 calendar days if requested by the client) beginning with the receipt of the first sample.

NOTE: The Army Corps of Engineers **(US ACE) and SC DHEC** do not accept the SDG approach, unless the samples are prepared in a single batch. When a group of up to 20 field samples of a similar matrix are prepared as one batch, method-specified QC samples such as a method blank, laboratory control sample, matrix spike, matrix spike duplicate, and matrix duplicate must also be prepared together at a rate of 5% **and 10% for SC DHEC**. If samples are batched together from different sites, project-specific QC must be processed.

3.5 SC DHEC – South Carolina Department of Health and Environmental Control

4.0 Interferences

4.1 Solvents, reagents, glassware, and other sample processing hardware may yield discrete artifacts and/or elevated baselines, causing misinterpretation of the chromatograms. All of these materials must be demonstrated to be free from interferences.

4.2 2,4-DNT and 2,6-DNT have similar retention times (retention time difference of 0.2 minutes). A large concentration of one isomer may mask the response of the other isomer. If it is not apparent that both isomers are present (or are not detected), an isomeric mixture should be reported.

4.3 Tetryl decomposes rapidly in methanol/water solutions, as well as with heat. All aqueous samples expected to contain tetryl should be diluted with acetonitrile before filtration. All samples expected to contain tetryl should not be exposed to temperatures above room temperature. Note: Due to the fact that tetryl is a target analyte included in this procedure, the use of the aqueous solution, calcium chloride and methanol have been eliminated to allow for adequate recovery.

4.4 Degradation products of tetryl appear as a shoulder on the 2,4,6-TNT peak. Peak heights rather than peak areas should be used when tetryl is present in concentrations that are significant relative to the concentration of 2,4,6-TNT.

5.0 Safety

5.1 All of these compounds are either used in the manufacture of explosives or are products of the degradation of compounds used for that purpose. When making stock solutions for calibration, treat each explosive compound with caution.

5.2 Standard precautionary measures used for handling other organic compounds should be sufficient for the safe handling of the analytes targeted by Method 8330. The only extra precaution that should be taken is when handling the analytical standard neat material for the explosives themselves and in rare cases where soil or waste samples are highly contaminated with the explosives. Follow the note for drying the neat materials at ambient temperatures.

5.3 Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous. During sample preparation glasses, gloves and lab coats are a minimum requirement. The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

5.4 Laboratory staff are encouraged to review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets for reagents used in the laboratory.

6.0 Equipment & Supplies

6.1 HPLC System

6.1.1 Waters 600E Controller -- equipped with a pump capable of achieving 4000 psi, a 100 µl loop injector and a 254-nm Water 484 UV detector. For the low concentration option, the detector must be capable of a stable baseline at 0.001 absorbance units full scale.

6.2 Columns

Note: While the Allure C18 column is presented as the primary column and the Pinnacle Cyano column is presented as an alternate column, either one may be characterized as the primary column while the remaining column is used for confirmation.

6.2.1 Primary column – Restek Allure C18 - 4.6 x 250 mm (or equivalent).

6.2.2 Confirmation column - Restek Pinnacle Cyano, 4.6 x 250 mm (or equivalent).

6.3 Column Phase

6.3.1 Primary mobile phase:

50/50 (v/v) organic free reagent water/methanol.

6.3.2 Confirmation mobile phase:

79/5/16 (v/v/v)water/methanol/acetonitrile.

6.4 HP 1000 A900 with analog/digital converters

6.5 Autosampler - Waters WISP 700E

6.6 Materials

6.6.1 High pressure injection syringe -- 500-µL (Hamilton liquid syringe or equivalent)

6.6.2 Disposable cartridge filters -- 0.45-µm Teflon filter

6.6.3 Pipets -- Class A glass pipets, appropriate sizes

6.6.4 Pasteur pipets

6.6.5 Scintillation vials -- 20-ml glass vials

6.6.6 Vials -- 15-ml glass vials with Teflon-lined caps. Also 40-ml glass vials with Teflon-lined caps.

6.6.7 Volumetric flasks -- Appropriate sizes with ground glass stoppers, Class A. Note that the 100-ml and 1-l volumetric flasks used for the magnetic stirrer extraction must be round bottom.

6.6.8 Graduated cylinders -- Appropriate sizes

7.0 Reagents and Standards

7.1 Reagents

Reagent grade chemicals must be used in all tests.

7.1.1 Reagent water – All water used in this procedure must be equivalent to ASTM Type II water (as it relates to specific conductance and specific resistance) which is demonstrated to meet the blank contamination acceptance criteria contained in this Standard Operating Procedure (SOP).

7.1.2 Acetonitrile -- HPLC grade

7.1.3 Methanol -- HPLC grade

7.2 Stock Standard Solutions

7.2.1 Ampulated stock standards are purchased with certificates of purity.

7.3 Intermediate Standards Solutions

7.3.1 Intermediate stock standard solutions should be prepared at 1000 µg/L, in acetonitrile.

7.3.2 Dilute the concentrated intermediate stock solution with the appropriate solvent, to prepare intermediate standard solutions that cover the range of 2.5-1000 µg/L. These solutions should be refrigerated on preparation, and may be used for 30 days.

7.4 Working Standards

7.4.1 Calibration curve

7.4.1.1 A five point calibration curve is prepared daily by making the appropriate dilutions of an intermediate standard.

7.4.1.1.1 Prepare the 8330 High Calibration standard at 2.5 µg/ml and 5.0 µg/ml by adding 125 µl AccuStandard 8330 Calbration Mix A, 250 µl AccuStandard Calibration Mix B, and 500 µl of a 1 mg/ml Intermediate 1,4-DNB standard (described below) to

an amount of acetonitrile in a 50 ml volumetric flask and bring to volume.

7.4.1.1.2 Prepare this standard every three months.

7.4.1.2 These solutions must be refrigerated and stored in the dark, and prepared fresh on the day of calibration.

7.4.1.3 Dilute in order to achieve the five concentration levels.

Table 2. Initial Calibration Standard Levels

	µg/ml				
Analyte	**Low**	**Med 1**	**Med 2**	**Med 3**	**High**
HMX	0.125	0.25	0.50	1.25	2.5
RDX	0.125	0.25	0.50	1.25	2.5
1,3,5-TNB	0.125	0.25	0.50	1.25	2.5
1,3-DNB	0.125	0.25	0.50	1.25	2.5
Tetryl	0.25	0.50	1.00	2.50	5.0
NB	0.125	0.25	0.50	1.25	2.5
2,4,6-TNT	0.125	0.25	0.50	1.25	2.5
2 Am-4,6-DNT	0.25	0.50	1.00	2.50	5.0
4 Am-2,6-DNT	0.25	0.50	1.00	2.50	5.0
2,4-DNT	0.125	0.25	0.50	1.25	2.5
2,6-DNT	0.25	0.50	1.00	2.50	5.0
2-NT	0.25	0.50	1.00	2.50	5.0
3-NT	0.25	0.50	1.00	2.50	5.0
4-NT	0.25	0.50	1.00	2.50	5.0
1,4-Dinitrobenzene (Surrogate)	0.25	0.50	1.0	2.5	5.0

7.4.2 Initial Calibration Verification

7.4.2.1 The initial calibration must be verified once using a second source standard. This is prepared from a source other than that used to prepare the calibration standards and **contains analytes at 4.0 µg/ml and 6.0 µg/ml. The standard is diluted 2x prior to analysis.**

7.4.2.1.1 To prepare this standard add 0.2 ml Restek 8330 Calibration Mix #1, 0.3 ml Restek Calibration Mix #2, and 0.5 ml Intermediate 1,4-DNB in an amount of acetonitrile in a 50 ml volumetric flask and bring to volume.

7.4.2.1.2 Prepare this standard every three months.

7.4.3 Continuing Calibration

7.4.3.1 The continuing calibration standard is the mid-point of the curve. It is the Med 3 standard.

7.5 Surrogate Spiking Solution

7.5.1 A surrogate solution containing 1,4-dinitrobenzene is used to monitor the performance of the extraction and analytical system, and to determine the effect of the matrix on the method. Surrogate is added to each sample, method blank, matrix spike, and Laboratory Control Sample (LCS).

7.5.1.1 Prepare a 1 mg/ml Intermediate 1,4-DNB standard by weighing 0.0250 gm neat material purchased from ChemService into a 25 ml volumetric flask and bring to volume with 25 ml 1:1 methanol/acetonitrile.

7.5.1.2 Prepare this standard annually.

7.6 8330 Full List Spike Standard

7.6.1 This standard contains the full target list of compounds at 4 µg/ml or 6 µg/ml and is spiked into the LCS and MS/MSD.

7.6.2 Prepare the standard by adding 0.2 ml AccuStandard 8330 Calibration Mix A, 0.3 ml AccuStandard Calibration Mix B, and 0.1 ml AccuStandard HMX standard to an amount of acetonitrile in a 50 ml volumetric flask and bring to volume.

7.6.3 Prepare this standard every three months.

8.0 Sample Collection, Preservation, & Storage

8.1 Samples are collected, preserved, and stored according to the tables in Sample Control SOP 4.1, "Receiving Samples" and 4.6, "Storing Samples." Sample holding times are also listed.

8.2 All extracts must be analyzed within 40 days of extraction.

8.3 Prior to analysis, all extracts must be stored in the dark and under refrigeration at 2-4.4° C in the reach-in storage unit in the laboratory. After analysis, extracts are returned to Sample Control for long-term storage and disposal.

9.0 Quality Control

9.1 Method blanks

9.1.1 Method blanks are prepared with each preparation batch of up to 20 samples.

9.1.1.1 For aqueous samples submitted to meet the regulatory requirements for SC DHEC, the required frequency is 10%.

9.1.2 The acceptance criteria for method blanks includes the following:

- Surrogate recovery must be within acceptance criteria of 39-132% for water and 38-155% for soil.
- No target analytes are present above the reporting limit.

9.1.3 If the method blank exceeds acceptance criteria, the source of the problem (s) must be investigated and appropriate corrective action taken.

9.1.3.1 All samples processed with a method blank that does not meet acceptance criteria must be re-extracted and reanalyzed.

9.2 Matrix spike and matrix spike duplicate (MS/MSD)

9.2.1 A MS/MSD must be performed for each SDG of up to 20 samples.

9.2.1.1 For aqueous samples submitted to meet the regulatory requirements for SC DHEC, the required frequency is 10%.

9.2.2 The recovery criteria for the MS/MSD is 50-150%.

9.2.2.1 If recovery fails in the MS/MSD but the LCS passes, the data may be reported and the failure attributed to sample matrix interference.

9.2.3 The precision criteria for the MS/MSD is +/-30% RPD.

9.3 Laboratory Control Sample (LCS)

9.3.1 The LCS, or blank spike (BS), is prepared with each extraction batch of up to 20 samples. For the NYSASP, the LCS is called a matrix spike blank.

9.3.1.1 For aqueous samples submitted to meet the regulatory requirements for SC DHEC, the required frequency is 10%.

9.3.2 The LCS results are used to verify control in the laboratory and to demonstrate that any matrix spike recoveries outside acceptance criteria are due to matrix interferences and not attributed to the sample preparation and analytical processes.

9.3.3 The percent recovery for the LCS analytes must be in the range of 50-150% or the extraction batch must be repeated.

9.3.3.1 For samples submitted to meet the regulatory requirements of the State of South Carolina, the required LCS control limits are 70-130% recovery except for the difficult compounds such as tetryl.

9.4 Surrogates

9.4.1 Surrogate percent recovery criteria are 39-132% for water and 38-155% for soil.

9.4.2 If the criteria are not met in a sample, check to verify that the injection was good and there was nothing wrong with the surrogate spiking solution. If no problems exist there, the sample needs to be re-extracted and reanalyzed to verify the unacceptable surrogate recovery was due to the sample matrix.

9.5 Duplicates

9.5.1 Duplicates at a frequency of 10%, are required when processing samples submitted to meet the regulatory requirements of **South** Carolina DHEC. This requirement may be satisfied with the MS/MSD. The duplicate precision requirement is +/- 20 % RPD.

9.6 Calibration Verification

9.6.1 If a "closing" standard, injected after a group of samples, contains analyte responses with >15% difference when compared to the mean calibration

factor from the initial calibration, and the analyte was not detected in that group of samples, the samples do not require reinjection. However, if the standard is more than 15% below the mean calibration factor from the initial calibration, then re-injection is required.

9.6.2 The continuing calibration verification standards are used to evaluate retention time stability. If any of the standards fall outside their retention time windows, the system is out of control and corrective action must be taken to correct the problem. If, after re-injection of the standard following corrective action, the retention times are still outside the windows, a new initial calibration must be analyzed.

9.7 Instrument Maintenance

All instrument maintenance activities must be recorded in the Instrument Maintenance Log (Attachment 2.)

9.7.1 When the criteria for calibration verification is exceeded, examine the system and check for drips that are indicative of plumbing leaks. Check that tubing connectors are of short length to minimize dead volumes and reduce band broadening. Compatible guard columns may be installed to protect analytical column.

9.7.2 Columns must eventually be replaced as the bonding and end-capping groups used to modify the silica are lost with time. Loss of these groups will result in chromatographic tailing and changes in analyte retention times. Retention times may also change because of differences in column temperature or because the composition of the solvents gradient is not completely reproducible.

9.7.3 When peaks co-elute, indicating degradation in resolution, or when changes in back pressure are observed, the first action should be to replace the guard column, if one is installed.

Secondly, temporarily reverse the flow through the column, with the column disconnected from the detector, to dislodge contamination in the frit. If this does not correct the problem, place the analytical column in a vise, remove the inlet compression fitting and examine the column.

9.8 Contingency

9.8.1 If due to a lab accident or to QC failure a re-preparation is required for the sample and insufficient volume remains, the Project Manager must be alerted and will contact the client for direction on how to proceed.

9.8.2 If persistent contamination occurs in the laboratory, analyses must be halted until the source can be identified and isolated. When the contamination issue is resolved, sample analyses may proceed.

9.8.3 Any other issues that potentially affect data quality should be addressed with the Project Manager.

10.0 Calibration and Standardization

10.1 Initial Calibration

10.1.1 Five calibration standards over the concentration range of interest, described in Section 7.4, are sequentially injected into the HPLC. Each calibration standard is injected using the same technique that is used to introduce the actual samples into the HPLC (e.g., 25 µl injections). Calibration factors (CF) are obtained from the peak areas and the amount injected for each analyte. The results can be used to prepare a calibration curve for each analyte.

10.1.2 Technical acceptance criteria for initial calibration will be met if the percent relative standard deviation (%RSD) of the CFs is ≤20% over the working range. When the criteria are met, linearity through the origin can be assumed, and the average CF can be used in place of a calibration curve for quantitation.

10.1.3 If the % RSD is greater than 20% then an alternate method for quantitation, such as least squares regression or a non-linear calibration method may be used. When one of these options is used, the correlation coefficient of the equation must be 0.99 or greater for a valid calibration. If a quadratic equation is used, six levels of standards must be used. If a third degree polynomial is used, seven levels are required. These alternate methods of quantitation are available in the ThruPut system.

10.1.4 Because of the large number of target analytes, some of them may exceed the 20% criteria. When this occurs, certain steps may be performed.

10.1.4.1 Check the instrument operating conditions and perform maintenance as necessary.

10.1.4.2 Compare responses for the analyte in each of the standard levels to verify that a single standard analysis is not producing the outliers. If so, reanalyze that standard and recalculate the %RSD.

10.1.4.3 The calibration range may be narrowed to determine if linearity can be achieved. This may cause more dilution re-analyses or even change the reporting limit if the lower standard is eliminated. For this method, the method quantitation limit is defined by the lowest standard.

10.1.5 The initial calibration may still be acceptable when some analytes exceed the 20% RSD criteria, if the following conditions are met.

10.1.5.1 The mean of <u>all</u> %RSD values for the analytes is less than or equal to 20%.

10.1.5.2 All analytes in the calibration standard must be included in the calculation.

10.1.5.3 A summary of the initial calibration data and/or a list of the analytes not meeting the 20% RSD criteria and the actual %RSD for each of these analytes must be included as a data deliverable. If the conditions in 10.1.5 are met, then the average calibration factor may be used to determine the concentration of analytes in samples.

10.1.5.4 For samples submitted to meet the regulatory requirements of the State of South Carolina, the grand mean option is not allowed, therefore, the linear regression calibration model is used.

10.2 Initial Calibration Verification

10.2.1 The Initial Calibration Verification (ICV) Standard is required in order to assess the accuracy of the calibration **standards**. It is prepared from a second source standard other than that used to prepare the calibration curve. The ICV is analyzed **once** after an initial calibration is performed.

The ICV is at the mid-concentration of the curve. The results should be within ± 20% of the true value.

10.3 Daily (Continuing) Calibration Verification

10.3.1 Analyze midpoint calibration standards, at a minimum, at the beginning of the day, at the midpoint of the run and after the last sample of the day. Obtain the response factor for each analyte and compare it with the response factor obtained for the initial calibration.

10.3.2 The analyte calibration factors in all continuing calibration verification standards must be within ±15% difference (%D) when compared to the calibration factors of the initial calibration on both analytical columns. If the ± 15% criterion is exceeded for any analyte, calculate the average percent difference across all analytes. If this average is within ± 15%, the calibration has been verified. When this occurs the following conditions must be met:

- The average must include all analytes.
- Clients must be provided with the calibration verification data or a list of those analytes exceeding the ± 15% limit, together with their actual Calibration Factors.
- **For samples submitted to meet the regulatory requirements of the State of South Carolina, the grand mean option is not allowed, therefore, the linear regression analysis calibration model is used.**

11.0 Procedure

Documentation must follow the requirements in QC SOP: Proper Documentation Procedures. Record the analysis sequence information on the instrument run log (Attachment 3).

11.1 Operating Conditions

11.1.1 All electronic equipment is allowed to warm up for 30 minutes. During this period, at least 15 void volumes of mobile phase are passed through the column (approximately 3.0 minutes at 1.0 ml/minute) and continued until the baseline is level at the UV detector's greatest sensitivity.

11.1.2 Allure C18 Column

- Flow rate of phase is set at 1.0 ml/minute.
- Composition of phase is 50% water, 50% methanol.
- Helium sparge rate: 100 ml/minute

11.1.3 Pinnacle Cyano Column

- Flow rate is set at 1.2 ml/minute.
- Gradient is set initially at 79% water, 16% acetonitrile and 5% methanol. It then goes to 81% water, 14% acetonitrile and 5% methanol in 32 minutes on a linear gradient, and equilibrates back to 79% water, 16% acetonitrile and 5% methanol in 33.5 minutes.

Table 4. Operating Conditions for the Pinnacle Cyano Column

		% Solvent		
Time (minutes)	Flow (ml/minute)	Water	Acetonitrile	Methanol
Initial	1.2	79	16	5
5	1.2	79	16	5
32	1.2	81	14	5
53	1.2	79	16	5
55	1.2	79	16	5

11.1.4 Sample injection volume -- 25 µl

11.1.5 UV detector – 254nm wavelength

11.2 HPLC Analysis

11.2.1 Analyze the samples using the chromatographic conditions given in Section 11.1.

11.2.2 All positive measurements observed must be confirmed by injection onto a dissimilar column.

11.2.3 Any target analyte detected above the highest initial calibration standard must be diluted and reinjected in order to get the on-column amount within the upper half of the calibration range.

11.2.4 HPLC Sequence

11.2.4.1 The sequence begins with the calibration verification. The calibration must be verified during each 12 hour shift. Calibration verification standards are also injected after every 10 samples and at the end of the analytical sequence.

Since an analytical sequence may continue as long as instrumental QC criteria are met, the end of one 12-hour sequence is considered to be the beginning of the next 12-hour sequence.

If the continuing calibration fails, re-inject the continuing calibration verification standard (s) or analyze a new initial calibration before more samples analyzed.

11.2.4.2 Each sample analysis must be bracketed with an acceptable initial calibration, "opening" or "closing" continuing calibration verification standards (each 12 hr shift), or calibration standards interspersed with the samples.

11.3 Retention Time Windows

11.3.1 Retention time windows are established for each analyte. The width of each retention time window is based on the actual retention times of standards assessed over a 72 hour period. A standard deviation is calculated for the retention time of each analyte in these standards.

11.3.2 The absolute retention time of each analyte from the standard injected at the beginning of a 24-hour period is used as the midpoint of the window. Values at plus and minus three times the standard deviation, as determined from above, are applied to the absolute retention time of the analyte in the daily standard to generate retention time windows.

11.4 Data Interpretation

11.4.1 Analyst experience is critical in the interpretation of chromatograms.

11.4.2 Tentative identification of an analyte occurs when a peak from a sample extract falls within the retention time window.

11.4.3 A target analytes is confirmed when a peak is present within the expected retention time window on both columns.

11.4.4 Use the external calibration procedure (which establishes mean response factors for each analyte from the initial calibration by dividing peak area by mass injected).

11.4.4.1 Peak areas from peaks within an analyte's retention time window on analytical columns are used to calculate the quantity of each target analyte.

11.4.4.2 Retention times are used to identify each component.

11.4.4.3 The concentration reported is from the column designated as primary, typically the Allure C18. The second column is used as a qualitative confirmation of the presence of the target analytes.

12.0 Data Analysis & Calculations

Calculations must be consistent with the QC SOP: Numerical Data Reduction.

12.1 Calculation of the mean or average of a set of values:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where: n = total number of values
x_i = each individual value used to calculate the mean
x = the mean of n

12.2 Calculation of the standard deviation of a set of values:

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n} \left(X_n - \overline{X}\right)^2}{n-1}}$$

12.3 Calculation of percent recovery:

12.3.1 LCS and surrogates:

$$\%R = \frac{Amount\ found}{Amount\ spiked} x\ 100$$

12.3.2 Matrix spikes:

$$\%\,R = \frac{Amount\ in\ spiked\ sample - Amount\ in\ unspiked\ (native)\ sample}{Amount\ spiked} x\ 100$$

12.4 Calculation of % RSD

$$\%RSD = \left(\frac{Standard\ deviation}{\overline{X}}\right) \times 100$$

12.5 Calculation of RPD

$$RPD = \frac{|Value\ 1 - Value\ 2|}{(Value\ 1 + Value\ 2)/2} x100$$

12.6 Calculation of %Difference (%D)

$$\%Diff = \frac{Value - \overline{Reference\ \ value}}{\overline{Reference\ \ value}} x\ 100$$

12.6.1 If a regression fit model was used for analytes in the initial calibration, the continuing calibration verification is performed by using percent drift, determined using the following equation:

$$\%\,drift = \frac{Cc - Ct}{Ct} x100$$

where: C_C = Calculated concentration determined from initial calibration with regression fit.

C_T = Theoretical concentration/concentration at which the standard was prepared.

12.7 Calibration factors are calculated by dividing the total peak area for the component in the standard by the total mass injected (in nanograms).

$$Calibration\ Factor\ (CF) = \frac{Peak\ area}{Total\ mass\ injected}$$

12.8 Linear Calibration using Least Squares Regression

$y = ax + b$

where: **y = Instrument response (peak area)**
a = Slope of the line (coefficient of x)
x = Concentration of the calibration standard
b = The intercept

12.8 Concentration

12.8.1 Concentration of aqueous samples

$$ug/L = \frac{(Ax)(Vt)(Df)}{(\overline{CF})(Vi)(Vs)}$$

where: Ax = area response for the analyte
Vt = volume of the concentrated extract (µl)
Df = dilution factor. If no dilution, Df = 1.0
$\overline{CF}$ = mean calibration factor from the initial calibration
Vo = volume of water sample extracted (ml)
Vi = volume of extract injected (µl)

12.8.2 Concentration of aqueous samples by GC using linear regression analysis:

$$x = \frac{(y - b)}{a}$$

where: y = Instrument response (peak area)
a = Slope of the line (coefficient of x)
x = Concentration of the calibration standard
b = The intercept

12.8.3 Concentration of soil samples

Note: Soils for the 8330 extraction are dried prior to prepping. A dry weight is not performed for soils and is not included in the calculation.

$$mg/kg = \frac{(Ax)(Vt)(Df)}{(\overline{CF})(Vi)(Ws)(1000)}$$

where: Ws = weight of sample extracted, in grams
Ax, Vt, Df, $\overline{CF}$, Vi have the same definitions as for water.
1000 = conversion factor from µg/Kg to mg/Kg

12.8.4 Concentration of soil samples (dry weight basis) by GC using linear regression analysis:

$$x = \frac{(y-b)}{a}$$

where: y = Instrument response (peak area)
a = Slope of the line (coefficient of x)
x = Concentration of the calibration standard
b = The intercept

12.9 Calculating Dilutions

If a sample concentration exceeds the high level standard a dilution must be performed. Determine a level of dilution that will result in a value within the upper half of the calibration range. This is an acceptable dilution. A 10x dilution is performed using 1 mL sample plus 9 mL diluent for a total volume of 10 mL. It should be recorded on the run log as "10x (1 mL in 10 mL)."

13.0 Method Performance

13.1 This method was validated through in-house laboratory studies of method detection limits (Attachment 1) and precision and accuracy for single analyst (Attachment 4.) The data are retained by the QA department.

14.0 Pollution Prevention

14.1 The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 thing.

15.0 Waste Management

15.1 It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Samples preserved with HCl or H_2SO_4 to pH <2 are hazardous and must be neutralized before being disposed, or must be handled as hazardous waste.

Refer to the Hazardous Waste Management and Safety SOPs located in the lab.

16.0 References

16.1 "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods", SW846, 3rd Edition, Update III, 12/96, Method 8330

16.2 Standard Methods for the Examination of Water and Wastewater, 20th (1998) Edition, Method 1080

16.3 New York State Analytical Services Protocol (NYSASP), June, 2000

16.4 QCSOP: Proper Documentation Procedures

16.5 QCSOP: Numerical Data Reduction

16.6 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477.

16.7 Hazardous Waste Management & Safety SOPs: "Hazardous Waste Disposal" and "Spill Control & Cleanup."

16.8 NELAC Standards, approved May 2001, plus revisions

16.9 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995.

16.10 New York State Environmental Laboratory Approval Program, Certification Manual, October 15, 1999, plus revisions.

16.11 CompuChem Quality Manual, Revision 4, 12/10/03, plus revisions

16.12 Sample Control SOP 4.1, "Receiving Samples"

16.13 Sample Control SOP 4.6, "Storing Samples"

16.14 Code of Federal Register, 40 CFR, Part 136, "Guidelines for Establishing Test Procedures for Priority Pollutants"

16.15 Sample Preparation Procedure –1052, "Preparation of Water Samples for the Analysis of Nitroaromatics and Nitramines by HPLC in SW846 and NYSASP."

16.16 Sample Preparation Procedure –220, "Preparation of Soil/Sediment/Sludge Samples for the Analysis of Nitroaromatics and Nitramines by HPLC in SW846."

16.17 SPP –1082, "Solid Phase Extraction of Water Samples for Analysis of Nitroaromatics and Nitroamines by HPLC in SW846 and NYSASP"

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.1 Attachment 1 - MDLs and Reporting Limits

17.2 Attachment 2 – Instrument Maintenance Log

17.3 Attachment 3 - HPLC Runlog

17.4 Attachment 4 - Single Analyst Capability Study

Attachment 1

Study date: March 11, 2003					Explosives in Water by Method 8330,									
Instrument: Varian 73/74			Salting Out Extraction Procedure, Higher of two column MDLs											
Compound Name	Rep #1	Rep #2	Rep #3	Rep#4	Rep#5	Rep#6	Rep#7	Rep#8	Rep#9	Mean	Amt.	S.Dev.	MDL	Report Limit
	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
HMX	*	*	2.20	1.55	1.29	2.05	2.02	1.76	2.38	1.89	7.79	0.38	1.1	4.0
RDX	2.37	2.63	2.35	2.62	2.27	1.73	1.42	2.94	1.99	2.26	5.19	0.48	1.4	3.0
1,3,5-Trinitrobenzene	2.82	2.73	2.55	2.48	2.58	2.07	1.79	2.77	2.45	2.47	5.19	0.34	0.98	3.0
1,3-Dinitrobenzene	2.64	2.64	2.49	2.39	2.48	1.95	1.78	2.68	2.44	2.39	5.19	0.32	0.91	3.0
Nitrobenzene	2.37	2.27	2.10	2.12	2.24	1.66	1.44	2.26	1.89	2.04	5.19	0.31	0.91	3.0
2,4,6-Trinitrotoluene	3.00	2.84	2.60	2.76	2.63	2.10	1.53	3.08	2.55	2.57	5.19	0.48	1.4	3.0
Tetryl	3.05	3.70	4.07	4.16	4.68	2.99	2.55	3.74	2.89	3.54	7.79	0.70	2.0	4.0
2,4-Dinitrotoluene	3.32	3.30	3.10	2.99	3.14	2.55	2.09	3.44	3.01	2.99	5.19	0.43	1.2	3.0
2-Amino-4,6-dinitrotoluene	3.33	3.66	3.41	3.53	3.52	2.80	2.07	3.70	3.30	3.26	7.79	0.52	1.5	4.0
2,6-Dinitrotoluene	4.23	4.48	4.09	4.10	3.62	3.33	2.39	4.51	3.95	3.86	7.79	0.67	1.9	4.0
4-Amino-2,6-dinitrotoluene	4.16	4.03	3.76	3.70	3.94	3.04	2.60	4.07	3.77	3.67	7.79	0.52	1.5	4.0
2-Nitrotoluene	3.94	3.83	3.62	3.48	3.74	3.00	2.45	3.92	3.35	3.48	7.79	0.49	1.4	4.0
4-Nitrotoluene	3.71	3.85	3.31	3.51	3.56	2.86	2.77	3.66	3.14	3.37	7.79	0.38	1.1	4.0
3-Nitrotoluene	*	6.29	5.86	5.51	5.52	*	4.63	6.64	5.98	5.78	7.79	0.65	1.9	4.0

Study date: January 23, 2004				Explosives in Water by Method 8330,										
Instrument: Varian 74, C8 column				Solid Phase Primary Column										
mpound Name	Rep #1	Rep #2	Rep #3	Rep#4	Rep#5	Rep#6	Rep#7	Rep#8	Rep#9	Mean	Test Conc.	S.Dev.	MDL	Report Limit
	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
HMX	5.69	5.68	5.63	5.78	5.75	5.62	5.37	5.59	*	5.64	6.0	0.13	0.38	2.50
RDX	4.04	3.75	3.88	3.55	3.70	4.02	3.70	3.93	*	3.82	4.0	0.17	0.52	2.50
1,3,5-Trinitrobenzene	3.89	3.82	4.12	3.92	3.78	3.94	3.79	3.76	*	3.88	4.0	0.12	0.36	2.50
1,3-Dinitrobenzene	3.90	3.80	4.09	3.63	3.96	3.88	3.67	4.02	*	3.87	4.0	0.16	0.48	2.50
Nitrobenzene	3.91	3.78	3.90	3.80	3.69	3.90	3.83	3.95	*	3.85	4.0	0.09	0.26	2.50
2,4,6-Trinitrotoluene	4.70	4.62	4.73	4.61	5.09	4.70	4.52	4.65	*	4.70	4.0	0.17	0.51	2.50
Tetryl	7.82	7.56	7.79	7.60	7.38	7.79	7.66	7.91	*	7.69	6.0	0.17	0.52	5.00
2,4-Dinitrotoluene	4.30	4.19	4.51	4.06	4.38	4.41	4.30	4.34	*	4.31	4.0	0.14	0.41	2.50
2-Amino-4,6-dinitrotoluene	6.11	6.37	6.71	6.18	6.41	6.23	6.08	6.03	*	6.27	6.0	0.22	0.67	5.00
2,6-Dinitrotoluene	6.16	6.65	6.66	5.95	6.57	6.47	6.33	6.45	*	6.41	6.0	0.25	0.74	5.00
4-Amino-2,6-dinitrotoluene	6.29	6.16	6.79	6.13	6.52	6.23	6.07	5.97	*	6.27	6.0	0.27	0.80	5.00
2-Nitrotoluene	5.18	5.47	5.38	5.66	5.60	5.75	5.83	5.60	*	5.56	6.0	0.21	0.63	5.00
4-Nitrotoluene	5.38	5.81	5.95	5.57	5.86	5.79	5.62	5.81	*	5.72	6.0	0.19	0.56	5.00
3-Nitrotoluene	5.48	5.43	5.53	5.31	5.21	5.45	5.16	5.50	*	5.38	6.0	0.14	0.42	5.00
* Replicate data not available														

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Attachment 1 (continued)

Study date: January 29, 2004				Explosives in Soil by Method 8330										
Instrument: Varian 76														
Compound Name	Rep #1	Rep #2	Rep #3	Rep#4	Rep#5	Rep#6	Rep#7	Rep#8	Rep#9	Mean	Test Conc.	S.Dev.	MDL	Report Limit
	mgKg	mgKg	mgKg	mgKg	mgKg	mgKg	mgKg	mgKg	mgKg	mgKg	mgKg	mgKg	mgKg	mgKg
HMX	0.89	0.86	0.81	0.84	0.89	0.84	0.84	0.84	0.87	0.85	1.5	0.026	0.077	0.625
RDX	1.65	1.61	1.61	1.67	1.67	1.55	1.65	1.63	1.64	1.63	1.0	0.038	0.109	0.625
1,3,5-Trinitrobenzene	0.27	0.27	0.25	0.31	0.24	0.25	0.23	0.24	0.31	0.26	1.0	0.030	0.086	0.625
1,3-Dinitrobenzene	0.59	0.52	0.54	0.53	0.58	0.53	0.55	0.50	0.45	0.53	1.0	0.042	0.121	0.625
Nitrobenzene	0.36	0.37	0.37	0.36	0.38	0.39	0.40	0.40	0.37	0.38	1.0	0.016	0.045	0.625
2,4,6-Trinitrotoluene	0.33	0.32	0.36	0.39	0.34	0.35	0.41	0.43	0.39	0.37	1.0	0.038	0.110	0.625
Tetryl	0.72	0.74	0.74	0.73	0.76	0.78	0.80	0.79	0.74	0.76	1.5	0.028	0.082	1.25
2,4-Dinitrotoluene	0.70	0.68	0.64	0.69	0.71	0.64	0.64	0.68	0.65	0.67	1.0	0.028	0.081	0.625
2-Amino-4,6-dinitrotoluene	0.94	0.90	0.87	0.91	1.01	0.89	0.86	0.95	0.87	0.91	1.5	0.048	0.140	1.25
2,6-Dinitrotoluene	0.87	0.94	0.87	0.98	1.08	0.83	1.02	0.80	0.83	0.91	1.5	0.097	0.280	1.25
4-Amino-2,6-dinitrotoluene	1.05	0.91	1.04	0.89	1.05	0.87	0.95	0.85	1.01	0.96	1.5	0.081	0.235	1.25
2-Nitrotoluene	1.06	1.00	1.07	1.00	1.07	0.91	0.97	1.04	0.95	1.01	1.5	0.057	0.165	1.25
4-Nitrotoluene	0.89	0.86	0.84	0.89	0.88	0.93	0.88	0.95	0.97	0.90	1.5	0.043	0.123	1.25
3-Nitrotoluene	0.92	0.87	0.86	0.93	0.94	0.90	0.95	0.97	0.99	0.93	1.5	0.043	0.125	1.25

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Attachment 2

CompuChem a division of Liberty Analytical Corp. Logbook 23 I 1
CompuChem Instrument Service Log: Waters HPLC 74/75

Date: _____ Time: _____

System: _____

Problem: _____

_____

_____

_____

_____

Action Taken: _____

_____

_____

_____

_____

_____

Parts used:

Part Number	Description	Quantity

Performed By: _____ Date: _____

Reviewed By: _____ Date: _____

Attachment 3

COMPUCHEM a division of Liberty Analytical Corp Instrument ID ___74___/___75___ DATE ___/___/___
HPLC RUN LOG Sequence ID: _____ SHIFT/S(A)_____(B)_____(C)_____
COMPUCHEM .LOGBOOK 5 C 2 Amt. Inj. 25 µl
Method : 610 8310 8330 Other_____

		FILE NAME		DATE	CompuChem #	CASE/SDG#	CHEMIST	COMMENTS(ETC.)/DISPOSITION
1				/ /				
2				/ /				
3				/ /				
4				/ /				
5				/ /				
6				/ /				
7				/ /				
8				/ /				
9				/ /				
10				/ /				
11				/ /				
12				/ /				
13				/ /				
14				/ /				
15				/ /				
16				/ /				
17				/ /				
18				/ /				
19				/ /				
20				/ /				
21				/ /				
22				/ /				
23				/ /				
24				/ /				

SUPERVISOR APPROVAL_____

DATE _____

The presence of the Chemist's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist together with the chemist's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

7/30/01:dce

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Attachment 4

8330Hooker-Mizlo

Laboratory Name/North Carolina Certificate Number: CompuChem/79
Analyst: Carl Hooker/Traci Mizlo
Study Date: October 27, 1998
Method: 8330 Soils
Instrument/Column/Detector: HPLC74/C8 column

Compounds	TrueVal ug/kg	Rep #1 ug/kg	Rep #2 ug/kg	Rep #3 ug/kg	Rep #4 ug/kg	Mean (x)ug/kg	Mean (r)% R	EPA (x*)%R	SD(n-1) (s)ug/kg	RSD %	EPAlim (s*)ug/l	-3SD of (x)	+3SD of (x)	-3SD % R	+3SD %R
HMX	3.0	4.23	3.65	3.81	3.57	3.82	127	89	0.29	7.7	5.9	2.9	4.7	77	123
1,3,5-Trinitrobenzene	2.0	2.56	2.27	2.18	2.22	2.31	115	89	0.17	7.5	5.9	1.8	2.8	78	122
RDX	2.0	1.93	1.61	1.91	1.72	1.79	90	89	0.15	8.6	5.9	1.3	2.3	74	126
1,3-Dinitrobenzene	2.0	2.80	2.92	3.02	3.07	2.95	148	89	0.12	4.0	5.9	2.6	3.3	88	112
2,4,6-Trinitrotoluene	2.0	2.07	2.13	1.94	2.13	2.07	103	89	0.09	4.3	5.9	1.8	2.3	87	113
Tetryl	3.0	2.58	2.41	0.74	2.35	2.02	67	89	0.86	42.5	5.9	-0.6	4.6	-28	228
Nitrobenzene	2.0	2.29	2.03	2.29	2.17	2.20	110	89	0.12	5.6	5.9	1.8	2.6	83	117
2,4-Dinitrotoluene	2.0	2.08	2.01	2.04	2.13	2.07	103	89	0.05	2.5	5.9	1.9	2.2	92	108
2,6-Dinitrotoluene	3.0	3.33	3.30	3.16	3.33	3.28	109	89	0.08	2.5	5.9	3.0	3.5	93	107
2-Amino-4,6-dinitrotoluene	3.0	2.89	2.86	3.20	3.12	3.02	101	89	0.17	5.6	5.9	2.5	3.5	83	117
4-Amino-2,6-dinitrotoluene	3.0	2.73	2.75	2.89	2.56	2.73	91	89	0.14	4.9	5.9	2.3	3.1	85	115
2-Nitrotoluene	3.0	2.58	2.95	2.73	2.67	2.73	91	89	0.16	5.8	5.9	2.3	3.2	83	117
4-Nitrotoluene	3.0	2.54	2.91	2.69	2.63	2.69	90	89	0.16	5.9	5.9	2.2	3.2	82	118
3-Nitrotoluene	3.0	2.49	2.58	2.74	3.05	2.72	91	89	0.25	9.1	5.9	2.0	3.5	73	127

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CompuChem
A Division Of
Liberty Analytical Corp.

501 Madison Avenue
Cary, NC 27513

NELAP accredited

SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire block below (except effective date).

This is a new procedure _____ revised procedure _____ outdated procedure (archive) _____

- Procedure Code: IP1400 SOP Section #: 2.4.4.3 Revision #: 2

SOP Title: GC/MS Scan and SIM Analyses of Semivolatiles in Water and Soil Matrices by EPA CLP SOM01.1

Effective date: (QA fills in) 8/31/06

- Procedure prepared by: [signature] Date: 8/4/06
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) Bob Merena Date: 8-30-06
- Reason for change: Add QC conditions to Section 6.1
- This procedure meets the requirements of the following approved method references: "US EPA CLP SOW for Organic Analysis, Multi-Media, Multi-Concentration" SOM01.1

Procedure approved by Quality Assurance Representative: Date:
(Not needed if signed above)

Effective 1-1-96, on an annual basis: Lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary, indicate by your signature that the SOP has been reviewed.

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Instrument Procedure 1400: GC/MS Scan and SIM Analyses of Semivolatiles in Water and Soil Matrices by EPA CLP SOM01.1

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Instrument Procedure 1400: GC/MS Scan and SIM Analyses of Semivolatiles in Water and Soil Matrices by EPA CLP SOM01.1

1.0 Scope and Application

This method is for the analysis of extractable, aqueous and solid samples for semivolatile compounds. The target compound list (TCL) for this method and the Contract Required Quantitation Limits (CRQL) are listed in Attachment 1.

Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

2.0 Summary of Method

2.1 A two microliter aliquot of sample extract is injected onto the gas chromatograph (GC). The GC is temperature programmed to separate the semivolatile compounds that are then detected by the mass spectrometer (MS).

2.2 Target and deuterated monitoring compounds are identified in the samples by analyzing standards under the same conditions used for samples and comparing resultant mass spectra and GC retention times. Internal standards are added to all samples and standards. A response factor is established for each target and deuterated monitoring compound during the initial and continuing calibrations by comparing the MS response for the primary ion produced by the compound's extracted ion current profile (EICP) to the MS response for the primary ion produced by an internal standard. Each identified target and deuterated monitoring compound in a sample is quantified by comparing the response for the target compound and the internal standard, while taking into account the mean relative response factor from the most recent initial calibration, the sample volume for water samples (sample weight and percent moisture for solid samples), and any sample dilutions.

2.3 Non-target compounds are identified by comparing the resultant mass spectra from the non-target compounds, to mass spectra contained in the National Institute of Standards and Technology Mass Spectral Library. Non-target compounds are quantified by comparing the MS response from the reconstructed ion chromatogram (RIC) for the non-target compound peaks to the MS response

produced by the nearest internal standard. A response factor of 1 is assumed. Non-target compounds are referred to as Tentatively Identified Compounds (TICs).

2.4 Selected Ion Monitoring (SIM) is performed on the Polynuclear Aromatic Hydrocarbons (PAHs) and pentachlorophenol, when requested.

3.0 Definitions

3.1 Method detection limit (MDL) – The minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR, Part 136, Appendix B.)

3.2 Reporting Limit – The laboratory reporting limit is based on the lowest multipoint calibration standard concentration. Values detected below the reporting limit and above the MDL may be reported and qualified as an estimated concentration.

For CLP methods, the MDL is required to be lower than the reporting limit and must be verified annually.

For CLP, the reporting limit is the Contract Required Quantitation Limit (CRQL).

3.5 Reporting Units – µg/L or µg/Kg

3.4 An SDG is defined by the following, whichever is more frequent:

- each case of field samples received, or
- each 20 field samples (excluding PE samples) received within a case, or
- each 7 calendar day period (3 calendar day period for 7 day turnaround) during which field samples in a case are received beginning with the receipt of the first sample.

3.5 Analytical range for organics – The analytical range is defined by the concentration of the highest standard in the initial calibration. Samples containing target analytes above this limit must be diluted, or a lesser amount of sample analyzed, in order to bring the concentration to within the upper half of the initial calibration range. For CLP the upper half is defined as the concentration between the midpoint standard and the high standard.

3.6 DMC – Deuterated Monitoring Compounds

3.7 I.S. – Internal Standard

3.8 SMO – Sample Management Office

4.0 Interferences

Contaminants in solvents, reagents, glassware, and other sample processing hardware may cause method interferences such as discrete artifacts and/or elevated baselines in the reconstructed ion current (RIC) profiles. All of these materials must be routinely demonstrated to be free from interferences under the conditions of the analysis by running laboratory method blanks. Matrix interference may be caused by contaminants that are co-extracted from the sample. The extent of matrix interferences will vary considerably from source to source.

5.0 Safety

5.1 Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous. During sample preparation, glasses, gloves and lab coats are a minimum requirement. The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

5.2 Laboratory staff must review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets (MSDS) for solvents and reagents used in the laboratory. The MSDS are located in the Quality Assurance department.

6.0 Equipment & Supplies

6.1 Gas Chromatograph/Mass Spectrometer

6.1.1 Gas Chromatograph – The gas chromatograph (GC) system must be capable of temperature programming and have a flow controller that maintains a constant column flow rate throughout the temperature program. The system must be suitable for splitless injection and have all required accessories including syringes, analytical columns, and gases. All GC carrier gas lines must be constructed from stainless steel or copper tubing. Non-polytetrafluoroethylene (PTFE) thread sealants, or flow controllers with rubber components are not to be used.

6.1.1.1 Gas Chromatographic conditions

GC Conditions	Scan	SIM
Injector	**Split/Splitless**	**Split/Split less**
Carrier Gas	**Helium**	**Helium**
Injection Port Temp	**280 – 320°C**	**280 – 320°C**
Sweep Flow (mL/min)	**100**	**100**
Column Flow (mL/min)	**1.5 – 2.7**	**1.5 – 2.7**
Initial Temp	**40**	**45° C**
Hold (min)	**2**	**0.5**
Ramp Rate	**4° C/min to 60° C hold 1 min**	**10° C/min to 280° C hold 9 min**
	10° C/min to 100° C hold 1 min	
	12° C/min to 300° C hold 6.5 min	
Final Temp	**300 ° C**	**280° C**

GC conditions may vary based upon regular column maintenance and column manufacturer specifications.

6.1.2 Gas Chromatography Columns

6.1.2.1 RTX-5MS (30m x 0.25 mm ID x 0.25 µm film thickness)

6.1.2.2 RTX-5MS (30m x 0.32 mm ID x 0.25 µm film thickness)

6.2 Mass Spectrometer

6.2.1 Hewlett Packard (HP) 5890GC, 5972 MSD

6.2.2 Hewlett Packard (HP) 6890GC, 5973 MSD

6.3 Interface

6.3.1 The GC interfaces with the MS through direct insertion of the GC column.

6.4 Data System

6.4.1 The standards and samples are processed using the Hewlett Packard HP 9000 735 Unix Workstation, employing HP Chemserver with Target3/ Envision™ software from Thru-Put Systems (ThermoQuest).

6.5 Data Storage Device

6.5.1 Data is collected on the instrument's ChemServer data system and is transferred via FTP to the Target3 data system for processing and review.

6.5.2 Data is stored on the Target3 data system on a short-term basis and is stored long-term on a data server.

6.6 Glassware

6.6.1 Sample preparation vials: amber, 12 x 32 mm with 350 µL or 400 µL inserts, with 11 mm crimp seals with Teflon® septum.

6.7 Syringes

6.7.1 Hamilton microliter syringes: 10 µL with low heat transfer from hand to sample.

7.0 Reagents & Standards

Prepare all standards according to the details for the preparation contained in the standard operating procedures (SOP) for that area (Section 7.0 of the SOP collection). Store standards separately from samples at 2 - 6° C in the laboratory when not in use.

7.1 Reagent Water-All water used during preparation must be reagent-grade Type I with regard to resistivity of > 10 megohm-cm (19th and 20th Editions of Standard Methods, Method 1080), and is demonstrated to meet the blank criteria contained in this Standard Operating Procedure (SOP). It is referred throughout this SOP as DI water.

7.2 Methylene chloride, pesticide residue analysis grade

7.3 Instrument Performance Check (Tuning) Solution

7.3.1 Prepare the instrument performance check solution, decafluorotriphenylphosphine (DFTPP), at a concentration of 25 ηg/µL. The DFTPP is used to verify the mass calibration and resolution of the MS.

7.3.2 Prepare the DFTPP solution fresh once every twelve months, or sooner, if the solution has degraded or concentrated.

7.4 Initial and Continuing Calibration Solutions

7.4.1 Prepare five initial calibration standards with each target analyte and deuterated monitoring compound (DMC) at concentrations of 5, 10, 20, 40, and 80 ηg/µL except the seven target compounds listed below. These seven compounds require a preparation of a four point calibration at 10, 20, 40, and 80 ηg/µL.

- 2,4-dinitrophenol
- pentachlorophenol
- 2-nitroaniline
- 3-nitroaniline
- 4-nitroaniline
- 4-nitrophenol
- 4,6-dinitro-2-methylphenol

7.4.1.1 Ampulated DMC standards for full-scan analyses are purchased from Cambridge Isotope Laboratories, Inc. (CIL). The 16 full-scan DMCs are each at a concentration of 2000 µg/mL in methylene chloride. The two SIM DMCs are also purchased from CIL in separate ampules, each at a concentration of 200 µg/mL in isooctane. These as-received ampules are used to prepare analytical standards and the DMC spiking solution.

7.4.2 Prepare five initial calibration standards for each SIM DMC and compound at concentrations of 0.10, 0.20, 0.40, 0.80, and 1.00 ηg/µL. A four point calibration is required for pentachlorophenol at 0.20, 0.40, 0.80, and 1.00 ηg/µL.

7.4.3 Add internal standard to each calibration standard for a concentration of 20 ηg/µL for each internal standard. (0.4 ηg/µL for SIM analysis)

7.4.4 Use the 20 ηg/µL initial calibration solution (0.4 ηg/µL for SIM analysis) as the opening and closing continuing calibration verification solution.

7.4.5 Prepare the initial and continuing calibration standards fresh once every twelve months or sooner if the solution has concentrated or compound degradation occurs.

7.5 Deuterated Monitoring Compounds (DMC) Spiking Solution

7.5.1 Prepare the DMC spiking solution in methanol. The solution consists of the following:

- Phenol-d_5
- bis-(2-Chloroethyl) ether-d_8
- 2-Chlorophenol-d_4
- 4-Methylphenol-d_8
- Nitrobenzene-d_5
- 2-Nitrophenol-d_4
- 2,4-Dichlorophenol-d_3
- 4-Chloroaniline-d_4
- Dimethylphthalate-d_6
- Acenaphthylene-d_8
- 4-Nitrophenol-d_4
- Fluorene-d_{10}
- 4,6-Dinitro-2-methylphenol-d_2
- Anthracene-d_{10}
- Pyrene-d_{10}
- Benzo (a) pyrene-d_{12}
- Fluoranthene-d_{10} (SIM)
- 2-Methylnapthalene-d_{10} (SIM)

7.5.2 Add the DMC spiking solution to all method blanks, duplicate matrix spikes, and samples.

7.5.2.1 For SIM analyses, add SIM DMC to each sample, method blank, and matrix spike.

7.5.3 Add an aliquot of DMC solution to each method blank, sample, and matrix spike to result in a 40 ηg (0.40 ηg for SIM) concentration before extracting.

7.5.4 Prepare the DMC spiking solution fresh once every twelve months, or sooner, if the solution has degraded or concentrated.

7.6 Internal Standard Spiking Solution

7.6.1 Prepare the internal standard spiking solution, containing the compounds listed below, at 20 ηg/µL. Add to each calibration standard and sample prior to analysis.

- 1,4-dichlorobenzene-d_4

- naphthalene-d_8
- acenaphthene-d_{10}
- phenanthrene-d_{10}
- chrysene-d_{12}
- perylene-d_{12}

7.6.2 Prepare the SIM internal standard at 0.4 ηg/µL. Add to each calibration standard and sample prior to analysis.

7.6.3 Prepare the internal standard spiking solution fresh once every twelve months, or sooner, if the solution has degraded or concentrated.

7.7 Matrix Spike Spiking Solution

7.7.1 The matrix spiking solution consists of the compounds listed in the following Table.

Base/Neutrals Compounds	**Acid Compounds**
Acenaphthene	Pentachlorophenol
2,4-Dinitrotoluene	Phenol
Pyrene	2-Chlorophenol
N-nitroso-di-n-propylamine	4-Chloro-3-methylphenol
	4-Nitrophenol

7.7.2 Before extraction, add an aliquot of matrix spiking solution to the matrix spike and matrix spike duplicate samples. The compounds in the matrix spike are at a concentration of 40 ηg/µL (0.4 ηg/µL for SIM) in the sample aliquot being analyzed.

7.7.3 Prepare the matrix spiking solution every twelve months, or sooner, if the solution has degraded or concentrated.

8.0 Sample Preservation **and** Storage

8.1 Samples are preserved and stored according to the tables in Sample Control SOP 4.1, "Receiving Samples" and 4.6, "Storing Samples." Sample holding times are also listed.

8.2 **Extract water samples within 5 days of Validated Time of Sample Receipt (VTSR). Extract soil/sediment samples within 10 days of VTSR.** Analyze all extracts within 40 days of extraction.

8.3 Prior to analysis, protect all extracts from light and store under refrigeration at 2 - 6° C in the laboratory. After analysis, return extracts to Sample Control for long-term storage and disposal.

9.0 Quality Control

9.1 Method Blank

9.1.1 Analyze the method blank on each instrument used to analyze associated samples.

9.1.2 For the analysis of aqueous and low level soil samples, no target analyte in the method blank may be present at a concentration equal to or greater than the CRQL, except bis (2-ethylhexyl) phthalate. The concentration of bis (2-ethylhexyl) phthalate, in the method blank, must be less that 5x the CRQL.

9.1.3 For medium level soils, the concentration of all target compounds must be less than the CQRL.

9.1.4 The percent recovery for each of the DMCs in the blank must be within the acceptance windows listed in 9.2.1.

9.1.5 The area response of the internal standards must be within the range of 50.0% and 200.0% of their response from the most recent opening continuing calibration verification standard (CCV). The retention time shift of each internal standard must be within ± 0.50 minutes (30.0 seconds) of its retention time from the most recent opening continuing calibration verification standard.

9.1.6 Corrective action for method blanks.

9.1.6.1 If internal standards do not meet criteria:

- check calculations
- check standard solution for degradation or concentration
- check instrument for malfunction
- reanalyze method blank

9.1.6.2 If DMCs fail acceptance criteria:

- re-analyze the method blank

- if DMC criteria are not met after reanalysis, re-extract all associated samples

9.1.6.3 If the method blank is contaminated:

- contamination source must be determined and corrective action taken
- samples associated with a contaminated blank must be re-extracted and reanalyzed

9.2 DMCs

9.2.1 All DMC recoveries must fall within acceptance ranges shown in the table below. Up to four DMCs per sample may fail to meet the recovery limits, but their recoveries must be greater than zero. The DMC recovery requirements do not apply to a diluted sample.

Deuterated Monitoring Compound Recovery Limits

Compound	% Recovery for Water Samples	% Recovery for Soil Samples
Phenol-d_5	39-106	17-103
bis-(2-Chloroethyl) ether-d_8	40-105	12-98
2-Chlorophenol-d_4	41-106	13-101
4-Methylphenol-d_8	25-111	8-100
Nitrobenzene-d_5	43-108	16-103
2-Nitrophenol-d_4	40-108	16-104
2,4-Dichlorophenol-d_3	37-105	23-104
4-Chloroaniline-d_4	1-145	1-145
Dimethylphthalate-d_6	47-114	43-111
Acenaphthylene-d_8	41-107	20-97
4-Nitrophenol-d_4	33-116	16-166
Fluorene-d_{10}	42-111	40-108
4,6-Dinitro-2-methylphenol-d_2	22-104	1-121
Anthracene-d_{10}	44-110	22-98
Pyrene-d_{10}	52-119	51-120
Benzo (a) pyrene-d_{12}	32-121	43-111
Fluoranthene-d_{10} (SIM)	50-150	50-150
2-Methylnapthalene-d_{10} (SIM)	50-150	50-150

9.2.2 Both SIM DMCs must meet recovery limits.

9.3 Use internal standards as the basis for quantitation of the target and DMC compounds. Attachment 2 summarizes the target and DMC compounds with corresponding internal standards for quantitation.

9.4 Sample Analysis

9.4.1 The internal standard area response must be within the inclusive range of 50.0% and 200.0% of the respective response in the most recent opening continuing calibration verification standard.

9.4.2 The retention time shift for each of the internal standards must be within ± 30 seconds of the respective internal standard in the most recent continuing calibration verification standard.

9.4.3 No ion may saturate the detector and no target compound may exceed the upper limit of the initial calibration range, unless a more dilute aliquot of the sample extract is analyzed.

9.5 Corrective action for sample analysis

9.5.1 If the sample fails to meet DMC acceptance criteria:

- Check calculations.
- Check if correct amount of DMC solution was added; if not, re-extract sample.
- Check if DMC solution was properly prepared; if not, re-extract sample.
- If DMC recoveries were low, check GPC injection volume; if wrong injection volume was used, re-prepare and reanalyze.
- Check for instrument malfunction; correct and reanalyze.

9.5.1.1 If none of the above is true, the problem may be with the sample matrix. Re-extract and reanalyze to confirm matrix effect. If the sample is the original for the duplicate matrix spikes and the DMC failure is observed in one or both of the duplicate matrix spikes, matrix effect is confirmed. If the DMC criteria are met in the duplicate matrix spikes, re-extract the original sample.

9.6 Duplicate Matrix Spikes (only needed when requested by the Client)

9.6.1 Duplicate matrix spike recovery criteria are listed in the table given in 9.6.5. Since the limits are advisory, no further action is required; however, frequent failures should be investigated and may result in questions by the client.

9.6.2 Prepare duplicate matrix spikes for every 20 samples, or as designated.

9.6.3 Do not perform duplicate matrix spike analyses on any field QC samples (including PE samples).

9.6.4 If the submitting client designates a field sample to be used for the duplicate matrix spikes, that sample must be used. The lab is to contact the client if there is insufficient sample left to perform the tests and another sample is selected, or there is insufficient sample remaining in any of the samples.

Matrix Spike Recovery and Relative Percent Difference Limits

Compound	% Recovery Water	RPD Water	% Recovery Soil/Sediment	RPD Soil/Sediment
Phenol	12-110	0-42	26-90	0-35
2-Chlorophenol	27-123	0-40	25-102	0-50
N-nitroso-di-n-propylamine	41-116	0-38	41-126	0-38
4-Chloro-3-methylphenol	23-97	0-42	26-103	0-33
Acenaphthene	46-118	0-31	31-137	0-19
4-Nitrophenol	10-80	0-50	11-114	0-50
2,4-Dintrotoluene	24-96	0-38	28-89	0-47
Pentachlorophenol	9-103	0-50	17-109	0-47
Pyrene	26-127	0-31	35-142	0-36

9.6.5 Internal standard criteria in 9.4.1 and 9.4.2 must be met.

9.7 Method Detection Limit (MDL) Determination

9.7.1 Determine the MDL for each semivolatile target analyte on each of the instruments to be used for sample analyses.

Note: MDLs are matrix-specific and level-specific, that is, the MDL must be determined for water, low-level soils and medium-level soils.

9.7.2 The MDLs are determined, following the procedures specified in 40 CFR Part 136.

9.7.3 The determined concentration of the MDL has to be less than the CRQL.

9.7.4 The MDLs must be verified annually thereafter, while the contract is in effect, and after major instrument maintenance, e.g., cleaning or replacing the source, mass filters, or electron multiplier, or replacement of the GC column.

9.7.4.1 Verify the MDL by spiking with each target analyte at two times the analytically determined MDL. The resulting mass spectra of each target analyte must meet the qualitative identification criteria, presented in the SOW.

9.7.4.2 Verify the MDL for low-level soil by spiking a single purified soil matrix blank with each target compound at a concentration 1-4 times the determined MDL.

9.7.4.3 Verify the MDL for medium-level soil by spiking a single purified soil matrix blank with each target compound at a concentration two times the determined MDL.

9.7.5 All MDL documentation must be maintained at the laboratory and submitted to the client upon written request.

9.8 Contingency

9.8.1 If, due to a lab accident or to QC failure, a re-preparation is required for the sample and insufficient volume remains, the Project Manager must be alerted and will contact the client for direction on how to proceed. For the CLP, the Sample Management Office must be contacted.

9.8.1 If persistent contamination occurs in the laboratory, analyses must be halted until the source can be identified and isolated. When the contamination issue is resolved, sample analyses may proceed.

9.8.1 Any other issues that potentially affect data quality should be addressed with the Project Manager.

10.0 Calibration & Standardization

10.1 GC/MS Instrument Performance Check

10.1.1 Tune the GC/MS to meet manufacturer's specifications using perfluoro-tri-n-butyl amine (FC-43).

10.1.2 Verify the instrument's mass calibration and resolution by analyzing the DFTPP instrument performance check solution every 12 hours. Inject 2 µL of the 25 ηg/µL DFTPP solution into the GC using the cold needle technique. (See Section 7.3.1.) The acceptance criteria for the ion abundances found in the DFTPP spectrum are as follows:

Mass	Ion Abundance Criteria
51	10 - 80 % of mass 198
68	< 2 % of mass 69
69	Present
70	< 2 % of mass 69
127	10 - 80 % of mass 198
197	< 2 % of mass 198
198	Base peak, 100 % relative abundance (see note)
199	5 - 9 % of mass 198
275	10 - 60 % of mass 198
365	Greater than 1 % of mass 198
441	Present but < mass 443
442	≥50.0 % - ≤100 % of mass 198
443	15 - 24 % of mass 442

Note: Normalize all ion abundances to m/z 198, the nominal base peak, even though the ion abundances of m/z 442 may be up to 100 % that of m/z 198.

10.1.3 These abundance criteria must be met for a 50 ηg injection of DFTPP. Acquire the mass spectrum of DFTPP in the following manner:

- Acquire three scans (the peak apex scan and the scans immediately preceding and following the apex) and average.

- Perform background subtraction using a single scan acquired no more than 20 scans prior to the beginning of the elution of DFTPP. Do not subtract part of the DFTPP peak.

Note: The DFTPP solution contains DFTPP, D10-phenanthrene, benzidine, pentachlorophenol, 4, 4′-DDT and endrin. While there is no criterion for the pentachlorophenol response, a very low response indicates that the column and/or the injector is degraded or dirty and needs to be cleaned.

If this is the case, clean the injection port and perform column maintenance prior to continuing with the analysis. The other compounds also assist in diagnosing the condition of the instrument. Endrin is only assessed when the instrument is used for GC/MS pesticide/PCB confirmations because of the lower injector temperature.

10.1.4 The requirement to analyze the instrument performance check doesn't apply when performing SIM analyses.

10.2 Initial Calibration Procedure

10.2.1 Perform an initial five-point calibration (multipoint), at the concentration levels listed in 7.4.1 (7.4.2 for SIM before any method blanks, matrix spikes, or field samples are analyzed.

10.2.2 Perform a multipoint whenever the column is changed or an ion source is replaced.

10.2.3 Allow all standard solutions to equilibrate to ambient temperature.

10.2.4 Perform one injection of each of the five standard concentrations.

10.2.5 Acquire all standard analyses after acceptable DFTPP analysis.

10.2.6 All compounds must be present in all applicable standard levels

10.3 Initial Calibration Acceptance Criteria

10.3.1 All minimum response factor and maximum percent relative standard deviation (%RSD) criteria listed in Attachment 3 must be met for the multipoint to be acceptable.

10.3.1.1 Four of the compounds listed in Attachment 3 may fail acceptance criteria, however, the relative response factors (RRF) for these compounds must be greater than 0.01 and their % RSD less than or equal to 40%.

10.3.1.2 For SIM analysis of PAHs and pentachlorophenol, the multipoint must meet the criteria in 10.3.1. Two compounds may fail acceptance critieria, however, they must meet a minimum RRF of 0.01 and a % RSD of less than or equal to 40 %.

10.4 Opening Continuing Calibration Verification Procedure

10.4.1 Calibrate the GC/MS every twelve hours. This twelve hour period begins with the injection of the DFTPP for full scan analysis.

10.4.1.1 For the SIM analysis, the twelve hour time period begins with the injection of the first standard in the multipoint or the opening CCV.

10.4.2 Inject a 2 µL aliquot of standard, resulting in a 20 ηg concentration (0.4 ηg for SIM onto the GC/MS. Calculate the RRFs for this opening continuing calibration verification (CCV) and compare with the mean RRFs from the multipoint.

10.4.3 Opening CCV Acceptance Criteria

10.4.3.1 As with the initial calibration, up to four (2 for SIM) semivolatile target compounds listed in Attachment 3 may fail to meet the minimum RRF or maximum percent difference criteria (% D), but the RRFs of those compounds must be greater than or equal to 0.01, and the% D must be less than or equal to 40 % for the continuing calibration to be acceptable.

10.5 Closing Continuing Calibration Verification Procedure

10.5.1 Analyze the closing CCV prior to the end of the twelve hour analysis period, and after the last sample is analyzed.

10.5.2 Inject a 2 µL aliquot of the 20 ηg/µL (0.4 ηg/µL for SIM) standard concentration onto the GC/MS. Calculate the RRF for each compound in the closing CCV and compare to the mean RRFs from the multipoint calibration.

10.5.3 Closing CCV Acceptance Criteria

10.5.3.1 The RRF for each compound listed in Attachment 3 must be greater than or equal to 0.01 and the % D must be in the inclusive range of ± 50.0%.

10.5.3.2 For SIM analysis, pentachlorophenol and all PAH compounds must meet the criteria in 10.5.3.1.

Note: If SIM analysis is requested, a full-scan analysis must be performed first.

10.5.3.3 If a closing CCV meets the technical acceptance criteria for an opening CCV and samples are analyzed within the next 12-hour time period, then an additional DFTPP tune isn't required. In this case, the 12-hour time period begins with that calibration verification standard.

11.0 Procedure

Documentation must follow the requirements in Quality Control SOP 13.6, "Proper Documentation Procedures". Record all instrument information in the GC/MS SVOA Run Log (Attachment 4).

11.1 Analysis

11.1.1 Aliquot an amount of DFTPP solution into an autosampler vial. Place vial in autosampler tray on the instrument. The autosampler injects 2 µL of the 25 ηg/µL DFTPP solution, resulting in 50 ηg on-column amount.

11.1.2 Aliquot calibration standard solution(s) into autosampler vials. Place vials in the autosampler tray on the instrument. The autosampler injects 2 µL of standard solution onto the instrument. The initial calibration consists of at least five injections, the continuing calibration, at least one injection.

11.1.3 Aliquot 100 µL of method blank or sample extracts (including duplicate matrix spikes) and add 2.5 µL of internal standard solution into autosampler vials. Place vials in the autosampler tray on the instrument. The autosampler injects 2 µL of the extract onto the instrument.

11.2 Quantitation

11.2.1 Acquire analytical data from each analysis (DFTPP, calibration standard, method blank, or sample) on the instrument's data system and transfer via the file transfer program (FTP) to data processing software.

11.2.2 Use the data processing software (Target) to quantitate the data files. Review the data files for compliance with SOW acceptance criteria.

11.2.3 Process the DFTPP data file. If the data meet acceptance criteria, print the Reconstructed Ion Chromatograph (RTC), mass listing and spectrum with listing of ion abundance criteria.

11.2.4 Process the calibration standard data.

11.2.4.1 For a multipoint calibration:

- Review each standard data file ensuring that each target compound is present. Manual integration may be needed.
- Check the Initial Calibration Data Summary Form on Target and print out if multipoint meets acceptance critiera.
- Print each standard file and arrange in the following order: RIC, quantitation report, and EICP.

11.2.4.2 For opening or closing CCV, follow the points outline in 11.2.4.1

11.2.5 Process each sample data file. Review file(s) to insure that internal standard, DMC and dilution acceptance criteria are met.

11.2.6 After the analysis and acceptance of the closing CCV, make all entries onto the appropriate logbook page(s). Have the logbook page(s) reviewed and signed by the supervisor or designee and make a copy. This copy will accompany the data. Attach the DFTPP and calibration data to the log book copy.

11.3 Qualitative Identification of Target Compounds

11.3.1 An analyst/data reviewer competent in the interpretation of mass spectra must identify the compounds listed in Attachment 1 by comparing the sample mass spectra to the standard mass spectra.

11.3.2 Identify each target compound by verifying that the compound in the sample eluted at the same GC Relative Retention Time (RRT) as the compound in the standard and that the compound's mass spectrum in the sample is comparable to the compound's mass spectrum in the standard.

11.3.2.1 The RRT of the compound in the sample must be within ±0.06 RRT units of the RRT of the compound in the corresponding opening CCV. For samples analyzed in the same 12-hour period as the initial calibration, the sample RRT is compared to that of the 20 ηg/µL standard (0.4 ηg/µL standard for SIM analysis).

11.3.2.1.1 If co-elution of interfering compounds prohibits accurate assignment of the RRT of a compound in the sample from the total ion chromatograph, assign the RRT using the EICP or ions unique to the compound of interest.

11.3.2.2 Compare the mass spectra of the target compounds in the sample to those in the standard used in section 11.3.2.1.

11.3.2.2.1 All ions present in the standard mass spectrum at a relative intensity of >10% (most abundant ion in the spectrum equals 100%) must be present in the sample mass spectrum.

11.3.2.2.2 The relative intensities of the ions in the sample mass spectrum must agree within ±20% of the ions in the standard mass spectrum (e.g., for an ion with an abundance of 50% in the standard spectrum the corresponding abundance of the ion in the sample must be between 30 and 70 %.)

11.3.2.2.3 Ions with an abundance >10% in the sample spectrum but not present in the standard spectrum must be considered and accounted for by the analyst/data reviewer making the comparison. The verification process should favor false positives. All compounds meeting the identification criteria must be reported with their spectra. Compounds meeting the identification criteria, but at concentration below the adjusted CRQL are reported with as estimated concentrations (flagged with a "J").

11.3.3 If a compound cannot be verified by all of the identification criteria in section 11.3.2.2, but in the technical judgment of the analyst/data reviewer that the identification is correct, the compound is reported.

11.4 Qualitative Analysis of Non-Target Compounds

11.4.1 Tentatively identify all compounds in the sample that have not already been identified as target compounds, DMC, or internal standard compounds by performing a computer-generated library search using the NIST 129K.1 mass spectral library. The library search must not be normalized.

11.4.2 Up to 30 tentatively identified compounds (TICs), excluding alkanes, of the greatest concentration are reported for each sample.

11.4.3 TICs identified as alkanes are not counted among the TICs in section 11.15.3. Their concentrations summed as a single result and reported as "total alkanes".

11.4.4 Peaks identified as aldol-condensation reaction products, such as 4-methyl-4-hydroxy-2-pentanone and 4-methyl-3-pentene-2-one, must be reported and counted among the 30 most concentrated TICs. Flag these compounds with an "A" on the Form I SV-TIC.

11.4.5 Rules for making tentative identification:

11.4.5.1 TICs receiving a library search match of 85% or higher are considered a "probable match". Report the compound identified.

11.4.5.2 For TICs receiving more than one library search match of 85% or higher, report the compound with the highest percent match.

11.4.5.3 For TICs receiving two or more library search matches of 85% or higher with the same percent match, report the first compound.

11.4.5.4 For TICs that are isomers receiving library search matches of 85% or higher, report the compound with the highest percent match.

Note: If in the opinion the experienced analyst/data reviewer there is sound technical evidence not to identify the

compound as specified in sections 11.4.5.1 to 11.4.5.4 the justification must be documented in the narrative.

11.4.5.5 TICs receiving a library search match of < 85% are given a tentative identification by the analyst/data reviewer, if possible. If no identification can be made the TIC is reported as "unknown". If possible the unknown is further identified as part of a class of compounds (for example "unknown aromatic").

11.4.6 TIC identification does not apply to SIM analyses.

11.5 Sample Quantitation

11.5.1 The concentration of each target and non-target compound is calculated using the equations is section 12.0.

12.0 Data Analysis & Calculations

Calculations must be consistent with the QC SOP: Numerical Data Reduction.

12.1 Calculation of the mean or average of a set of values:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where: n = total number of values
x_i = each individual value used to calculate the mean
$\overline{x}$ = the mean of n

12.2 Calculation of the standard deviation of a set of values:

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n} \left(X_n - \overline{X}\right)^2}{n-1}}$$

12.3 Calculation of percent recovery

12.3.1 Surrogates

$$\%R = \frac{Amount\ found}{Amount\ spiked}\ x\ 100$$

12.3.2 Matrix spikes

$$\%\ R = \frac{Amount\ in\ spiked\ sample - Amount\ in\ unspiked\ (native)\ sample}{Amount\ spiked}\ x\ 100$$

12.4 Calculation of % RSD

$$\%RSD = \left(\frac{Standard\ deviation}{\overline{X}}\right) \times 100$$

12.5 Calculation of RPD

$$RPD = \frac{|Value\ 1 - Value\ 2|}{(Value\ 1 + Value\ 2)/2} x100$$

12.6 Calculation of %Difference (%D)

$$\%Diff = \frac{Value - \overline{Reference\ value}}{\overline{Reference\ value}}\ x\ 100$$

12.7 Calculation of Relative Response Factor (RRF)

$$RRF = \frac{Ax}{Ais}\ x\ \frac{Cis}{Cx}$$

Where: Ax = area of the characteristic ion from the EICP for the compound to be measured
Ais = area of the characteristic ion for the EICP for the internal standard
Cis = concentration of the internal standard
Cx = concentration of the compound to be measured

12.8 Concentration of aqueous samples by GC/MS analysis

$$\mu g / L = \frac{(Ax)(Is)(Vt)(Df)}{(Ais)(\overline{RRF})(Vo)(Vi)}$$

where:

Ax = area of the characteristic ion from the EICP for the compound to be measured
Ais = area of the characteristic ion for the EICP for the internal standard
Is = amount of internal standard injected (ηg)
$\overline{RRF}$ = mean relative response factor from most multipoint
Vo = volume of water extracted (**mL**)
Vi = volume of extract injected (μ**L**)
Vt = volume of the concentrated extract (μ**L**)
Df = dilution factor. If no dilution, Df = 1.0

12.9 Concentration of soil samples (dry weight basis) by GC/MS

$$\mu g / kg = \frac{(Ax)(Is)(Vt)(Df)(2.0)}{(Ais)(\overline{RRF})(Vi)(Ws)(D)}$$

where:

Ax, Ais, Is, Vt, Vi, $\overline{RRF}$, and Df are the same as given for water
2.0 = GPC factor (if used)
Ws = weight of sample extracted, in grams
D (dry weight) = $\frac{100 - \%\ \text{moisture}}{100}$

12.10 Calculating Dilutions

If a sample concentration exceeds the high level standard a dilution must be performed. Determine a level of dilution that will result in a value within the calibration range by dividing the concentration of the high analyte in the sample by the desired concentration. Dilute the extract with methylene chloride and note the dilution factor and preparation on the run log. (A 10x dilution = 100 μL sample plus 900 μL diluent for a total volume of 1000 μL.)

12.10.1 The maximum dilution factor permitted for low-level soils is 30.0. If a dilution greater than 30.0 is required, then the medium-level method shall be utilized.

13.0 Method Performance

This method was validated through in-house laboratory studies and precision and accuracy for single analyst. The data are retained by the QA department.

14.0 Pollution Prevention

The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 thing. See SOP 12.1, Hazardous Waste Disposal, regarding laboratory procedures for recycling solvent waste streams.

15.0 Waste Management

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Samples preserved with HCl, HNO_3, or H_2SO_4 to pH <2 must be handled as hazardous waste.

Refer to the Hazardous Waste Management and Safety SOPs located in the lab.

16.0 References

16.1 U.S. EPA CLP SOW for Organic Analysis, Multi-Media, Multi-Concentration SOM01.1 (May, 2005)

16.2 "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods", SW-846, 3rd Edition, Update III, 12/96

16.3 Methods for Chemical Analysis of Water and Wastes, March 1983

16.4 Standard Methods for the Examination of Water and Wastewater, 20th (1998) Editions upon promulgation, Method 1080

16.5 Code of Federal Register, 40 CFR, Part 136, "Guidelines for Establishing Test Procedures for Priority Pollutants"

16.6 Quality Control SOP 13.6, "Proper Documentation Procedures"

16.7 Quality Control SOP 13.4, "Numerical Data Reduction"

16.8 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477.

16.9 NELAC Standards, June 2003

16.10 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995

16.11 New York State Environmental Laboratory Approval Program, Certification Manual, December 2005

16.12 CompuChem Quality Manual, Revision 7, Update 1, 12/13/05

16.13 Sample Control SOP 4.1, "Receiving Samples"

16.14 Sample Control SOP 4.6, "Storing Samples"

16.15 Quality Control SOP 13.15, "Documenting Refrigerator and Freezer Temperatures"

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.1 Attachment 1 – Target Compound List and CRQL

17.2 Attachment 2 – TCL and DMC with Corresponding IS for Quantitation

17.3 Attachment 3 - Relative Response Factor Criteria for Initial and Continuing Calibration Verifications of Semivolatile Target Compounds and Deuterated Monitoring Compounds

17.4 Attachment 4 – GC/MS Run Log Example

17.5 Attachment 5 – DMC Primary and Secondary Ions

Attachment 1

Target Compound List (TCL) and Contract Required Quantitation Limits (CRQLs)

Target Compounds	CRQLs			SIM CRQLs	
	µg/L	µg/Kg Low	µg/Kg Medium	µg/L	µg/Kg
Benzaldehyde	5.0	170	5000		
Phenol	5.0	170	5000		
Bis-(2-Chloroethyl) ether	5.0	170	5000		
2-Chlorophenol	5.0	170	5000		
2-Methylphenol	5.0	170	5000		
2,2'-oxybis (1-Chloropropane)	5.0	170	5000		
Acetophenone	5.0	170	5000		
4-Methylphenol	5.0	170	5000		
N-nitroso-di-n-propylamine	5.0	170	5000		
Hexachloroethane	5.0	170	5000		
Nitrobenzene	5.0	170	5000		
Isophone	5.0	170	5000		
2-Nitrophenol	5.0	170	5000		
2,4-Dimethylphenol	5.0	170	5000		
Bis (2-Chloroethoxy) methane	5.0	170	5000		
2,4-Dichlorophenol	5.0	170	5000		
Naphthalene	5.0	170	5000	0.10	3.3
4-Chloroaniline	5.0	170	5000		
Hexachlorobutadiene	5.0	170	5000		
Caprolactam	5.0	170	5000		
4-Chloro-3-methylphenol	5.0	170	5000		
2-Methylnaphthalene	5.0	170	5000	0.10	3.3
Hexachlorocyclopentadiene	5.0	170	5000		
2,4,6-Trichlorophenol	5.0	170	5000		
2,4,5-Trichlorophenol	5.0	170	5000		
1,1'-Biphenyl	5.0	170	5000		
2-Chloronaphthalene	5.0	170	5000		
2-Nitroaniline	10.0	330	10000		
Dimethylphthalate	5.0	170	5000		
2,6-Dinitrotoluene	5.0	170	5000		
Acenaphthylene	5.0	170	5000	0.10	3.3
3-Nitroaniline	10.0	330	10000		
Acenaphthene	5.0	170	5000	0.10	3.3

Attachment 1 (Continued)

Target Compound List (TCL) and Contract Required Quantitation Limits (CRQLs)

Target Compounds	CRQLs			SIM CRQLs	
	µg/L	µg/Kg Low	µg/Kg Medium	µg/L	µg/Kg
2,4-Dinitrophenol	10.0	330	10000		
4-Nitrophenol	10.0	330	10000		
Dibenzofuran	5.0	170	5000		
2,4-Dinitrotoluene	5.0	170	5000		
Diethylphthalate	5.0	170	5000		
Fluorene	5.0	170	5000	0.10	3.3
4-Chlorophenyl-phenylether	5.0	170	5000		
4-Nitroaniline	10.0	330	10000		
4,6-Dinitro-2-methylphenol	10.0	330	10000		
N-Nitrosodiphenylamine	5.0	170	5000		
1,2,4,5 Tetrachlorobenzene	5.0	170	5000		
4-Bromophenyl-phenylether	5.0	170	5000		
Hexachlorobenzene	5.0	170	5000		
Atrazine	5.0	170	5000		
Pentachlorophenol	10.0	330	10000	0.20	6.7
Phenanthrene	5.0	170	5000	0.10	3.3
Anthracene	5.0	170	5000		
Carbazole	5.0	170	5000		
Di-n-butylphthalate	5.0	170	5000		
Fluoranthene	5.0	170	5000	0.10	3.3
Pyrene	5.0	170	5000	0.10	3.3
Butylbenzylphthalate	5.0	170	5000		
3,3'-Dichlorobenzidine	5.0	170	5000		
Benzo (a) anthracene	5.0	170	5000	0.10	3.3
Chrysene	5.0	170	5000	0.10	3.3
Bis (2-ethylhexyl) phthalate	5.0	170	5000		
Di-n-octyl phthalate	5.0	170	5000		
Benzo (b) fluoranthene	5.0	170	5000	0.10	3.3
Benzo (k) fluoranthene	5.0	170	5000	0.10	3.3
Benzo (a) pyrene	5.0	170	5000	0.10	3.3
Indeno (1,2,3-cd) pyrene	5.0	170	5000	0.10	3.3
Dibenz (a,h) anthracene	5.0	170	5000	0.10	3.3
Benzo (g,h,i) perylene	5.0	170	5000	0.10	3.3
2,3,4,6-Tetracholophenol	5.0	170	5000		

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Attachment 2

Target Compounds and Deuterated Monitoring Compound (DMC)
with Corresponding Internal Standards For Quantitation

1,4-Dichlorobenzene-d_4	**Naphthalene-d_8**	**Acenaphthene-d_{10}**
Benzaldehyde	Nitrobenzene	Hexachlorocyclopentadiene
Phenol	Isophorone	2,4,6-Trichlorophenol
Bis(2-Chloroethyl)ether	2-Nitrophenol	2,4,5-Trichlorophenol
2-Chlorophenol	2,4-Dimethylphenol	2,3,4,6-Tetrachlorophenol
2-Methylphenol	Bis (2-Chloroethoxy) methane	1,1'-Biphenyl
2,2'-oxybis-(1-Chloro-propane)	2,4-Dichlorophenol	2-Chloronaphthalene
Acetophenone	4-Chloroaniline	2-Nitroaniline
4-Methylphenol	Hexachlorobutadiene	Dimethylphthalene
N-Nitroso-Di-n-propylamine	Caprolactam	Acenaphthylene
Hexachloroethane	4-Chloro-3-methylphenol	3-Nitroaniline
Phenol-d_5 (DMC)	2-Methylnaphthalene	Acenaphthene
Bis (2-chloroethyl) ether-d_8 (DMC)	Naphthalene	2,4-Dinitrophenol
2-Chlorophenol-d_4 (DMC)	Nitrobenzene-d_5 (DMC)	4-Nitrophenol
4-Methylphenol-d_8 (DMC)	2-Nitrophenol-d_4 (DMC)	Dibenzofuran
	2,4-Dichlorophenol-d_3 (DMC)	2,4-Dinitrotoluene
	4-Chloroaniline-d_4 (DMC)	2,6-Dinitrotoluene
	2-Methylnaphthalene-d_{10} (SIM DMC)	1,2,4,5-Tetrachlorobenzene
		Diethylphthalate
		4-Chlorophenyl-phenylether
		Fluorene
		4-Nitroaniline
		Acenaphthylene-d_8 (DMC)
		4-Nitrophenol-d_4 (DMC)
		Dimethylphthalate-d_6 (DMC)
		Fluorene-d_{10}

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Attachment 2 (Continued)

Target Compounds and Deuterated Monitoring Compound (DMC)
with Corresponding Internal Standards For Quantitation

Phenanthrene-d_{10}	**Chrysene-d_{12}**	**Perylene-d_{12}**
4,6-Dinitro-2-methylphenol	Pyrene	Di-n-octylphthalate
N-nitrosodiphenylamine	Butylbenzylphthalate	Benzo (b) fluoranthene
4-Bromophenyl-phenylether	3,3'-Dichlorobenzidine	Benzo (k) fluoranthene
Hexachlorobenzene	Benzo (a) anthracene	Benzo (a) pyrene
Atrazine	Bis (2-Ethylhexyl) phthalate	Indeno (1,2,3-cd) pyrene
Pentachlorophenol	Chrysene	Dibenzo (a,h) anthracene
Phenanthrene	Pyrene-d_{10} (DMC)	Benzo (g,h,i) perylene
Anthracene		Benzo (a) pyrene-d_{12} (DMC)
Carbazole		
Di-n-butylphthalate		
Fluoranthene		
4,6-Dinitro-2-methylphenol-d_2 (DMC)		
Anthracene-d_{10} (DMC)		
Fluoranthene-d_{10} (SIM-DMC)		

Attachment 3

Relative Response Factor Criteria for Initial and Continuing Calibration Verification of Semivolatile Target Compounds and Deuterated Monitoring Compounds

Semivolatile Compounds	**Minimum RRF**	**Maximum % RSD[1]**	**Maximum % Diff[1]**
Benzaldehyde	0.010	40.0	±40.0
Phenol	0.800	20.0	±25.0
Bis-(2-Chloroethyl) ether	0.700	20.0	±25.0
2-Chlorophenol	0.800	20.0	±25.0
2-Methylphenol	0.700	20.0	±25.0
2,2'-oxybis (1-Chloropropane)	0.010	40.0	±40.0
Acetophenone	0.010	40.0	±40.0
4-Methylphenol	0.600	20.0	±25.0
N-nitroso-di-n-propylamine	0.500	20.0	±25.0
Hexachloroethane	0.300	20.0	±25.0
Nitrobenzene	0.200	20.0	±25.0
Isophone	0.400	20.0	±25.0
2-Nitrophenol	0.100	20.0	±25.0
2,4-Dimethylphenol	0.200	20.0	±25.0
Bis (2-Chloroethoxy) methane	0.300	20.0	±25.0
2,4-Dichlorophenol	0.200	20.0	±25.0
Naphthalene	0.700	20.0	±25.0
4-Chloroaniline	0.010	40.0	±40.0
Hexachlorobutadiene	0.010	40.0	±40.0
Caprolactam	0.010	40.0	±40.0
4-Chloro-3-methylphenol	0.200	20.0	±25.0
2-Methylnaphthalene	0.400	20.0	±25.0
Hexachlorocyclopentadiene	0.010	40.0	±40.0
2,4,6-Trichlorophenol	0.200	20.0	±25.0
2,4,5-Trichlorophenol	0.200	20.0	±25.0
1,1'-Biphenyl	0.010	40.0	±40.0
2-Chloronaphthalene	0.800	20.0	±25.0
2-Nitroaniline	0.010	40.0	±40.0

[1]For a closing CCV, all target compounds and DMCs must meet a minimum RRF of 0.010 and a maximum % Difference of ± 50.0.

Attachment 3 (Continued)

Relative Response Factor Criteria for Initial and Continuing Calibration Verification of Semivolatile Target Compounds and Deuterated Monitoring Compounds

Semivolatile Compounds	**Minimum RRF**	**Maximum % RSD[1]**	**Maximum % Diff[1]**
Dimethylphthalate	0.010	40.0	±40.0
2,6-Dinitrotoluene	0.200	20.0	±25.0
Acenaphthylene	0.900	20.0	±25.0
3-Nitroaniline	0.010	40.0	±40.0
Acenaphthene	0.900	20.0	±25.0
2,4-Dinitrophenol	0.010	40.0	±40.0
4-Nitrophenol	0.010	40.0	±40.0
Dibenzofuran	0.800	20.0	±25.0
2,4-Dinitrotoluene	0.200	20.0	±25.0
Diethylphthalate	0.010	40.0	±40.0
1,2,4,5 Tetrachlorobenzene	0.010	40.0	±40.0
4-Chlorophenyl-phenylether	0.400	20.0	±40.0
Fluorene	0.900	20.0	±25.0
4-Nitroaniline	0.010	40.0	±40.0
4,6-Dinitro-2-methylphenol	0.010	40.0	±40.0
4-Bromophenyl-phenyl ether	0.100	20.0	±25.0
N-Nitrosodiphenylamine	0.010	40.0	±40.0
Hexachlorobenzene	0.100	20.0	±40.0
Atrazine	0.010	40.0	±25.0
Pentachlorophenol	0.050	20.0	±25.0
Phenanthrene	0.700	20.0	±25.0
Anthracene	0.700	20.0	±25.0
Carbazole	0.010	40.0	±40.0
Di-n-butylphthalate	0.010	40.0	±40.0
Fluoranthene	0.600	20.0	±25.0
Pyrene	0.600	20.0	±25.0
Butylbenzylphthalate	0.010	40.0	±40.0
3,3'-Dichlorobenzidine	0.010	40.0	±40.0
Benzo (a) anthracene	0.800	20.0	±25.0

[1]For a closing CCV, all target compounds and DMCs must meet a minimum RRF of 0.010 and a maximum % Difference of ± 50.0.

Attachment 3 (Continued)

Relative Response Factor Criteria for Initial and Continuing Calibration Verification of Semivolatile Target Compounds and Deuterated Monitoring Compounds

Semivolatile Compounds	Minimum RRF	Maximum % RSD[1]	Maximum % Diff[1]
Chrysene	0.700	20.0	±25.0
Bis (2-ethylhexyl) phthalate	0.010	40.0	±40.0
Di-n-octyl phthalate	0.010	40.0	±40.0
Benzo (b) fluoranthene	0.700	20.0	±25.0
Benzo (k) fluoranthene	0.700	20.0	±25.0
Benzo (a) pyrene	0.700	20.0	±25.0
Indeno (1,2,3-cd) pyrene	0.500	20.0	±25.0
Dibenzo (a,h) anthracene	0.400	20.0	±25.0
Benzo (g,h,i) perylene	0.500	20.0	±25.0
2,3,4,6-Tetrachlorophenol	0.100	20.0	±25.0

Deuterated Monitoring Compounds	Minimum RRF	Maximum % RSD[1]	Maximum % Diff[1]
Phenol-d_5	0.010	20.0	±25.0
Bis-(2-Chloroethyl) ether-d_8	0.010	20.0	±25.0
2-Chlorophenol-d_4	0.010	20.0	±25.0
4-Methylphenol-d_8	0.010	20.0	±25.0
Nitrobenzene-d_5	0.010	20.0	±25.0
2-Nitrophenol-d_4	0.010	20.0	±25.0
2,4-Dichlorophenol-d_3	0.010	20.0	±25.0
4-Chloroaniline-d_4	0.010	40.0	±40.0
Dimethylphthalate-d_6	0.010	40.0	±40.0
Acenaphthylene-d_8	0.010	20.0	±25.0
4-Nitrophenol-d_4	0.010	40.0	±40.0
Fluorene-d_{10}	0.010	20.0	±25.0
4,6-Dinitro-2-methylphenol-d_2	0.010	40.0	±40.0
Anthracene -d_{10}	0.010	20.0	±25.0
Pyrene-d_{10}	0.010	20.0	±25.0
Benzo (a) pyrene-d_{12}	0.010	20.0	±25.0
Fluoranthene-d_{10} (SIM)	0.010	20.0	±25.0
2-Methylnaphthalene-d_{10} (SIM)	0.010	20.0	±25.0

[1]For a closing CCV, all target compounds and DMCs must meet a minimum RRF of 0.010 and a maximum % Difference of ± 50.0.

Attachment 4

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COMPUCHEM a division of Liberty Analytical Corp DATE ___/___/___INITIAL TIME OF TUNE_____ SHIFT/S(A)_____(B)_____(C)_____
GC/MS SEMIVOLATILE RUN LOG TIME TUNE EXPIRES_____ LINKER/METHOD_____
COMPUCHEM LOGBOOK 4 YYY 11 (5972hp64)

PREVENTIVE MAINTENANCE_____

	REJECTED	FILE NAME	REPORTED	DATE	TIME	CLIENT ID#	CASE/SDG#	AMOUNT INJECTED	CHEMIST	COMMENTS(ETC.)/DISPOSITION
1				/ /						
2				/ /						
3				/ /						
4				/ /						
5				/ /						
6				/ /						
7				/ /						
8				/ /						
9				/ /						
10				/ /						
11				/ /						
12				/ /						
13				/ /						
14				/ /						
15				/ /						
16				/ /						
17				/ /						
18				/ /						
19				/ /						
20				/ /						
21				/ /						
22				/ /						
23				/ /						
24				/ /						

STANDARDS

	Tune	Analytical	Int. Std.	Column Type
Std. ID#	_____	_____	_____	_____
Lot #	_____	_____	_____	

SUPERVISOR APPROVAL_____

DATE_____

The presence of the Chemist's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist together with the chemist's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

Solvent Lot #_____

12/16/04:jad

Attachment 5

Target Compounds and Deuterated Monitoring Compounds Quantitation And Secondary Ions

Target Compound	Quantitation Ion	Secondary Ion(s)
Benzaldehyde	77	105, 106
Phenol	94	65, 66
Bis(2-Chloroethyl) ether	93	63, 95
2-Chlorophenol	128	64, 130
2-Methylphenol	108	107
2,2'-oxybis(1-Chloropropane)	45	77, 79
Acetophenone	105	77, 51
4-Methylphenol	108	107
N-nitroso-di-n-propylamine	70	42, 101, 130
Hexachloroethane	117	201, 199
Nitrobenzene	77	123, 65
Isophorone	82	95, 138
2-Nitrophenol	139	65, 109
2,4-Dimethylphenol	107	121, 122
Bis(2-chloroethoxy)methane	93	95, 123
2,4-Dichlorophenol	162	164, 98
Naphthalene	128	129, 127
4-Chloroaniline	127	129
Hexachlorobutadiene	225	223, 227
Caprolactam	113	55, 56
4-Chloro-3-methylphenol	107	144, 142
2-Methylnaphthalene	142	141
Hexachlorocyclopentadiene	237	235, 272
2,4,6-Trichlorophenol	196	198, 200
2,4,5-Trichlorophenol	196	198, 200
1,1'-Biphenyl	154	153, 76
2-Chloronaphthalene	162	164, 127
2-Nitroaniline	65	92, 138
Dimethyl phthalate	163	194, 164
Acenaphthylene	152	151, 153
3-Nitroaniline	138	108, 92
Acenaphthene	153	152, 154
2,4-Dinitrophenol	184	63, 154
4-Nitrophenol	109	139, 65

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Attachment 5 (Continued)

Target Compounds and Deuterated Monitoring Compounds Quantitation And Secondary Ions

Target Compound	Quantitation Ion	Secondary Ion(s)
Dibenzofuran	168	139
2,4-Dinitrotoluene	165	63, 182
2,6-Dinitrotoluene	165	89, 121
Diethylphthalate	149	177, 150
1,2,4,5-Tetrachlorobenzene	216	214, 179, 108, 143, 218
4-Chlorophenyl-phenylether	204	206, 141
Fluorene	166	165, 167
4-Nitroaniline	138	92, 108
4,6-Dintro-2-methylphenol	198	182, 77
N-Nitrosodiphenylamine	169	168, 167
4-Bromophenyl-phenylether	248	250, 141
Hexachlorobenzene	284	142, 249
Atrazine	200	173, 215
Pentachlorophenol	266	264, 268
Phenanthrene	178	179, 176
Anthracene	178	179, 176
Carbazole	167	166, 139
Di-n-butylphthalate	149	150, 104
Fluoranthene	202	101, 100
Pyrene	202	101, 100
Butylbenzylphthalate	149	91, 206
3,3'-Dichlrorbenzidine	252	254, 126
Benzo (a) anthracene	228	229, 226
Bis (2-Ethylhexyl) phthalate	149	167, 279
Chrysene	228	226, 229
Di-n-octyl phthalate	149	None
Benzo (b)fluoranthene	252	253, 125
Benzo (k) fluoranthene	252	253, 125
Benzo (a) pyrene	252	253, 125
Indeno (1,2,3-cd)pyrene	276	138, 227
Dibenz (a,h) anthracene	278	139, 279
Benzo (g,h,i) perylene	276	138, 277
2,3,4,6-Tetrachlorophenol	232	131, 230, 166, 234, 168

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SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire block below (except effective date).

This is a new procedure _____ revised procedure ✓ outdated procedure (archive) _____

- Procedure Code: IP 308 SOP Section #: 3.1.1.4 Revision #: 16

SOP Title: Determination of Metals by Inductively Coupled Plasma (ICP) by EPA CLP and NYSASP (ILM04, ILM05.3 SOW Documents) EPA Lab 11/4/05

Effective date: (QA fills in) 11/4/05

- Procedure prepared by: _____ Date: 11/3/05
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) _____ Date: 11-4-05
- Reason for change: EPA AUDIT FINDING REVISIONS AND ANNUAL REVIEW
- This procedure meets the requirements of the following approved method references: US EPA CLP SOW ILM04.1 and ILM05.3, plus revisions; NYSASP, June 2000, plus revisions

Procedure approved by Quality Assurance Representative: Date:
(Not needed if signed above)

_____ _____

Effective 1-1-96, on an annual basis: Lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary, indicate by your signature that the SOP has been reviewed.

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Instrument Procedure 308: Determination of Metals by Inductively Coupled Plasma (ICP) by EPA CLP and NYSASP **(ILM04.1, ILM05.3 SOW Documents)**

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Instrument Procedure 308: Determination of Metals by Inductively Coupled Plasma (ICP) by EPA CLP and NYSASP **(ILM04.1, ILM05.3 SOW Documents)**

1.0 Scope and Application

This method may be used for the determination of dissolved, suspended, **total,** and total recoverable metals in the digestates of liquid samples and solid samples such as sludge, sediments, and soil. This method is compliant with the requirements of the EPA CLP Statement of Work (SOW) ILM04.1 and ILM05.3 plus revisions, and with the New York State Analytical Services Protocol (NYSASP).

Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

2.0 Summary

ICP is a technique that enables an analyst to simultaneously determine multi-elements in solid or liquid samples after digestion of the samples. The basis of this method is the measurement of atomic emission by an optical spectroscopic technique. Samples in liquid form are nebulized, and the aerosols produced are transported to the plasma torch where excitation occurs. Characteristic atomic-line emission spectra are produced by a radio-frequency ICP. The spectra are dispersed by a grating spectrophotometer, and the intensities of the lines are monitored by photomultiplier tubes.

The photocurrents from the photomultiplier tubes are controlled by a computer system. A background correction technique is necessary to compensate for variable background contribution to the determination of metals.

Conventional ICP does not allow for the determination of the four elements, arsenic, selenium, lead, and thallium, at the levels detected by the graphite furnace techniques. However, the Trace ICP is capable of attaining lower detection limits and, therefore, the ICP analysis includes the four graphite furnace elements.

3.0 Definitions

3.1 dissolved metals – metals that will pass through a 0.45 micron membrane filter.

3.2 suspended metals – metals that are retained by a 0.45 micron membrane filter. The residue from the membrane filter is further digested with hot dilute mineral acid(s) and other oxidizing reagent(s).

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3.3 total metals – the concentration of metals determined on an unfiltered liquid sample following vigorous digestion. Total metals in solid samples are determined by digesting a known weight aliquot.

3.4 total recoverable metals – the concentration of metals determined on an unfiltered sample following digestion with hot mineral acid

3.5 Instrument Detection Limit (IDL) – determined by multiplying by three the standard deviation obtained for the analysis of a standard solution (each analyte in reagent water) at a concentration of 3x - 5x IDL on three nonconsecutive days with seven consecutive measurements per day

3.**6** Method detection limit (MDL) – The minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR, Part 136, Appendix B.)

3.**7** Reporting Limit – The laboratory reporting limit is based on the lowest multipoint calibration standard concentration. For some inorganic methods, the reporting limit is based on the MDL, and is usually 4 - 8 times higher than the MDL.

For CLP the reporting limit is the Contract Required Quantitation Limit (CRQL) for ILM05.3 and the Contract Required Detection Limit (CRDL) for ILM04.1.

3.**8** Reporting Units – **µ**g/L for water and mg/Kg for soil

3.**9** An SDG is defined by the following, whichever is more frequent:

- each 20 field samples received within a case, or
- each 7 calendar day period during which field samples in a case are received (**3 calendar day period for 7-day turnaround,** 14 calendar days if requested by the client) beginning with the receipt of the first sample.

NOTE: The Army Corps of Engineers does not accept the SDG approach, unless the samples are prepared in a single batch. When a group of up to 20 field samples of a similar matrix are prepared as one batch, method-specified QC samples such as a method blank, laboratory control sample, matrix spike, matrix spike duplicate, and matrix duplicate must also be prepared together at a rate of 5%. If samples are batched together from different sites, project-specific QC must be processed.

3.**10** CLP – Contract Laboratory Program

3.11 SOW – Statement of Work

3.**12** VTSR – Verified time of sample receipt

4.0 Interferences

4.1 Try to avoid or compensate for the following interferences in ICP measurements:

- Spectral Interferences
- Physical Interferences
- Chemical Interferences

Note**:** Refer to EPA Method 200.7-CLPM, SOW ILM04.1, Section D for details about how to minimize/compensate for each of the above-mentioned interference effects.

4.**2** For the determination of metals, contamination and loss of metals of interest are of prime concern. Dust in the laboratory and impurities on laboratory apparatus and in the reagents are sources of potential contamination. Sample containers can introduce either positive or negative errors in the measurement of metals. Therefore, laboratory glassware, sample bottles, etc., should be thoroughly prepared. **Chemical interferences are partially compensated for by the use of interelement correction factors (IECs). These are analytically determined and adjusted quarterly. See Section 9.2 for additional information.**

5.0 Safety

5.1 Many metal salts are extremely toxic if inhaled or swallowed, so wash your hands after handling salts.

5.2 Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous. During sample preparation, glasses, gloves and lab coats are a minimum requirement. The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

5.3 Laboratory staff are encouraged to review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets (MSDS) for solvents and reagents used in the laboratory. The MSDS are located in the Quality Assurance department.

6.0 Equipment & Supplies

6.1 Inductively Coupled Plasma (ICP) spectrometers

6.1.1 TJA Trace Analyzer (P3)

6.1.2 TJA Trace Analyzer (P4)

6.2 Computer-controlled ICP with background correction

6.3 Radio Frequency Generator

6.4 Argon gas supply

6.5 Nitrogen gas supply (for P4)

7.0 Reagents & Standards

Standard lot numbers are assigned by using the identification of the standard, the date of preparation, and the initials of the preparer each separated by a hyphen. Example: ICSA-031700-abc is the lot number of the ICSA solution prepared on March 17, 2000 by an analyst with the initials of A.B.C. This is recorded in the **Daily** QC/Standards Preparation for Trace ICP Log (Attachment **1**). This logbook also contains instructions for preparation of each standard and QC sample as well as other required traceability documentation.

Standards prepared for quarterly and annual instrument verifications (IDL, IECs, LRS, and MDLs) are reported on the applicable Standards Preparation Logs for Trace ICP, (Attachments 2-5)

7.1 Reagent Water-All water used during preparation should be reagent-grade Type I with regard to resistivity of > 10 megohm-cm (**20**th Editions of Standard Methods, Method 1080), and referred throughout this SOP as DI water.

7.2 Concentrated acids - ultra-high purity grade acids

7.2.1 J.T. Baker Instra-analyzed

7.2.2 Hydrochloric acid (HCl)

7.2.3 Nitric acid (HNO3)

7.2.4 All acids must be used in the preparation lab under a hood.

7.3 Stock standard solutions - commercially available

7.3.1 Standard stock solutions may be purchased from High Purity (XCL-11, XCL-2, XCL-3A) or prepared from ultra-high purity grade chemicals or metals (99.99 -99.999% pure).

7.3.2 Refer to the QC/Standards Prep for Trace ICP **and the Standards Preparation Logs for Trace ICP LRS, MDL, IDL, and IEC studies** for details **regarding solutions and standards used for preparation of these materials.**

7.3.3 Label and refer to these solutions as Calibration Standards.

7.3.4 Prepare **as needed**.

7.3.5 Calibration standards must be verified using an independent source EPA Quality Control sample immediately after instrument calibration.

7.4 Prepare and analyze interference check samples to check for spectral interferences.

7.4.1 **Refer to the QC/Standards Prep for Trace ICP and the Standards Preparation Logs for Trace ICP LRS, MDL, IDL, and IEC studies for details regarding solutions and standards used for preparation of these materials.**

7.5 Prepare and analyze a CRI standard at **the contract required quantitation limit (CRQL, Attachment 6) for ILM05.3. For ILM04.1, the CRI standard is prepared and analyzed at two times the CRDL.**

7.5.1 **Refer to the QC/Standards Prep for Trace ICP and the Standards Preparation Logs for Trace ICP LRS, MDL, IDL, and IEC studies for details regarding solutions and standards used for preparation of these materials.**

7.6 Calculations for typical stock standard solutions are made based on the weight of pure metal added, or with the use of the mole fraction and the weight of the metal added.

$$Concentration\ (ppm) = \frac{weight\ (mg)}{volume\ (L)}$$

Metal salts:

$$Concentration\ (ppm) = \frac{weight\ (mg)\ x\ mole\ \ fraction}{volume\ (L)}$$

7.7 When required, a serial dilution is performed on the sample picked for QC at a five-fold dilution. An aliquot of the sample is combined with four parts acidified reagent water (1% nitric acid, 5% hydrochloric acid) before analysis.

8.0 Sample Collection, Preservation, & Storage

8.1 Samples are collected, preserved, and stored according to the tables in Sample Control SOP 4.1, "Receiving Samples" and 4.6, "Storing Samples." Sample holding times are also listed.

8.2 Metals samples are collected in plastic or glass containers and preserved at the time of collection with HNO_3 to a pH <2. **For ILM04.1, l**iquid samples may be stored at ambient temperature whereas solid samples must be stored in the cooler at 4 ± 2°C. **For ILM05.3, all samples must be refrigerated at 4 ± 2°C from the time of receipt until 60 days after the delivery of a complete, reconciled data package.**

8.3 Prior to analysis, all digestates are stored at ambient temperature in the ICP laboratory. After analysis, **ILM04.1** digestates are maintained for a period of three months and then returned to the Sample Custodian for storage until disposal into the acid waste stream. **Digestates for ILM05.3 are stored until 365 days after delivery of a complete, reconciled data package.**

8.4 Samples must be analyzed within 180 days of verified time of sample receipt (VTSR) in order to meet the method holding time.

9.0 Quality Control

9.1 Method Detection Limits (MDLs) – for ILM05.3

9.1.1 MDLs are to be determined annually for non-prepared analyses (NP1), soil analyses (HS1), and digested water analyses (HW1) on both P3 and P4. After major maintenance or a change in instrument conditions, the MDLs must be rerun to verify instrument sensitivity.

9.1.1.1 Actual analyte concentrations and preparation procedures are reported on the Standards Preparation Log for Trace ICP (P3&P4) MDL Studies, Attachment 5.

9.1.1.2 Under standard analysis conditions (including full calibration, CCV/CCB, CRI, ICSA and ICSAB analyses), eight replicates of the MDL solution are run.

9.1.2 The determined concentration of the MDL must be less than half the concentration of the CRQL.

9.1.3 The test concentration must be less than ten times the calculated MDL. The MDL solution should be made up at a concentration of 3 to 5 times the expected MDL.

9.1.3.1 A spreadsheet to calculate the results is maintained by QA and shall be updated by the analyst upon completing each set of MDLs.

9.2 Interelement corrections **(IECs)**

9.**2**.1 Before the analysis of any samples, the ICP interelement correction factors (IEC) must be determined prior to the start of contract analyses and at least **quarterly** thereafter**, annually for ILM04.1**. Correction factors for spectral interference due to **Al**, Ca, Fe, and Mg must be determined at all wavelengths used for each analyte reported by ICP. Correction factors for spectral interference due to analytes other than Al, Ca, Fe, and Mg must be reported if applied. See Attachment **6** for wavelengths used.

9.2.2 The preparation of standards used for IECs is documented in the Standards Preparation Log for Trace ICP (P3&P4) IEC Studies, Attachment 2.

9.2.3 To determine the IECs, the existing IECs must first be turned off in the method. (Keeping a backup copy of the method is highly recommended.) The analysis of the IEC standards must be preceded by calibration. However, no calibration verification (CCV/CCB) is required.

9.2.4 Calculation of the IEC for a given element is done by dividing the deviation of that element from zero by the measured concentration of the interferent. If the deviation is very small (less than 40% of the ILM04.1 CRDL, see Attachment 6), it can be disregarded. Additional thresholds may be implemented to determine the validity of a correction factor, but it must be noted that the minimum corrections must be sufficient to allow the ICSA and ICSAB solutions to pass.

9.3 Linear Range **Standard** (**LRS**)

9.3.1 For all ICP analyses, a Linear Range Standard (LRS) must be analyzed and reported quarterly for each element on Form XII-IN. The standard must be analyzed during a routine analytical run.

9.3.2 The preparation of the standards used and the analyte concentration is documented in the Standards Preparation Log for Linear Range Standard (LRS) Determination, Attachment 3.

9.3.3 The concentration of this standard must be measured within 5% of the true value.

9.3.4 This concentration is the upper limit of the ICP linear range. Results beyond the range cannot be reported without dilution of the sample.

9.3.5 For certain elements (Al, Ba, Ca, K, Mg, and Na), a curve-fit is used. Multiple calibration standards are prepared and analyzed to develop a calibration curve. Once the curve is determined, the range is confirmed in the same manner as for the linear range elements.

9.**4** Instrument Detection Limits **(IDLs) – for ILM04.1**

9.4.1 Before any field samples are analyzed and quarterly thereafter, the instrument detection limits (IDL) must be determined (in µg/L) for the ICP instrument. IDLs are determined and reported for each wavelength used in the analysis of the samples.

9.4.2 Instrument IDLs are to be used by that instrument for the quarter. If the instrument is adjusted in any way that may affect the IDL, the IDL for that instrument must be re-determined and the results submitted for use as the established IDL for the remainder of the quarter.

9.4.3 The IDLs are determined by multiplying by three, the average of the standard deviations obtained on three non-consecutive days (e.g., Monday, Wednesday, and Friday) from the analysis of a standard solution (each analyte in DI water at a concentration 3x - 5x the instrument manufacturer's suggested IDL **or the most recently determined IDL**), with seven consecutive measurements per day. Each measurement should be performed as though it were a separate analytical sample (i.e., each measurement shall be followed by a rinse and/or any other procedure normally performed between analysis of separate samples)**.**

9.**4**.3.1 NYSASP requires its own set of IDLs to be reported for analytical data. NYSASP IDLs are derived from the same source as typical IDLs but are subjected to a different mathematical process described in the NYASP methods.

9.**5** Initial Calibration Verification (ICV)

9.**5**.1 Use the following sample solutions to verify the calibration:

- ICV1 (**Ag,** Al, **As,** Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Na, **Pb, Tl, Sb, Se,** V, and Zn)
- SPEXASSE (used to report additional non-CLP elements when required by the client)
- Blank (ICB)

9.5.2 The results of the initial calibration **verification** must agree within 10% of the "true" values.

9.5.3 Follow the ICV with the Initial Calibration Blank (ICB).

9.**5**.3.1 Any analyte present in the blank must be less than the EPA **CRQL for ILM05.3 or the CRDL for ILM04.1.**

9.5.4 If criteria are not met, the run must be terminated and the instrument re-calibrated. If re-calibration does not fix the problem, shut down the instrument and request instrument service.

9.**6** **CRQL/CRDL Check** Standard (CRI)

9.6.1 Analyze the CRI standard before the ICS solutions, at the end of the analytical run and at a frequency of no greater than 20 analytical samples.

9.6.2 The CRI standard concentration is **equal to the CRQL for ILM05.3 and equal to 2x CRDL for ILM04.1.**

9.6.3 There are no criteria for this solution in ILM04.1. The criteria for ILM05.3 are ± 30% (± 50% for Sb, Pb, and Tl). Under ILM05.3, the sample **shall** be re**analyzed** once for failing **analytes**. **However, due to the limitations of the autosampler software, the analyst shall terminate the run, recalibrate, and reanalyze any samples affected by the failing CRI standard.**

9.**7** Interference Check Sample

9.7.1 Follow the CRI analysis with the Interference Check **Samples** (ICSA and ICSAB, consecutively). The **Interference** Check **Samples** and the CRI are analyzed at the beginning and the end of the analytical run. Also, the ICS and CRI samples are analyzed and reported at a frequency **of not less** than **once per** 20 analytical samples. (CRI, ICSA and ICSAB samples are **counted as** analytical samples.) The Interference Check **Samples** should be followed, immediately, by the analysis of a CCV/CCB pair.

9.7.2 The Interference Check **Samples** consist of two solutions: Solution A (ICSA) and Solution AB (ICSAB). Solution A contains the interferents and Solution AB **contains** the analytes and interferents.

9.7.3 The analysis of the ICSA **and ICSAB** should agree with the **true** values. The results for analytes **must be within ± 2 times the CRQL of the analyte's true value or ± 20% of the analyte's true value, whichever is greater** (the true value shall be 0 μg/L unless otherwise stated). If these results do not fall within the**se control limits,** check the system**, correct the problem, and recalibrate.**

9.7.4 ICS reference material **shall** be obtained from EPA**, if available,** or an independent source such as ERA. Certificates of analysis with true values for each lot are maintained in a three ring binder in the laboratory.

9.**8** Continuing Calibration Verification (CCV)

9.8.1 Verify the calibration every 10 samples, or every 2 hours during the analytical run, whichever is more frequent, and at the end of analytical run.

9.8.2 The results of the check standard must agree within ±10% of the true value. If not, terminate the analysis, correct the problem, and recalibrate the instrument.

9.**9** Continuing Calibration Blank (CCB)

9.9.1 A calibration blank must be analyzed at each wavelength used for analysis immediately after every initial and continuing calibration verification and at a frequency of 10% or every 2 hours during the run, whichever is more frequent.

9.9.2 Calibration blanks are prepared using same acid **concentrations** as calibration standards.

9.9.3 Any analyte present in the blank must be less than the **CRQL for ILM05.3 or CRDL for ILM04.1**.

9.9.4 If criteria are not met, terminate the analysis and recalibrate. If re-calibration does not fix the problem, shut down the instrument and request instrument service.

9.**10** **Preparation** Blank Analysis

9.10.1 A **preparation** blank is prepared with each digestion batch of up to 20 samples**, contains all reagents in the same volumes used in processing samples, and is carried through the complete procedure used for samples**.

9.10.2 **The preparation** blank is used to ascertain whether sample concentrations reflect contamination.

9.10.3 The blank must contain absolute values of analyte concentrations at less than or equal to the EPA **CRQL for ILM05.3 or CRDL for ILM04.1.**

9.10.4 If the blank exceeds the **CRQL/CRDL**, the entire sample batch associated with the blank must be re-prepared along with a new method blank. The only circumstance under which the method blank can be reported with analyte values greater than the **CQDL/CRDL** is when the concentration of the affected analyte in **all associated** sample**s** exceeds the blank concentration by a factor of 10 or more.

9.**11** Spiked Sample

9.11.1 One sample spike must be prepared with each SDG.

9.11.2 If the sample concentration is less than four times the amount spiked and the recovery of the spike is less than 75% or greater than 125%, the corresponding element is flagged with an "N" on Form 1 to indicate that the element did not recover in the matrix spike acceptably (See Attachment **8** for spiking levels.)

9.11.3 Prepare and analyze a Post Digestion Spike (PDS) for those elements flagged with an "N" (except Ag).

9.11.3.1 The PDS should be spiked at 2 times the **CRQL/CRDL** or 2 times the indigenous level of the analyte in the original sample, whichever is greater.

9.**12** Duplicate Sample

9.12.1 A duplicate sample analysis should be performed once per SDG.

9.12.2 If the sample and duplicate do not agree within a 20% RPD when the concentration is either greater than or equal to 5 X **CRQL/CRDL**, or ± **CRQL/CRDL** when the concentration is < 5 X **CRQL/CRDL**, then the affected element is flagged with an "*" to indicate poor duplication of results.

9.**13** Laboratory Control Sample (LCS)

9.13.1 A matrix-specific Laboratory Control Sample is prepared with **each** digestion batch of up to 20 samples.

9.13.2 The LCS is received certified, with certificate of analysis showing true values and acceptance limits for each element. The results of the aqueous LCS must agree within ± 20% of the true values for all the elements. **(Exeption: Ag and Sb)**

9.13.3.1 If the aqueous LCS falls outside these control limits, the samples associated with that LCS must be re-digested and reanalyzed.

9.13.3 The solid LCS has special control limits that have been established by the vendor. Control limits vary with lot numbers. For the solid LCS control limits see the binder of certificates in the laboratory for the current lot number in use.

9.13.3.2 If the control limits for the solid LCS cannot be met, the samples associated with that LCS must be re-digested and reanalyzed.

9.**14** Serial Dilution

9.14.1 One serial dilution must be performed for each SDG.

9.14.2 Perform a 5x serial dilution on the sample to determine if a chemical or physical interference exists.

9.14.3 If the analyte concentration is 50 times or more above the instrument detection limit in the original sample, the serial dilution must then agree within 10% of the original sample**, after correction for dilution**. If not then flag the appropriate elements with an "E" to indicate that an interference exists.

9.**15** Field Blanks

9.**15**.1 Samples identified as field blanks should not be used for sample spike, duplicate, or serial dilution analysis.

9.**16** Sample Tracking Records

9.**16**.1 Each sample bottle must be labeled with a CompuChem sample identification number.

9.**17** Instrument Printout

9.**17**.1 Because of the nature of the data being collected, all analytical data generated must be labeled so that it can be identified.

9.17.2 Note any dilutions, duplicate analysis, spike analysis, and blank and standard analyses.

9.18 Contingency

9.18.1 If, due to a lab accident or to QC failure, a re-preparation is required for the sample and insufficient volume remains, the Project Manager must be alerted and will contact the client for direction on how to proceed. For the CLP, the Sample Management Office must be contacted.

9.18.2 If persistent contamination occurs in the laboratory, analyses must be halted until the source can be identified and isolated. When the contamination issue is resolved, sample analyses may proceed.

9.18.3 Any other issues that potentially affect data quality should be addressed with the Project Manager.

10.0 Calibration & Standardization

10.1 The instrument calibration standards are analyzed at the beginning of the analytical sequence, in the order shown in the Trace ICP Run Log (Attachment **7**) and must meet acceptance criteria before samples can be analyzed. Calibration is further discussed in the Procedure section that follows.

11.0 Procedure

Documentation must follow the requirements in QC SOP: Proper Documentation Procedures. The sequence information must be recorded in the Trace ICP Run Log.

11.1 TJA Trace Analyzer (P3 or P4) instrument setup

11.1.1 Set up the TJA Trace Analyzer:

- COOLING WATER: Turn on the re-circulation pump. Thirty psi is required at a flow rate of 700 **mL**/minute.

- ARGON SUPPLY: Open the argon supply to the instrument. A volume rate of 30 SCFH and delivery pressure of 60 psi is required.

- VENTING SYSTEM: A permanent vent has been installed to provide a proper draft in the torch compartment. A torch fan is permanently installed to force a 22 mph-draft across the end of the plasma torch.

- WATER IN DRAIN BARREL: A hose is connected to the drain outlet from the spray chamber to allow the flow of unused sample waste from the chamber. This drain line acts as a positive seal to the spray chamber; therefore, liquid must always be present in the waste container.

11.1.2 Power Up (TJA Trace Analyzer) (P3 or P4)

11.1.2.1 To start the ICP Trace Analyzer, turn on the video display, the printer, and the computer. At the "C" prompt, Type "P" and press “ENTER.” This will start the Thermospec™ software and

bring up the main menu. To start the RF generator and the plasma torch, select "SETUP" at the main menu. Then select "PLASMA CONTROL PANEL" and press "ENTER." Select "F1."

11.1.2.2 The default startup time, during which argon purges the spray chamber and the plasma torch, is 90 seconds. The purge time can be reduced to as little as 20 seconds by pressing "PURGE TIME" if the plasma has been off for less than 15 minutes. After the purge time and power have been set, the automated plasma startup sequence is initiated by pressing "CONTINUE." If the pump and gas have not been started, select "F2" and start the pump rate at **100** RPM and switch the **nebulizer** gas to "ON." Press "LEVELS" if you want to change any of the plasma operating conditions.

11.2 Analysis

Note: The plasma torch should be allowed to run for at least 30 minutes after ignition to reach optimum stability.

11.2.1 Profile

11.2.1.1 Profiling the instrument assures that the optical pathway is clean and in alignment. Emission intensities are essential to accurate data.

At the THERMOSPEC main menu, select "Setup" and highlight "Profile" then "Enter."

11.2.2.2 Begin aspirating the 1 ppm As standard for analysis. Note the peak position. This number must be less than 0.10. A perfect reading would be 0.000000. If an adjustment is necessary, select the "F1" key. At the bottom of the screen, a box labeled "Enter Vernier Position" will appear. Check the dial on the face of the instrument labeled "Hg Profile." The digital number on this dial is the number that is entered in the box labeled "Enter Vernier Position." Press enter. At this point, a line reading "New Vernier Position at:" will appear within the graph. This number is the number that should be set on the instrument dial. Repeat the automatic profile procedure until the peak position is within acceptable limits. **Record this information in the run log as described in Section 11.7.4.1.**

11.3 Autosampler Table Setup

11.3.1 Obtain all data necessary from each case that will be set up on the run i.e**.,** prep logs and login chain of custody report from the LIMS. The information contained on these sheets will be used to create the autosampler table.

11.3.2 From the main menu of Thermospec, select "OPERATION," and then "Autosampler Setup," then press enter. The software will prompt for an autosampler table name. An existing table can be edited from this point, or a new autosampler table name can be typed in at this point. Press enter. Press F3 "Add Set." Enter the appropriate run parameters to be used. Parameters that should always be entered here are Method Name, Rinse Time (**90** seconds), # of Unknowns in this set, Default Limit Check Table Name (Sample). Press the F1 "EdSamples" key. This will allow for sample IDs to be entered.

11.3.3 Under the column titled "Sample Name," enter the CompuChem sample ID. Be certain the proper check table is selected for each analysis that is assigned. The "F" key allow for various modifications to the autosampler table. Use these keys as necessary. It is very important that the proper QC samples be inserted into the table at the necessary frequencies. See section 9.0 for a description of necessary QC and frequencies.

11.3.4 Also, if the "Alt" key on the keyboard is pressed, additional options will appear. One of these options is "EdSampInfo." This option is selected by pressing the "Alt" key and the "F2" key simultaneously. From this screen, additional comments can be added that will appear on the raw data printout. Under the column titled "Comment," the SDG, client sample ID and dilution of the sample should be entered.

11.3.5 When all entries are finished, press the "F9," Done/Keep key to save the table. It is important to remember the name of the table created, as this will be used to start the analysis. Press F2 to print the table.

11.3.6 Create a configuration file to store all analytical data. From the main menu of THERMOSPEC select "SETUP" and highlight "CONFIGURATION." Press "Enter" twice then "F9" four times. This will provide the screen to enter the configuration file name. Configuration file names should identify the instrument used and the date of the analysis. Use the scheme, xxmmdd, to construct the file name. The letter "x" is used to identify the instrument, the letter "m" identifies the month, and the letter "d" is for the day. If there is more than one run in a day, a letter suffix should be used to identify the runs. In the example filename,

P30922B, the instrument is identified as "P3", the run **occurred** on September 22, and the "B" suffix identifies this as the third run of the day.

11.3.7 Proceed to analysis. From the main menu of THERMOSPEC select "OPERATION." Highlight "ANALYSIS" then "Enter." Confirm that the correct method is being used and select the autosampler table to be used. Continue to follow on-screen instructions to initiate run.

IMPORTANT: If the run should fail at any time, remember to change the configuration file name before restarting the analytical run.

11.4 Standardization and Analysis

Start the autosampler table following these instructions.

11.4.1 Select "OPERATION" and highlight "Analysis." Enter the correct method for analysis and select the autosampler table for samples to be analyzed.

11.4.2 Fill all standards cups and QC cups with the appropriate solutions. The autosampler table provides the information for cup positions. With regard to standards cups, their positions will change as the number of samples that will be analyzed. Improper cup position will seriously affect analysis to the point that there may not be any salvageable data.

11.4.3 Press "F1" to begin the analytical run. Sample racks should be loaded accurately following the rows and positions provided by the autosampler table. Samples in the wrong position can produce erroneous data that may not be detectable.

11.4.4 Although software drives the instrument operation, the instrument should not be left completely unattended. In the course of the run, matrix spike analyses must be evaluated to determine percent recoveries. Some samples will have concentrations of analytes that are beyond the established linear ranges and will need to be diluted and reanalyzed within those ranges. Serial dilution analyses particularly should be evaluated for proper dilution. Responding to the need for dilutions or a PDS analysis quickly within the same analytical run saves time by not requiring an additional run, hence higher productivity. Sheets to assist in assessing PDS determinations are available.

11.4.5 Attention should be given to periodic QC analyses. Analytes may be found to be outside of their established control limits. The loss of one or more analytes does not necessarily mean the run has ended. Early

detection of failed analytes by the analyst will prevent lost time and productivity.

11.4.6 Standards cups have limited capacity and should be filled frequently and monitored at all times.

11.4.7 ILM04.1 and ILM05.3 require CRI, ICSA and ICSAB analyses performed every 20 analytical samples. The structure of the autosampler table must incorporate this requirement. CRI, ICSA and ICSAB are numbered with the analytical samples. If this maximum is exceeded, the run has ended and all data that does not comply is lost. CRI, ICSA and ICSAB must immediately be followed by a CCV/CCB.

11.4.8 The analytical run is not complete until all final paperwork is complete. A run log (Attachment **7**) must be completed by the analyst, and the standards prep log (Attachment **1**) must also be filled out for the day. **See Section 11.7 for more information on required documentation.**

11.5 Transferring Data

11.5.1 At the completion of the analytical run, exit analysis and return to the THERMOSPEC main menu. Change the configuration file name.

11.5.2 Exit THERMOSPEC and return to Desktop. Double-click on the Explorer icon. While in Explorer, open the STATION directory in the left column, and then open the BIN directory. In the right column, find the name of the file from the analytical run that was just finished. Next, find the MARRS directory in the left column and open that directory. Click on the file name in the right column and copy it to the appropriate directory in MARRS (P3 ICP Trace Files or P4 ICP Trace Files.) Explorer can then be closed.

11.5.3 Transfer the file to the computer used to run the SQUEEZE program. The squeeze function combines two pages of data onto one page. Type "SQZ61E" and follow the instructions to squeeze the data file, and then print the .SQZ file.

11.6 Instrument Shutdown

11.6.1 TJA Trace Analyzer (P3 or P4)

11.6.1.1 Aspirate DI water for approximately one minute.

11.6.1.2 From the MAIN MENU go to SETUP and PLASMA CONTROL PANEL and press enter.

11.6.1.3 Press F7 for PLASMA SHUT off.

11.6.1.4 Remove pump tubing from peristaltic pumps.

11.7 Proper documentation of the run is crucial to compliance with the ILM05.3 and ILM04.1 SOW documents. The primary parts of post-run documentation for regular analyses are the raw data, Run Log, and Daily Standards prep log. For quarterly and annual instrument studies (IECs, IDLs, LRS, MDLs), the relevant prep logs are also required.

11.7.1 Raw data

11.7.1.1 Calibration analyses: on the first page, where the "Blank" was analyzed, write "S0," initial and date. On the subsequent five calibration standard analyses, write "S," initial and date.

11.7.2 Daily Standards Prep Log

11.7.2.1 This should be updated with any new standards used on the first page, and the following pages should have the standard lot numbers updated for any new solutions made. The data file name must be recorded in the designated space on the upper right of the first page. Fill out completely, including required signatures. If no dissolved metal cases are on the run, make sure "N/A" is entered for those sections.

11.7.3 Other Prep Logs

11.7.3.1 If a run includes data for Method Detection Limits (MDLs), Inter-Element Corrections (IECs), Linear Range Standard (LRS), or Instrument Detection Limits (IDLs), the relevant prep logs must be completed (Attachments 2-5).

11.7.4 Run Log

11.7.4.1 Profiling information – on the top of the first page of the run log, fill out the section for instrument profile. If the Vernier position was adjusted, it is only necessary to record the final

measurement. Make note of the Vernier position, the peak intensity, the peak position, and the nebulizer pressure.

11.7.4.2 Maintenance – routine maintenance (cleaning the torch, replacing or switching tubes, adjusting tension on the pump, cleaning the nebulizer, replacing internal standard or acid rinse) should be recorded here. For major maintenance (anything else), record an entry in the instrument's Maintenance Log Book and reference that page in the Run Log.

11.7.4.3 Method – circle the method(s) used on the run.

11.7.4.4 Operator – the name of the analyst running the instrument

11.7.4.5 File name – the name of the file where the raw data was recorded.

11.7.4.6 Date – the date of analysis (NOT the day the run is written up)

11.7.4.7 Time – the time of the analysis of the blank

11.7.4.8 Case information – fill out completely for each SDG on the run

11.7.4.8.1 SDG – the CompuChem-assigned number for non-EPA cases.

11.7.4.8.2 Matrix – specify S for solid, L for leachate, W for water, and B for biological tissue.

11.7.4.8.3 Analytes – indicate TAL, TCLP, RCRA, etc., or "custom" for a specific list.

11.7.4.8.4 Comments – fill out after the run, and will include any information about required re-analysis. If re-running a case, make sure to indicate the data file where the original run took place.

11.7.5 Fill out and number pages sequentially.

11.7.6 Record the run exactly as it happened, with one line per sample analysis. Unused lines must be Z'd out, initialed, and dated.

11.7.6.1 Make sure the proper codes are used for QC.

11.7.6.2 Record any instrument errors, QC failures, or other reason to re-analyze the samples using the symbols in the legend.

11.7.6.3 Make a copy of the run log after it has been reviewed and signed. This copy becomes the "original" for making additional copies for multiple folders on the run.

11.8 Before passing the data package on, make sure all the required components are present and completely filled out. This may also include relevant Chain of Custody documentation and sample preparation documentation (standards log and sample prep).

11.8.1 The original printout and copy of the run log (along with other required documentation) shall be assigned to the lowest alphanumeric EPA SDG. After copies are made, the first page of the original run log is stamped "ORIGINAL" and all other copies are stamped with the "Copy – original included in CSF-_____" stamp. Sign and date this stamp in the spaces provided.

12.0 Data Analysis & Calculations

Calculations must be consistent with the QC SOP: Numerical Data Reduction.

12.1 Calculation of the mean or average of a set of values:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where: n = total number of values
x_i = each individual value used to calculate the mean
x = the mean of n

12.2 Calculation of the standard deviation of a set of values:

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n}\left(X_n - \overline{X}\right)^2}{n-1}}$$

12.3 Calculation of percent recovery:

12.3.1 LCS and surrogates:

$$\%R = \frac{Amount\ found}{Amount\ spiked}\ x\ 100$$

12.3.2 Matrix spikes:

$$\%\ \mathrm{R} = \frac{Amount\ in\ spiked\ sample - Amount\ in\ unspiked\ (native)\ sample}{Amount\ spiked}\ x\ 100$$

12.4 Calculation of % RSD

$$\%\mathrm{RSD} = \left(\frac{Standard\ deviation}{\overline{\mathrm{X}}}\right) \times 100$$

12.5 Calculation of RPD

$$RPD = \frac{|Value\ 1 - Value\ 2|}{(Value\ 1 + Value\ 2)/2} x100$$

12.6 Calculation of %Difference (%D)

$$\%Diff = \frac{Value - \overline{Reference\ \ value}}{\overline{Reference\ \ value}}\ x\ 100$$

12.7 Concentration

12.7.1 Concentration of aqueous samples

$$ug / L = \frac{(C)(V)(D)}{(W)}$$

where: C - Concentration (mg/**L**)
D- Dilution factor
V - Final volume of digestate (L)
W - Volume of sample (L)

12.7.2 Concentration of soil samples (dry weight basis)

$$ug/kg = \frac{(C)(V)(D)}{(W)(S)}$$

where: C - Concentration (mg/**L**)
D - Dilution factor
V - Final volume of digestate (L)
W - Weight in kg of wet sample
S - % Solids/100

12.7.2.1 The concentration of soil samples determined in the digestate are to be reported on the basis of the dry weight of the sample. A separate determination of percent solids must be performed for solid samples as described in Sample Preparation Procedure – 190: "% Solids Determination."

12.8 Calculating Dilutions

If a sample concentration exceeds the linear range of the instrument, a dilution must be performed. Determine a level of dilution that will result in a value within the upper **75%** of the calibration range. This is an acceptable dilution. A 10x dilution is performed using 1 mL sample plus 9 mL diluent for a total volume of 10 mL. It should be recorded on the run log as "10x (1 mL in 10 mL)."

13.0 Method Performance

This method was validated through in-house laboratory studies of method detection limits (**See Section 9.1**) and precision and accuracy for single analyst. The data are retained by the QA department.

14.0 Pollution Prevention

The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 thing.

15.0 Waste Management

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Samples preserved with HCl, HNO_3, or H_2SO_4 to pH <2 are hazardous and must be neutralized before being disposed, or must be handled as hazardous waste.

Refer to the Hazardous Waste Management and Safety SOPs located in the lab.

16.0 References

16.1 U.S. EPA CLP SOW for Inorganic Analysis ILM04.1 and ILM05.3 plus revisions

16.2 TJA ICAP Trace Analyzer Set-up and Operating Manual

16.3 Standard Methods for the Examination of Water and Wastewater, 20th (1998) Edition, Method 1080

16.4 QCSOP: Proper Documentation Procedures

16.5 QCSOP: Numerical Data Reduction

16.6 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477.

16.7 Hazardous Waste Management & Safety SOPs: "Hazardous Waste Disposal" and "Spill Control & Cleanup."

16.8 NELAC Standards, Ju**ly 2003**, plus revisions

16.9 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995.

16.10 New York State Environmental Laboratory Approval Program, Certification Manual, **April 2005**, plus revisions.

16.11 CompuChem Quality Manual, Revision **6**, **Update 1, 5/20/05**, plus revisions

16.12 Sample Preparation Procedure –190: "% Solids Determination."

16.13 New York State Analytical Services Protocol (NYASP), June 2000, plus revisions

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.**1** Attachment **1 – Daily** Standard/QC Preparation for Trace ICP Logbook

17.**2** Attachment **2 – Standards Preparation Log for Trace ICP IEC Studies**

17.**3** Attachment **3 – Standards Preparation Log for Trace ICP LRS Studies**

17.**4** Attachment **4 – Standards Preparation Log for Trace ICP IDL Studies**

17.**5** Attachment **5 – Standards Preparation Log for Trace ICP MDL Studies**

17.6 Attachment 6 – Wavelengths and Reporting Limits for Analytes

17.7 Attachment 7 – Trace ICP Run Log

17.8 Attachment 8 – List of spiking levels for spike sample analysis

Attachment 1

Daily Standards/QC Preparation Log for Trace ICP (P3 & P4) 1 of 4 CompuChem a division of Liberty Analytical Corp. Worksheet 1 P(6)

Seq. File Name: P 3 1 1 0 3

STANDARDS and REAGENTS TRACEABILITY

	Ref #*	Manufacturer	Lot #	Expiration Date
HNO3 [Baker Instra-analyzed Trace-Metals grade]	1M2-176-23	JT Baker	B21039	05/06
HCl [Baker Instra-analyzed Trace-Metals grade]	1M2-176-22	Caledon	54537A	04/06
XCL-11 multi-element standard mix	7M1-33-5	High Purity	516115	07/06
XCL-2 multi-element standard mix	7M1-33-4	High Purity	516116	07/06
XCL-3B multi-element standard mix	7M1-32-3	High Purity	503324	03/06
SPEX multi-element standard mix	7M1-32-04	High Purity	503325	03/06
ICV1 multi-element standard mix	7M1-34-14	EPA	1201	08/06
ICSA multi-element standard mix	7M1-34-23	EPA	0503	05/07
ICSB multi-element standard mix	7M1-34-24	EPA	0203	05/07
LRS multi-element standard mix	7M1-34-25	CPI	05J032	04/07
PDS-A multi-element standard mix	7M1-33-19	High Purity	518610	08/06
PDS-B multi-element standard mix	7M1-33-20	High Purity	518610	08/06
ANTIMONY (Sb) 1,000 PPM single-element standard	7M1-33-13	High Purity	510306	01/07
BISMUTH (Bi) 1,000 PPM single-element standard	7M1-33-9	High Purity	506220	01/07
BORON (B) 1,000 PPM single-element standard	7M1-33-2	High Purity	511014	01/07
BORON (B) 1,000 PPM single-element standard (2nd source)	7M1-31-22	CPI	4IG102	05/06
TITANIUM (Ti) 1,000 PPM single-element standard	7M1-33-15	High Purity	515212	01/07
TIN (Sn) 1,000 PPM single-element standard	7M1-33-14	High Purity	511820	01/07
IRON (Fe) 1,000 PPM single-element standard	7M1-33-12	High Purity	509522	01/07
IRON (Fe) 10,000 PPM single-element standard	7M1-31-10	High Purity	424536	06/06
ALUMINUM (Al) 1,000 PPM single-element standard	7M1-33-24	High Purity	518220	02/07
ALUMINUM (Al) 10,000 PPM single-element standard	7M1-33-11	High Purity	517431	01/07
CALCIUM (Ca) 10,000 PPM single-element standard	7M1-33-10	High Purity	513226	01/07
MAGNESIUM (Mg) 10,000 PPM single-element standard	7M1-33-3	High Purity	513903	01/07
MOLYBDENUM (Mo) 1,000 PPM single-element standard	7M1-33-1	High Purity	419721	01/07
LITHIUM (Li) 1,000 PPM single-element standard	7M1-34-12	CPI	04L037	09/06
LITHIUM (Li) 1,000 PPM single-element standard (2nd source)	7M1-34-13	High Purity	500309	11/06
ARSENIC (As) 1, 000 PPM single-element standard	7M1-31-12	High Purity	428701	06/06
CESIUM (Cs) 50,000 PPM single-element standard	7M1-34-15	High Purity	526211	09/06
YTTRIUM (Y) 1,000 PPM single-element standard	7M1-34-10	High Purity	519220	04/07
Internal Mix	7M1-34-5	High Purity	434138	01/06

The following standard solutions are applicable only when dissolved samples are analyzed.

	Ref #*	Manufacturer	Lot #	Expiration Date
XCL-LCS A multi-element mix	1M2-176-4	High Purity	510803	11/05
XCL-LCS B multi-element mix	1M2-176-5	High Purity	510803	11/05
XCL-20 multi-element mix	1M2-176-3	High Purity	510802	12/05

Entered By: J. BRAUN

Reviewed By: _____ Date: _____

*Ref# = Logbook ID, Page number, and item number from Materials Receipt Log

09/15/05.jbb

Attachment 1 (Continued)

Daily Standards/QC Preparation Log for Trace ICP (P3 & P4) 2 of 4 CompuChem a division of Liberty Analytical Corp. Worksheet 1 P(6)

Standard Lot Number*	Preparation instructions	Resultant Analyte Conc. (µg/L)
S0/ICB/CCB–_11_03_05_–JB	Place in a 500-ml volumetric flask: 100 mL deionized water, _5_ mL concentrated HNO_3, and _25_ mL concentrated HCl. Bring up to volume with deionized water. Prepare as needed	N/A
XCL-11–_11_01_05_–JB	Place in a 100-ml volumetric flask: 50 mL deionized water, _1_ mL concentrated HNO_3, and _5_ mL concentrated HCl. Pipet 0.2 mL XCL-11 into flask. Bring up to volume with deionized water. Prepare as needed	Al:2,000 Cd:2,000 Cr:2,000 Cu:2,000 Pb:2,000 Ni:2,000 Se:2,000 Ag:200 Tl:2,000 Zn:2,000
XCL-2–_10_27_05_–JB	Place in a 100-ml volumetric flask: 50 mL deionized water, _1_ ml concentrated HNO_3, and _5_ mL concentrated HCl. Pipet 0.2 mL XCL-2 into flask. Bring up to volume with deionized water. Prepare as needed	As:2,000 Ba:2,000 Be:2,000 Co:2,000 Fe:2,000 Mn:2,000 Mo:2,000 V:2,000
XCL-3B–_10_27_05_–JB	Place in a 100-ml volumetric flask: 50 mL deionized water, _1_ mL concentrated HNO_3, and _5_ mL concentrated HCl. Pipet 1.0 mL XCL-3B into flask. Bring up to volume with deionized water. Prepare as needed	K:100,000 Na:100,000
PLSBR–_10_27_05_–JB	Place in a 100-ml volumetric flask: 50 mL deionized water, _1_ mL concentrated HNO_3, and _5_ mL concentrated HCl. From 1,000-ppm standards, pipet 0.2 mL of each: Sn, Bi, Ti, Sb, and B into flask. Bring up to volume with deionized water. Prepare as needed.	Sn:2,000 Bi:2,000 Ti:2,000 Sb:2,000 B:2,000
STD3–_11_02_05_–JB	Place in a 100-ml volumetric flask: 50 mL deionized water, _1_ mL concentrated HNO_3, and _5_ mL concentrated HCl. From 10,000-ppm standards, pipet 1.0 mL of each: Al, Mg, and Ca, and 0.5 mL Fe. Bring up to volume with deionized water. Prepare as needed	Al:100,000 Mg:100,000 Ca:100,000 Fe:50,000
CCV/CVS1–_10_31_05_–JB	Place in a 500-ml volumetric flask: 300 mL deionized water, 20 mL concentrated HNO_3, and 100 mL concentrated HCl. From 1,000-ppm standards, pipet 2 mL of each: Sb, Sn, Ba, Ti, and B; and 0.2 mL Zn. From 10,000-ppm standards, pipet 10 mL Ca, 10 mL Mg, 4.8 mL Fe, and 9.8 mL Al. Pipet 2 mL XCL-2, 2 mL XCL-11, and 10 mL XCL-3B. Bring to volume with deionized water. Transfer to a 2 L Teflon bottle. Add 1.5 L deionized water. Prepare as needed.	Al:50,000 Ba:1,000 K:50,000 Mg:50,000 Na:50,000 Ca:50,000 Ag:100 Be:1,000 Cd:1,000 Co:1,000 Cr:1,000 Cu:1,000 Fe:25,000 Mn:1,000 Ni:1,000 Tl:1,000 V:1,000 Zn:1,100 Pb:1,000 Se:1,000 As:1,000 Mo:1,000 Sn:1,000 Bi:1,000 Ti:1,000 Sb:1,000 B:1,000

Standard Solutions Prepared By: _____

Entered By: J. BRAUN

Reviewed By: _____ Date: _____

*Standard Lot Number consists of standard ID, date prepared, and initials of preparer. 09/15/05:jbb

Attachment 1 (Continued)

Daily Standards/QC Preparation Log for Trace ICP (P3 & P4) 3 of 4 CompuChem a division of Liberty Analytical Corp. Worksheet 1 P(6)

Standard Lot Number*	Preparation instructions	Resultant Analyte Conc. (µg/L)
ICV1–_10_13_05_–JB	Place in a 200-ml volumetric flask: 100 mL deionized water, _2_ mL concentrated HNO_3 and _10_ mL concentrated HCl. Pipet 20.0 mL ICV1 into flask. Bring up to volume with deionized water.	Al:2,482 Ba:502 K:10,008 Mg:6,003 Na:10,039 Ca:10,180 Ag:495 Be:493 Cd:494 Co:496 Cr:490 Cu:490 Fe:5,107 Mn:495 Ni:492 Tl:1,027 V:501 Zn:1,000 Pb:996 Se:1,005 As:996
SPEXASSE–_10_11_05_–JB	Place in a 200-ml volumetric flask: 50 mL deionized water, _1_ mL concentrated HNO_3 and _5_ mL concentrated HCl. Pipet 0.2 mL CompuChem SPEX, 0.2 mL Li 1,000-ppm standard (2nd source) and 0.2 mL B 1,000-ppm standard (2nd source). Bring up to volume with deionized water.	Mo:1,000 Sn:1,000 Bi:1,000 Ti:1,000 Sb:1,000 B:1,000 Li:1,000
ICSA–_10_27_05_–JB	Place in a 500-ml volumetric flask: 350 mL of deionized water, _5_ mL concentrated HNO_3, and _25_ mL concentrated HCl. Pipet 50.0 mL ICSA into flask. Bring up to volume with deionized water.	Al:243,900 Ba:2 Ca:234,100 Co:3 Cr:36 Cu:15 Fe:94,900 Mg:248,800 Mn:19 Ni:10 V:1 Zn:39 Pb:5
ICSAB–_10_27_05_–JB	Place in a 500-ml volumetric flask: 50 mL of deionized water, _5_ mL concentrated HNO_3 and _25_ mL concentrated HCl. Pipet 50.0 mL ICSA and 50.0 mL ICSB into flask. From 1,000-ppm standards, add 0.5 mL of each: Bi, Sn, Ti, and Mo. Bring up to volume with deionized water.	Ag:210 Al:248,400 Ba:475 Be:482 Ca:234,300 Cd:916 Co:455 Cr:506 Cu:537 Fe:95,100 Mg:254,100 Mn:483 Ni:930 Tl:96 V:481 Zn:975 Pb:51 Se:51 Sb:585 As:97 Sn:1,000 Bi:1,000 Mo:1,000 Ti:1,000
LRS–_10_24_05_–JB	Place in a 200-ml volumetric flask: 100 mL of deionized water, _2_ mL concentrated HNO_3 and _10_ mL concentrated HCl. Pipet 0.20 mL LRS and 0.04 mL of B 1,000-ppm standard into flask. Bring up to volume with deionized water.	Al:100 Ba:10 K:1,000 Mg:1,000 Na:2,000 Ca:1,000 Ag:5 Be:5 Cd:5 Co:5 Cr:5 Cu:5 Fe:100 Mn:10 Ni:5 Tl:10 V:20 Zn:20 Pb:3 Se:5 As:10 Mo:5 Sn:20 Bi:50 Ti:40 Sb:10 B:200
EPA-CRI–_11_02_05_–JB	Place in a 200-mL volumetric flask: 100 mL deionized water, _2_ mL concentrated HNO_3 and _10_ mL concentrated HCl. Pipet 0.20 mL ICP-AES-CRQL-R into flask. From 1,000-ppm standards, add: 0.008 mL Bi 0.050 mL Sn 0.010 mL Mo 0.012 mL Ti 0.020 mL B 0.001 mL Li Bring up to volume with deionized water.	Ag:10 Be:5 Cd:5 Co:50 Cr:10 Cu:25 Mn:15 Ni:40 Tl:25 V:50 Zn:60 Pb:10 Se:35 As:10 Mo:50 Sn:250 Bi:40 Ti:60 Sb:60 B:100 Li:5

Standard Solutions Prepared By: _____

Entered By: J. BRAUN

Reviewed By: _____ Date: _____

*Standard Lot Number consists of standard ID, date prepared, and initials of preparer. 09/15/05;jbb

Attachment 1 (Continued)

Daily Standards/QC Preparation Log for Trace ICP (P3 & P4) 4 of 4 CompuChem a division of Liberty Analytical Corp. Worksheet 1 P (6)

Standard Lot Number*	Preparation instructions	Resultant Analyte Conc. (µg/L)
COMM-CRI-_10_25_05_-JB	Place in a 200-mL volumetric flask: 100 mL deionized water, 2 mL concentrated HNO_3 and 10 mL concentrated HCl. Pipet 0.20 mL PDS-A and 0.20 mL PDS-B into flask. From 1,000-ppm standards, pipet: 0.008 mL Bi 0.008 mL Sn 0.004 mL Mo 0.012 mL Ti 0.100 mL B Bring up to volume with deionized water.	Al:400 Ba:400 Ag:20 Be:10 Cd:10 Co:100 Cr:20 Cu:50 Fe:200 Mn:30 Ni:80 Tl:20 V:100 Zn:40 Pb:6 Se:10 As:20 Mo:20 Sn:50 Bi:50 Ti:50 Sb:120
As-_10_20_05_-JB	Place in a 100 mL volumetric flask: 50 mL deionized water, 1 mL concentrated HNO_3, and 0.1 mL 1000-ppm As standard. Bring to volume with deionized water.	As:1,000
INTSTD-_10_21_05_-JB	Place in a 10 L container: 8 L deionized water, 400 mL concentrated HNO_3, and 200 mL Internal Mix. Fill with deionized water.	Li:1,000,000 Y:5,000
INTSTD2-_09_21_05_-JB	Place in a 10 L container: 8 L deionized water, 400 mL concentrated HNO_3, 1000 mL 50,000-ppm Cs standard, and 60 mL 1,000-ppm Y standard. Fill with deionized water.	Cs:5,000,000 Y:6,000

Dissolved Metals only:	Prepared By	Date Prepared	Preparation Instructions
LCS	JB	11/3/05	Add 0.1 mL of XCL-LCS solution A and 0.1 mL of XCL-LCS solution B to 9.8 mL acidified water (1% HNO_3 + 5% HCl).
Prep Blank	JB	11/3/05	Use acidified water (1% HNO_3 + 5% HCl).
Sample Spike	JB	11/3/05	Add 0.1 mL of XCL-20 to 9.9 mL of sample.

Standard Solutions Prepared By: _____

Entered By: J. BRAUN

Reviewed By: _____ Date: _____

*Standard Lot Number consists of standard ID, date prepared, and initials of preparer. 09/15/05:jbb

The presence of the Chemist's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist together with the chemist's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

Note: Attachment subject to change without notice.

Attachment 2

Standards Preparation Log for Trace ICP (P3&P4) IEC Studies

1 of 3
Worksheet 1 P(A)

STANDARDS and REAGENTS TRACEABILITY

	Ref #*	Manufacturer	Lot #	Expiration Date
ALUMINUM (Al) 1,000 PPM	7M1-33-24	High Purity	518220	02/07
ALUMINUM (Al) 10,000 PPM	7M1-33-11	High Purity	517431	01/07
ANTIMONY (Sb) 1,000 PPM	7M1-33-13	High Purity	510306	01/07
ARSENIC (As) 1,000 PPM	7M1-31-12	High Purity	428701	06/06
BARIUM (Ba) 1,000 PPM	7M1-34-6	High Purity	513011	03/07
BARIUM (Ba) 10,000 PPM	7M1-31-4	High Purity	420806	06/06
BERYLLIUM (Be) 1,000 PPM	7M1-30-10	High Purity	412720	03/06
BISMUTH (Bi) 1,000 PPM	7M1-33-9	High Purity	506220	01/07
BORON (B) 1,000 PPM	7M1-33-2	High Purity	511014	01/07
BORON (B) 1,000 PPM (2nd source)	7M1-31-22	CPI	4IG102	05/06
CALCIUM (Ca) 10,000 PPM	7M1-33-10	High Purity	513226	01/07
CADMIUM (Cd) 1,000 PPM	7M1-30-13	High Purity	417528	03/06
CESIUM (Cs) 10,000 PPM	7M1-34-11	High Purity	522915	04/07
CHROMIUM (Cr) 1,000 PPM	7M1-31-5	High Purity	424704	06/06
COBALT (Co) 1,000 PPM	7M1-31-6	High Purity	423325	06/06
COPPER (Cu) 1,000 PPM	7M1-30-14	High Purity	421703	03/06
IRON (Fe) 1,000 PPM	7M1-33-12	High Purity	509522	01/07
IRON (Fe) 10,000 PPM	7M1-31-10	High Purity	424536	06/06
LEAD (Pb) 1,000 PPM	7M1-33-22	High Purity	516645	02/07
LITHIUM (Li) 1,000 PPM	7M1-34-12	CPI	04L037	09/06
LITHIUM (Li) 1,000 PPM (2nd source)	7M1-34-13	High Purity	500309	11/06
MAGNESIUM (Mg) 10,000 PPM	7M1-33-3	High Purity	513903	01/07
MANGANESE (Mn) 1,000 PPM	7M1-33-23	High Purity	514421	02/07
MOLYBDENUM (Mo) 1,000 PPM	7M1-33-1	High Purity	419721	01/07
NICKEL (Ni) 1,000 PPM	7M1-31-7	High Purity	426809	06/06
POTASSIUM (K) 10,000 PPM	7M1-30-7	High Purity	414913	03/06
SELENIUM (Se) 1,000 PPM	7M1-34-8	High Purity	518210	03/07
SILVER (Ag) 1,000 PPM	7M1-30-15	High Purity	411001	03/06
SODIUM (Na) 1,000 PPM	7M1-31-8	High Purity	423227	06/06
SODIUM (Na) 10,000 PPM	7M1-30-8	High Purity	419427	06/06
THALLIUM (Tl) 1,000 PPM	7M1-31-9	High Purity	425902	06/06
TIN (Sn) 1,000 PPM	7M1-33-14	High Purity	511820	01/07
TITANIUM (Ti) 1,000 PPM	7M1-33-15	High Purity	515212	01/07
VANADIUM (V) 1,000 PPM	7M1-31-11	High Purity	426130	06/06
YTTRIUM (Y) 1,000 PPM	7M1-28-17	High Purity	405815	11/05
ZINC (Zn) 1,000 PPM	7M1-34-7	High Purity	515819	03/07

Applies to Seq. File(s):_____

Entered By: J. BRAUN

Reviewed By:_____ Date:_____

*Ref# = Logbook ID, Page number, and item number from Materials Receipt Log

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Attachment 2 (Continued)

Standards Preparation Log for Trace ICP (P3&P4) IEC Studies

2 of 3
Worksheet 1 P(A)

Standard Name	Preparation instructions
Al-500 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 5 mL of 10,000-ppm Al. Bring up to volume with deionized water. Prepare annually.
Ag-2 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 0.2 mL of 1,000-ppm Ag. Bring up to volume with deionized water. Prepare annually.
As-10 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 1 mL of 1,000-ppm As. Bring up to volume with deionized water. Prepare annually.
B-20 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 2 mL of 1,000-ppm B. Bring up to volume with deionized water. Prepare annually.
Ba-50 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 0.5 mL of 10,000-ppm Ba. Bring up to volume with deionized water. Prepare annually.
Be-5 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 0.5 mL of 1,000-ppm Be. Bring up to volume with deionized water. Prepare annually.
Bi-5 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 0.5 mL of 1,000-ppm Bi. Bring up to volume with deionized water. Prepare annually.
Ca-500 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 5 mL of 10,000-ppm Ca. Bring up to volume with deionized water. Prepare annually.
Cd-15 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 1.5 mL of 1,000-ppm Cd. Bring up to volume with deionized water. Prepare annually.
Co-20 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 2 mL of 1,000-ppm Co. Bring up to volume with deionized water. Prepare annually.
Cr-20 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 2 mL of 1,000-ppm Cr. Bring up to volume with deionized water. Prepare annually.
Cu-20 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 2 mL of 1,000-ppm Cu. Bring up to volume with deionized water. Prepare annually.
Fe-300 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 3 mL of 10,000-ppm Fe. Bring up to volume with deionized water. Prepare annually.
K-200 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 2 mL of 10,000-ppm K. Bring up to volume with deionized water. Prepare annually.
Li-20 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 2 mL of 1,000-ppm Li. Bring up to volume with deionized water. Prepare annually.

Standard Solutions Prepared By:_____

Entered By: J. BRAUN

Reviewed By:_____ Date:_____

10/06/05:jbb

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Attachment 2 (Continued)

Standards Preparation Log for Trace ICP (P3&P4) IEC Studies

3 of 3
Worksheet 1 P(A)

Standard Name	Preparation instructions
Mg-500 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 5 mL of 10,000-ppm Mg. Bring up to volume with deionized water. Prepare annually.
Mn-10 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 1 mL of 1,000-ppm Mn. Bring up to volume with deionized water. Prepare annually.
Mo-5 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 0.5 mL of 1,000-ppm Mo. Bring up to volume with deionized water. Prepare annually.
Na-200 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 2 mL of 10,000-ppm Na. Bring up to volume with deionized water. Prepare annually.
Ni-20 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 2 mL of 1,000-ppm Ni. Bring up to volume with deionized water. Prepare annually.
Pb-20 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 2 mL of 1,000-ppm Pb. Bring up to volume with deionized water. Prepare annually.
Sb-5 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 0.5 mL of 1,000-ppm Sb. Bring up to volume with deionized water. Prepare annually.
Se-20 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 2 mL of 1,000-ppm Se. Bring up to volume with deionized water. Prepare annually.
Sn-5 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 0.5 mL of 1,000-ppm Sn. Bring up to volume with deionized water. Prepare annually.
Ti-5 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 0.5 mL of 1,000-ppm Ti. Bring up to volume with deionized water. Prepare annually.
Tl-20 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 2 mL of 1,000-ppm Tl. Bring up to volume with deionized water. Prepare annually.
V-20 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 2 mL of 1,000-ppm V. Bring up to volume with deionized water. Prepare annually.
Zn-20 PPM	Place in a 100-ml volumetric flask: 50 ml of deionized water, _1_ml concentrated HNO_3, and _5_ml concentrated HCl. Pipet 2 mL of 1,000-ppm Zn. Bring up to volume with deionized water. Prepare annually.
Li-10 PPM	In a 15-mL beaker, pipet 5 mL acidified water and 5 mL Li-20 PPM. Prepare immediately before analysis.

Standard Solutions Prepared By:_____

Entered By: J. BRAUN

Reviewed By:_____ Date:_____

10/06/05:jbb

Note: Attachment subject to change without notice.

Attachment 3

Standards Preparation Log for Trace ICP (P3&P4) Linear Range Standard(LRS) Studies 1 of 2
Worksheet 1 P(B)

STANDARDS and REAGENTS TRACEABILITY

	Ref #*	Manufacturer	Lot #	Expiration Date
XCL-11 multi-element standard mix	7M1-33-5	High Purity	516115	07/06
XCL-2 multi-element standard mix	7M1-33-4	High Purity	516116	07/06
XCL-3B multi-element standard mix	7M1-32-3	High Purity	503324	03/06
SPEX multi-element standard mix	7M1-32-04	High Purity	503325	03/06
ALUMINUM (Al) 1,000 PPM	7M1-33-24	High Purity	518220	02/07
ALUMINUM (Al) 10,000 PPM	7M1-33-11	High Purity	517431	01/07
ANTIMONY (Sb) 1,000 PPM	7M1-33-13	High Purity	510306	01/07
ARSENIC (As) 1,000 PPM	7M1-31-12	High Purity	428701	06/06
BARIUM (Ba) 1,000 PPM	7M1-34-6	High Purity	513011	03/07
BARIUM (Ba) 10,000 PPM	7M1-31-4	High Purity	420806	06/06
BERYLLIUM (Be) 1,000 PPM	7M1-30-10	High Purity	412720	03/06
BISMUTH (Bi) 1,000 PPM	7M1-33-9	High Purity	506220	01/07
BORON (B) 1,000 PPM	7M1-33-2	High Purity	511014	01/07
BORON (B) 1,000 PPM (2nd source)	7M1-31-22	CPI	4IG102	05/06
CALCIUM (Ca) 10,000 PPM	7M1-33-10	High Purity	513226	01/07
CADMIUM (Cd) 1,000 PPM	7M1-30-13	High Purity	417528	03/06
CESIUM (Cs) 10,000 PPM	7M1-34-11	High Purity	522915	04/07
CHROMIUM (Cr) 1,000 PPM	7M1-31-5	High Purity	424704	06/06
COBALT (Co) 1,000 PPM	7M1-31-6	High Purity	423325	06/06
COPPER (Cu) 1,000 PPM	7M1-30-14	High Purity	421703	03/06
IRON (Fe) 1,000 PPM	7M1-33-12	High Purity	509522	01/07
IRON (Fe) 10,000 PPM	7M1-31-10	High Purity	424536	06/06
LEAD (Pb) 1,000 PPM	7M1-33-22	High Purity	516645	02/07
LITHIUM (Li) 1,000 PPM	7M1-34-12	CPI	04L037	09/06
LITHIUM (Li) 1,000 PPM (2nd source)	7M1-34-13	High Purity	500309	11/06
MAGNESIUM (Mg) 10,000 PPM	7M1-33-3	High Purity	513903	01/07
MANGANESE (Mn) 1,000 PPM	7M1-33-23	High Purity	514421	02/07
MOLYBDENUM (Mo) 1,000 PPM	7M1-33-1	High Purity	419721	01/07
NICKEL (Ni) 1,000 PPM	7M1-31-7	High Purity	426809	06/06
POTASSIUM (K) 10,000 PPM	7M1-30-7	High Purity	414913	03/06
SELENIUM (Se) 1,000 PPM	7M1-34-8	High Purity	518210	03/07
SILVER (Ag) 1,000 PPM	7M1-30-15	High Purity	411001	03/06
SODIUM (Na) 1,000 PPM	7M1-31-8	High Purity	423227	06/06
SODIUM (Na) 10,000 PPM	7M1-30-8	High Purity	419427	06/06
THALLIUM (Tl) 1,000 PPM	7M1-31-9	High Purity	425902	06/06
TIN (Sn) 1,000 PPM	7M1-33-14	High Purity	511820	01/07
TITANIUM (Ti) 1,000 PPM	7M1-33-15	High Purity	515212	01/07
VANADIUM (V) 1,000 PPM	7M1-31-11	High Purity	426130	06/06
ZINC (Zn) 1,000 PPM	7M1-34-7	High Purity	515819	03/07

Applies to Seq. File(s):_____

Entered By: J. BRAUN

Reviewed By:_____ Date:_____

*Ref# = Logbook ID, Page number, and item number from Materials Receipt Log

10/06/05:jbb

Attachment 3 (Continued)

Standards Preparation Log for Trace ICP (P3&P4) Linear Range Standard(LRS) Studies 2 of 2
Worksheet 1 P(B)

Standard Name	Preparation instructions	True Values
LRS-1 50K	In a 15-ml beaker, dilute 0.5 mL of XCL-11 to a final volume of 10 mL.	Al: 50ppm Cd: 50ppm Cr: 50ppm Cu: 50ppm Pb: 50ppm Ni: 50ppm Se: 50ppm Ag: 5ppm Tl: 50ppm Zn: 50ppm
LRS-1 40K	In a 15-ml beaker, dilute 0.4 mL of XCL-11 to a final volume of 10 mL.	Al: 40ppm Cd: 40ppm Cr: 40ppm Cu: 40ppm Pb: 40ppm Ni: 40ppm Se: 40ppm Ag: 4ppm Tl: 40ppm Zn: 40ppm
LRS-1 20K	In a 15-ml beaker, dilute 0.2 mL of XCL-11 to a final volume of 10 mL.	Al: 20ppm Cd: 20ppm Cr: 20ppm Cu: 20ppm Pb: 20ppm Ni: 20ppm Se: 20ppm Ag: 2ppm Tl: 20ppm Zn: 20ppm
LRS-1 5K	In a 15-ml beaker, dilute 0.05 mL of XCL-11 to a final volume of 10 mL.	Al: 5ppm Cd: 5ppm Cr: 5ppm Cu: 5ppm Pb: 5ppm Ni: 5ppm Se: 5ppm Ag: 500ppb Tl: 5ppm Zn: 5ppm
LRS-2 40K	In a 15-ml beaker, dilute 0.4 mL of XCL-2 to a final volume of 10 mL.	As: 40ppm Ba: 40ppm Be: 40ppm Co: 40ppm Fe: 40ppm Mn: 40ppm Mo: 40ppm V: 40ppm
LRS-2 20K	In a 15-ml beaker, dilute 0.2 mL of XCL-2 to a final volume of 10 mL.	As: 20ppm Ba: 20ppm Be: 20ppm Co: 20ppm Fe: 20ppm Mn: 20ppm Mo: 20ppm V: 20ppm
LRS-2 5K	In a 15-ml beaker, dilute 0.05 mL of XCL-2 to a final volume of 10 mL.	As: 5ppm Ba: 5ppm Be: 5ppm Co: 5ppm Fe: 5ppm Mn: 5ppm Mo: 5ppm V: 5ppm
LRS-3 400K	In a 15-ml beaker, dilute 0.4 mL of XCL-3B to a final volume of 10 mL.	K: 400ppm Na: 400ppm
Li 2500	In a 15-ml beaker, dilute 0.025 mL of 1,000 ppm Li to a final volume of 10 mL.	Li: 2500ppb
Li 2000	In a 15-ml beaker, dilute 0.02 mL of 1,000 ppm Li to a final volume of 10 mL.	Li: 2000ppb

Standard Solutions Prepared By:_____

Entered By: J. BRAUN

Reviewed By:_____ Date:_____

10/06/05:jbb

Note: Attachment subject to change without notice.

Attachment 4

Standards Prep Log for Trace ICP (P3&P4) Instrument Detection Limit (IDL) Studies 1 of 2
Worksheet 1 P(C)

STANDARDS and REAGENTS TRACEABILITY

	Ref #*	Manufacturer	Lot #	Expiration Date
ALUMINUM (Al) 1,000 PPM	7M1-33-24	High Purity	518220	02/07
ALUMINUM (Al) 10,000 PPM	7M1-33-11	High Purity	517431	01/07
ANTIMONY (Sb) 1,000 PPM	7M1-33-13	High Purity	510306	01/07
ARSENIC (As) 1,000 PPM	7M1-31-12	High Purity	428701	06/06
BARIUM (Ba) 1,000 PPM	7M1-34-6	High Purity	513011	03/07
BARIUM (Ba) 10,000 PPM	7M1-31-4	High Purity	420806	06/06
BERYLLIUM (Be) 1,000 PPM	7M1-30-10	High Purity	412720	03/06
BISMUTH (Bi) 1,000 PPM	7M1-33-9	High Purity	506220	01/07
BORON (B) 1,000 PPM	7M1-33-2	High Purity	511014	01/07
BORON (B) 1,000 PPM (2nd source)	7M1-31-22	CPI	4IG102	05/06
CALCIUM (Ca) 10,000 PPM	7M1-33-10	High Purity	513226	01/07
CADMIUM (Cd) 1,000 PPM	7M1-30-13	High Purity	417528	03/06
CESIUM (Cs) 10,000 PPM	7M1-34-11	High Purity	522915	04/07
CHROMIUM (Cr) 1,000 PPM	7M1-31-5	High Purity	424704	06/06
COBALT (Co) 1,000 PPM	7M1-31-6	High Purity	423325	06/06
COPPER (Cu) 1,000 PPM	7M1-30-14	High Purity	421703	03/06
IRON (Fe) 1,000 PPM	7M1-33-12	High Purity	509522	01/07
IRON (Fe) 10,000 PPM	7M1-31-10	High Purity	424536	06/06
LEAD (Pb) 1,000 PPM	7M1-33-22	High Purity	516645	02/07
LITHIUM (Li) 1,000 PPM	7M1-34-12	CPI	04L037	09/06
LITHIUM (Li) 1,000 PPM (2nd source)	7M1-34-13	High Purity	500309	11/06
MAGNESIUM (Mg) 10,000 PPM	7M1-33-3	High Purity	513903	01/07
MANGANESE (Mn) 1,000 PPM	7M1-33-23	High Purity	514421	02/07
MOLYBDENUM (Mo) 1,000 PPM	7M1-33-1	High Purity	419721	01/07
NICKEL (Ni) 1,000 PPM	7M1-31-7	High Purity	426809	06/06
POTASSIUM (K) 10,000 PPM	7M1-30-7	High Purity	414913	03/06
SELENIUM (Se) 1,000 PPM	7M1-34-8	High Purity	518210	03/07
SILVER (Ag) 1,000 PPM	7M1-30-15	High Purity	411001	03/06
SODIUM (Na) 1,000 PPM	7M1-31-8	High Purity	423227	06/06
SODIUM (Na) 10,000 PPM	7M1-30-8	High Purity	419427	06/06
THALLIUM (Tl) 1,000 PPM	7M1-31-9	High Purity	425902	06/06
TIN (Sn) 1,000 PPM	7M1-33-14	High Purity	511820	01/07
TITANIUM (Ti) 1,000 PPM	7M1-33-15	High Purity	515212	01/07
VANADIUM (V) 1,000 PPM	7M1-31-11	High Purity	426130	06/06
YTTRIUM (Y) 1,000 PPM	7M1-28-17	High Purity	405815	11/05
ZINC (Zn) 1,000 PPM	7M1-34-7	High Purity	515819	03/07

Applies to Seq. File(s):_____

Entered By: J. BRAUN

Reviewed By:_____ Date:_____

*Ref# = Logbook ID, Page number, and item number from Materials Receipt Log

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Attachment 4 (Continued)

Standards Prep Log for Trace ICP (P3&P4) Instrument Detection Limit (IDL) Studies 2 of 2
Worksheet 1 P(C)

Standard Name	Preparation instructions	Analyte Concentration (ug/L)
IDL-09 09 05-JB	Place in a 1-L volumetric flask: 500 mL deionized water. From 1,000-ppm standards, pipet 1 uL each of Ba, Be, Cd, and Mn; 2 uL each of Cu and V; 3 uL each of Ag, Co, and Cr; 4 uL each of Ni and Mo; 6 uL Pb; 9 uL Sb; 10 uL each Zn and Li; 11 uL B; 12 uL As; 13 uL Se; 16 uL each Sn and Bi; 17 uL Ti; 18 uL Tl; 50 uL Fe; 75 uL Al; and 0.46 mL Na. From 10,000-ppm standards, pipet 2 uL Mg; 4.3 uL K; and 8.1 uL Ca. Prepare annually.	Ag:3 Al:75 Ba:1 Be:1 Ca:81 Cd:1 Co:3 Cr:3 Cu:2 Fe:50 K:43 Mg:20 Mn:1 Na:460 Ni:4 Tl:18 V:2 Zn:10 Pb:6 Se:13 Sb:9 As:12 Sn:16 Bi:16 Mo:4 Ti:17 B:11 Li:10

Standard Solutions Prepared By:_____

Entered By: J. BRAUN

Reviewed By:_____ Date:_____

10/06/05:jbb

Note: Attachment subject to change without notice.

Attachment 5

Standards Prep Log for Trace ICP (P3&P4) Method Detection Limit (MDL) Studies 1 of 2
Worksheet 1 P(D)

STANDARDS and REAGENTS TRACEABILITY

	Ref #*	Manufacturer	Lot #	Expiration Date
ALUMINUM (Al) 1,000 PPM	7M1-33-24	High Purity	518220	02/07
ALUMINUM (Al) 10,000 PPM	7M1-33-11	High Purity	517431	01/07
ANTIMONY (Sb) 1,000 PPM	7M1-33-13	High Purity	510306	01/07
ARSENIC (As) 1,000 PPM	7M1-31-12	High Purity	428701	06/06
BARIUM (Ba) 1,000 PPM	7M1-34-6	High Purity	513011	03/07
BARIUM (Ba) 10,000 PPM	7M1-31-4	High Purity	420806	06/06
BERYLLIUM (Be) 1,000 PPM	7M1-30-10	High Purity	412720	03/06
BISMUTH (Bi) 1,000 PPM	7M1-33-9	High Purity	506220	01/07
BORON (B) 1,000 PPM	7M1-33-2	High Purity	511014	01/07
BORON (B) 1,000 PPM (2nd source)	7M1-31-22	CPI	4IG102	05/06
CALCIUM (Ca) 10,000 PPM	7M1-33-10	High Purity	513226	01/07
CADMIUM (Cd) 1,000 PPM	7M1-30-13	High Purity	417528	03/06
CESIUM (Cs) 10,000 PPM	7M1-34-11	High Purity	522915	04/07
CHROMIUM (Cr) 1,000 PPM	7M1-31-5	High Purity	424704	06/06
COBALT (Co) 1,000 PPM	7M1-31-6	High Purity	423325	06/06
COPPER (Cu) 1,000 PPM	7M1-30-14	High Purity	421703	03/06
IRON (Fe) 1,000 PPM	7M1-33-12	High Purity	509522	01/07
IRON (Fe) 10,000 PPM	7M1-31-10	High Purity	424536	06/06
LEAD (Pb) 1,000 PPM	7M1-33-22	High Purity	516645	02/07
LITHIUM (Li) 1,000 PPM	7M1-34-12	CPI	04L037	09/06
LITHIUM (Li) 1,000 PPM (2nd source)	7M1-34-13	High Purity	500309	11/06
MAGNESIUM (Mg) 10,000 PPM	7M1-33-3	High Purity	513903	01/07
MANGANESE (Mn) 1,000 PPM	7M1-33-23	High Purity	514421	02/07
MOLYBDENUM (Mo) 1,000 PPM	7M1-33-1	High Purity	419721	01/07
NICKEL (Ni) 1,000 PPM	7M1-31-7	High Purity	426809	06/06
POTASSIUM (K) 10,000 PPM	7M1-30-7	High Purity	414913	03/06
SELENIUM (Se) 1,000 PPM	7M1-34-8	High Purity	518210	03/07
SILVER (Ag) 1,000 PPM	7M1-30-15	High Purity	411001	03/06
SODIUM (Na) 1,000 PPM	7M1-31-8	High Purity	423227	06/06
SODIUM (Na) 10,000 PPM	7M1-30-8	High Purity	419427	06/06
THALLIUM (Tl) 1,000 PPM	7M1-31-9	High Purity	425902	06/06
TIN (Sn) 1,000 PPM	7M1-33-14	High Purity	511820	01/07
TITANIUM (Ti) 1,000 PPM	7M1-33-15	High Purity	515212	01/07
VANADIUM (V) 1,000 PPM	7M1-31-11	High Purity	426130	06/06
YTTRIUM (Y) 1,000 PPM	7M1-28-17	High Purity	405815	11/05
ZINC (Zn) 1,000 PPM	7M1-34-7	High Purity	515819	03/07

Applies to Seq. File(s):_____

Entered By: J. BRAUN

Reviewed By:_____ Date:_____

*Ref# = Logbook ID, Page number, and item number from Materials Receipt Log

10/06/05:jbb

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If words above are not highlighted, this is an uncontrolled copy of this document.

Attachment 5 (Continued)

Standards Prep Log for Trace ICP (P3&P4) Method Detection Limit (MDL) Studies 2 of 2
Worksheet 1 P(D)

Standard Name	Preparation instructions	Analyte Concentration (ug/L)
MDLNP1-09 09 05-JF	Toa 1-L volumetric flask, add: 500 mL deionized water. From 1,000-ppm standards, pipet 1 uL each of Mo, Be, and Cd; 2 uL each of Ba, Cr, and V; 2.5 uL each of Co, Ag, and Li; 3 uL Mn; 5 uL each of As, Cu, and Ni; 7 uL Pb; 10 uL each Sb, Se, and Sn; 15 uL Bi; 20 uL each Tl and Zn; 50 uL B; 60 uL Ti; 100 uL Fe; and 200 uL Al. From 10,000-ppm standards, pipet 5 uL each Mg and Ca; 10 uL K; and 100 uL Na. Prepare as needed.	Al:200 Sb:10 As:5 Ba:2 Be:1 Bi:15 Cd:1 Ca:50 Cr:2 Co:2.5 Cu:5 Fe:100 Pb:7 Mg:50 Mn:3 Mo:1 Ni:5 K:100 Se:10 Ag:2.5 Na:1000 Tl:20 Sn:10 Ti:60 V:2 Zn:20 B:50 Li:2.5
MDLNP1 2X	In a 15-mL beaker, combine 5 mL MDLNP1-090905-JF with deionized water. Prepare immediately before analysis.	Al:100 Sb:5 As:2.5 Ba:1 Be:0.5 Bi:7.5 Cd:0.5 Ca:25 Cr:1 Co:1.25 Cu:2.5 Fe:50 Pb:3.5 Mg:25 Mn:1.5 Mo:0.5 Ni:2.5 K:50 Se:5 Ag:1.25 Na:500 Tl:10 Sn:5 Ti:30 V:1 Zn:10 B:25 Li:1.25

Standard Solutions Prepared By:_____

Entered By: J. BRAUN

Reviewed By:_____ Date:_____

10/06/05:jbb

Note: Attachment subject to change without notice.

Attachment 6

Table 1: Wavelength and Contract Required Quantitation Limits on Trace ICP Instruments P3 and P4

Elements	P3 Wavelength* (nm)	P4 Wavelength* (nm)	CRDL (µg/L) ILM04.1	CRQL (µg/L) ILM05.3
Aluminum	**308.215**	**308.215**	**200**	**200**
Antimony	**206.83**	**206.838**	**60**	**60**
Arsenic	**189.042**	**189.042**	**10**	**10**
Barium	**493.409**	**493.409**	**200**	**200**
Beryllium	**313.042**	**313.042**	**5**	**5**
Cadmium	**226.502**	**226.502**	**5**	**5**
Calcium	**317.933**	**317.933**	**5000**	**5000**
Chromium	**267.716**	**267.716**	**10**	**10**
Cobalt	**228.616**	**228.616**	**50**	**50**
Copper	**324.753**	**324.753**	**25**	**25**
Iron	**271.441**	**271.441**	**100**	**100**
Lead	**220.35**	**220.35**	**3**	**10**
Magnesium	**279.078**	**279.078**	**5000**	**5000**
Manganese	**257.610**	**257.610**	**15**	**15**
Nickel	**213.604**	**213.604**	**40**	**40**
Potassium	**766.491**	**766.491**	**5000**	**5000**
Selenium	**196.02**	**196.02**	**5**	**35**
Silver	**328.068**	**328.068**	**10**	**10**
Sodium	**330.232**	**330.232**	**5000**	**5000**
Thallium	**190.864**	**190.864**	**10**	**25**
Vanadium	**292.402**	**292.402**	**50**	**50**
Zinc	**213.856**	**206.200**	**20**	**60**
Titanium	**334.941**	**334.941**	**-**	**-**
Molybdenum	**202.030**	**202.030**	**-**	**-**
Tin	**189.989**	**189.989**	**-**	**-**
Bismuth	**223.061**	**223.061**	**-**	**-**
Boron	**249.678**	**-**	**-**	**-**
Lithium	**-**	**670.784**	**-**	**-**

***Wavelengths listed in the SOW are recommended because of their sensitivity and overall acceptance. Other wavelengths may be substituted if they can provide the needed sensitivity and are treated with the same corrective techniques for spectral interference (see SOW).**

Attachment 7

COMPUCHEM a division of Liberty Analytical Corp. LOGBOOK 1 O(4) 60

Trace ICP Run Log (P3) **Part (A) of a three-part form**

Instrument Profile:
Vernier position:_____
Peak position:_____
Peak intensity:_____
Nebulizer pressure:_____

Maintenance:_____
_____
_____
_____
_____

Method (circle one): CLP ILM04.1 CLP ILM05.3 SW-846 6010B MCAWW 200.7 _____

Operator:_____ **File name**: P3 _____ **Date/Time**:_____ Page___of___

SDG	Matrix	Analytes	Comments

Legend		No.	Sample ID	Comments	Action needed
↑	Specified element(s) fail(s) high	1			
↓	Specified element(s) fail(s) low	2			
RR	Re-run sample(s) neat	3			
RR #x	Re-run at a #-fold dilution	4			
#x	Sample run at a #-fold dilution (aliquot of sample diluted with acidified water)	5			
		6			
L	Matrix = leachate	7			
W	Matrix = water	8			
S	Matrix = solid	9			
B	Matrix = biological tissue	10			
			CCV		

No.	Sample ID	Comments	Action needed		CCB		
	S0	Blank		1			
	S	XCL-11		2			
	S	STD3		3			
	S	XCL-2		4			
	S	XCL-3B		5			
	S	PLSBR		6			
	ICV1			7			
	SPEXASSE			8			
	ICB			9			
	CRI			10			
	ICSA				CCV		
	ICSAB				CCB		
	CCV						
	CCB						

COMMENTS

Reviewed By: _____

Date: _____

The presence of the Chemist's/Analyst's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist/analyst together with the chemist's/analyst's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

11/09/05:jad

Attachment 7 (Continued)

COMPUCHEM a division of Liberty Analytical Corp. LOGBOOK 1 O(4) 60

Trace ICP Run Log (P3) **Part (B) of a three-part form** Page___of___

File name: P3

No.	Sample ID	Comments	Action needed	No.	Sample ID	Comments	Action needed
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			
7				7			
8				8			
9				9			
10				10			
	CCV				CCV		
	CCB				CCB		
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			
7				7			
8				8			
9				9			
10				10			
	CCV				CCV		
	CCB				CCB		
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			
7				7			
8				8			
9				9			
10				10			
	CCV				CCV		
	CCB				CCB		
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			
7				7			
8				8			
9				9			
10				10			
	CCV				CCV		
	CCB				CCB		

COMMENTS

Reviewed By: _____

Date: _____

The presence of the Chemist's/Analyst's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist/analyst together with the chemist's/analyst's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

11/9/05:jad

Attachment 7 (Continued)

COMPUCHEM a division of Liberty Analytical Corp. LOGBOOK 1 O(4) 60

Trace ICP Run Log (P3) **Part (C) of a three-part form** Page____of____

File name: P3

No.	Sample ID	Comments	Action needed	No.	Sample ID	Comments	Action needed
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			
7				7			
8				8			
9				9			
10				10			
	CCV				CCV		
	CCB				CCB		
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			
7				7			
8				8			
9				9			
10				10			
	CCV				CCV		
	CCB				CCB		
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			
7				7			
8				8			
9				9			
10				10			
	CCV				CCV		
	CCB				CCB		
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			
7				7			
8				8			
9				9			
10				10			
	CCV				CCV		
	CCB				CCB		

COMMENTS

Reviewed By: _____

Date: _____

The presence of the Chemist's/Analyst's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist/analyst together with the chemist's/analyst's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

11/9/05:jad

Attachment 5 (Continued)

Target Compounds and Deuterated Monitoring Compounds Quantitation And Secondary Ions

Deuterated Monitoring Compound	**Quantitation Ion**	**Secondary Ion(s)**
Phenol-d_5	99	71, 42
Bis(2-Chloroethyl)ether-d_8	67	99, 69
2-Chlorophenol-d_4	132	134, 68, 66
4-Methylpheno-d_8	113	115, 54
Nitrobenzene-d_5	128	82, 54
2-Nitrophenol-d_4	143	69, 41, 42
2,4-Dichlorophenol-d_3	165	167, 101
4-Chloroaniline-d_4	131	133, 69
Dimethylphthalate-d_6	166	78
Acenaphthylene-d_8	160	80, 158
4-Nitrophenol-d_4	143	113, 41, 42
Fluorene-d_{10}	176	174, 87, 86
4,6-Dinitro-2-methylphenol-d_2	200	170, 52
Anthracene-d_{10}	188	94, 80
Pyrene-d_{10}	212	106, 104
Benzo(a)pyrene-d_{12}	264	132, 118
Fluoranthene-d_{10} (SIM)	212	106, 104
2-Methylnaphthalene-d_{10} (SIM)	152	151
Internal Standards		
1,4-Dichlorobenzene-d_4	152	115
Naphthalene-d_8	136	68
Acenapthene-d_{10}	164	162, 160
Phenanthrene-d_{10}	188	94, 80
Chrysene-d_{12}	240	120, 236
Perylene-d_{12}	264	260, 265

Attachment **8**

Table 1. SPIKING LEVELS FOR SPIKE SAMPLE ANALYSIS

	For ICP-**AES ILM05.3**		**For ICP-AES ILM04.1**	
Element	Water µg/**L**	**Soil mg/kg**	**Water µg/L**	**Soil mg/kg**
Aluminum	2000	*	**2000**	**20**
Antimony	**100**	**20**	**500**	**50**
Arsenic	40	**8**	**40**	**4**
Barium	2000	**400**	**2000**	**200**
Beryllium	50	**10**	**50**	**5**
Cadmium	50	**10**	**50**	**5**
Calcium	*	*	*	*
Chromium	200	**40**	**200**	**20**
Cobalt	500	**100**	**500**	**50**
Copper	250	**50**	**250**	**25**
Iron	1000	*	**1000**	**100**
Lead	20	**4**	**20**	**2**
Magnesium	*	*	*	*
Manganese	500	**100**	**500**	**50**
Nickel	500	**100**	**500**	**50**
Potassium	*	*	*	*
Selenium	**50**	**10**	**10**	**1**
Silver	50	**10**	**50**	**5**
Sodium	*	*	*	*
Thallium	50	**10**	**50**	**5**
Vanadium	500	**100**	**500**	**50**
Zinc	500	**100**	**500**	**50**

∗No spike required.

CompuChem
a division of Liberty Analytical Corporation
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NELAP accredited

SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire block below (except effective date).

This is a new procedure ____ revised procedure ✓ outdated procedure (archive) ____

- Procedure Code: IP565 SOP Section #: 3.5.7.1 Revision #: 7

SOP Title: Total Hardness as Calcium Carbonate in Water by Lachat and MCAWW

Effective date: (QA fills in) 4/28/06

- Procedure prepared by: [signature] Date: 4/27/06
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) [signature] Date: 04-27-06
- Reason for change: Addition of DoD QSM Requirements
- This procedure meets the requirements of the following approved method references: NY State Analytical Services Protocol (NYSASP), June 2000, plus revisions; NELAC Standards, July 2003, plus revisions; ~~SW-846 3rd Ed., Update III~~ MCAWW 1983, Method 130.1 MC 4/27/06

Procedure approved by Quality Assurance Representative: (Not needed if signed above) Date: ____

Effective 1-1-96, on an annual basis: Lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary, indicate by your signature that the SOP has been reviewed.

Annual Review—Signature: ____ Date: ____

Annual Review—Signature: ____ Date: ____

Annual Review—Signature: ____ Date: ____

Instrument Procedure 565: Total Hardness as Calcium Carbonate in Water by Lachat and MCAWW

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Instrument Procedure 565: Total Hardness as Calcium Carbonate in Water by Lachat and MCAWW

1.0 Scope and Application

Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

2.0 Summary of Method

In this method, disodium magnesium EDTA is used to exchange magnesium on an equivalent basis for calcium and/or any other cation which forms a more stable EDTA chelate than magnesium. Magnesium is then reacted with calmagite at pH 11.0 to form a red-violet complex with a maximum absorbance at 520 ηm. The range for this analysis is 3.0-50 mg/L.

3.0 Definitions

3.1 Method detection limit (MDL) – The minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR, Part 136, Appendix B.)

3.2 Reporting Limit – The laboratory reporting limit is based on the lowest multipoint calibration standard concentration. For some inorganic methods, the reporting limit is based on the MDL, and is usually 4 - 8 times higher than the MDL.

3.3 Reporting Units – mg/L

3.4 An SDG is defined by the following, whichever is more frequent:

- each 20 field samples received within a case, or
- each 7 calendar day period during which field samples in a case are received (14 calendar days if requested by the client) beginning with the receipt of the first sample.

NOTE: The **DoD-QSM** and SC DHEC do not accept the SDG approach, unless the samples are prepared in a single batch. When a group of up to 20 field samples of a similar matrix are prepared as one batch, method-specified QC samples such as a method blank, laboratory control sample, matrix spike, matrix spike duplicate, and matrix duplicate must also be prepared together at a rate of 5% for **the DOD-QSM** and 10% for SC DHEC. If samples are batched together from different sites, project-specific QC must be processed.

3.5 SC DHEC – South Carolina Department of Health and Environmental Control

3.6 DoD-QSM – Department of Defense – Quality Systems Manual

4.0 Interferences

4.1 Aluminum, cobalt, copper, iron, nickel, and zinc form stable chelates and will be determined as hardness.

4.2 If the pH of the buffer is too high, calcium carbonate or magnesium hydroxide may precipitate.

5.0 Safety

Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous. During sample preparation, glasses, gloves and lab coats are a minimum requirement. The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

Laboratory staff are encouraged to review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets (MSDS) for solvents and reagents used in the laboratory. The MSDS are located in the Quality Assurance department.

6.0 Equipment & Supplies

6.1 Lachat QuikChem Automated Flow Injection Ion Analyzer - See manifold diagram in attachment 1.

6.1.1 Hardness module 10-301-31-1-A

6.1.2 Timing

Sample throughput:	60 samples/h; 60 s/sample
Pump speed:	35
Cycle period:	60 s
Inject to start of peak period:	20 s

7.0 Reagents & Standards

Note: Record the preparation of all reagents and standards in the Standards/QC Prepartion for Hardness on Lachat log book (Attachment 2).

7.1 Reagent water - All water used during preparation should be reagent-grade Type I with regard to resistivity of >10 megohm (20th edition of Standards Methods, Method 1080), and referred throughout this SOP as DI water.

7.2 Buffer, pH 11.0

CAUTION: THIS REAGENT GIVES OFF DANGEROUS FUMES! STORE IN A TIGHTLY CLOSED CONTAINER.

7.2.1 By Volume: In a fume hood, dissolve 67.6 g of ammonium chloride in 572 mL of concentrated ammonium hydroxide. Transfer to a 1 liter volumetric flask, and dilute to the mark with DI water. Invert three times. Degas with helium for one minute in a fume hood.

7.2.2 By Weight: To a tared 1 liter container add 372 g of DI water, 514.8 g of concentrated ammonium hydroxide, and 67.6 g of ammonium chloride. Shake or stir until all solid material dissolves.

7.3 Calmagite Indicator

7.3.1 Dissolve 0.50 g of calmagite in 500 mL of DI water by stirring for 30 minutes on a magnetic stirrer. The solution should be dark purple. Filter through rapid-flow qualitative filter paper. Filter reagent prior to any analysis thereafter**.** Degas with helium for one minute in a fume hood.

7.4 Magnesium EDTA Solution

7.4.1 This solution can be purchased from Lachem, Pittsburgh, PA, Catalog # LC16450-1. Or it can be prepared as described below:

7.4.2 Dissolve 0.20 g of ethylenediamine tetraacetic acid, magnesium disodium salt in 1 liter or 1 kg of DI water. Stir until dissolved. Degas with helium for one minute in a fume hood

7.5 1:1 HCl Solution

7.5.1 Add 200 mL concentrated hydrochloric acid (HCl) to 200 mL DI waster. Do not degas.

7.6 10% Ammonium Hydroxicd solution

7.6.1 Add 10 mL ammonium hydroxide (NH_4OH) to 90 mL water. Do not degas.

7.7 Stock Standard 1000 ppm

7.7.1 Quantitatively transfer 1.0 g of calcium carbonate that has been dried for one hour at 105°C into a 500-mL erlenmeyer flask. Add 1+1 HCl solution until all the solid has dissolved. Add 200 mL of DI water and boil for a few minutes. Cool and adjust to pH 5.4 with 10% ammonium hydroxide solution. Transfer to a 1 liter volumetric flask and dilute to the mark with DI water.

7.8 Set of Seven Working Standards

7.8.1 For 100.0, 50.0, 20.0, 10.0, 5.00, and 0.0 mg calcium carbonate/L, add to seven 100 mL volumetric flasks the following amounts of stock standard: 10.0, 5.0, 2.0, 1.0, 0.5, and 0 mL. Dilute each to the mark with DI water and invert three times.

Note: Add 2.0mL 1:1 HNO_3 to each volumetric before adding standard.

7.8.2 If samples always fall within a narrower range, more standards within this range can be added, and standards outside of this narrower range can be dropped.

7.9 Second Source Standard

7.9.1 A second source standard is commercially purchased or prepared from a different calcium carbonate lot and used for the ICV/LCS.

8.0 Sample Preservation **and** Storage

Samples preserved and stored according to the tables in Sample Control SOP 4.1, "Receiving Samples" and 4.6, "Storing Samples." Sample holding times are also listed.

9.0 Quality Control

9.1 After instrument calibration, the correlation coefficient must be determined to be 0.995 or better before sample analysis can begin. The reporting limit is the lowest non-zero datum on the calibration curve; for hardness this point represents 3.0 ppm. An initial calibration verification (ICV) and initial calibration blank (ICB) must be analyzed. The ICV is a second-source standard commercially available from ERA whose true value may vary with each lot. It may be diluted to achieve a concentration near the calibration mid-point. The analyst records the true value on the analysis run log (Attachment 3). The ICV must fall within 85 - 115% of the true value. The absolute ICB value must be less than the reporting limit. If these control limits cannot be met, determine and correct the problem, recalibrate and reanalyze until all control limits can be met. If instrument problems are suspect, notify your supervisor, document the problem in the maintenance log, and notify the instrument repair personnel.

9.2 A continuing calibration verification (CCV) and a continuing calibration blank (CCB) must be analyzed at a 10% frequency throughout the analytical run and at the end. The CCV is a mid range standard at 20 ppm. The control limit for the CCV is ± 10% of the true value. The control limits for the CCB are the same as the ICB above. In the event of a CCV/CCB failure, determine and correct the problem, recalibrate the instrument, and reanalyze all affected samples.

9.3 A method/preparation blank (designated as PBW) should be analyzed with every preparation batch of up to 20 samples or for each sample delivery group (SDG), whichever is more frequent. For SC DHEC the PBW is prepared with every 10 samples. The method blank value must not be greater than the reporting limit. If the blank exceeds the reporting limit, analysis is stopped, the problem is determined and corrected, the instrument is recalibrated, and any affected samples are reanalyzed.

9.3.1 To meet the requirements of the DoD-QSM, the method blank value must not exceed ½ the reporting limit.

9.4 A laboratory control sample (LCS) must be analyzed with every 20 samples or each case, whichever is more frequent. For SC DHEC the LCS is prepared with every 10 samples. The term “blank spike” may be used interchangeably. The LCS must agree within 75-120% of the true value. If the LCS falls outside these statistical control limits, the analysis must be evaluated and it must be determined if an instrument problem exists. If so, then correct the problem, recalibrate and reanalyze the entire batch.

9.5 For every 20 samples or each case, whichever is more frequent, a matrix spike/matrix spike duplicate (MS/MSD) analysis must be performed. For SC DHEC a duplicate is prepared at a 10% frequency. The MS/MSD count towards this duplicate requirement. If the spike recovery is not within 75 -125% recovery limits and the sample result does not exceed 4x the spike added, a matrix interference is suspected. Verify this by respiking another aliquot of the sample. If the control limits still cannot be met, then a quality assurance notice is required to indicate that a matrix interference is present. If the relative percent difference (RPD) between the MS/MSD exceeds control limit of 20, a quality assurance notice is required. Samples identified as field blanks should not be used for MS/MSD analysis.

9.6 A duplicate must be performed for every 10 samples for NCDENR. The sample and duplicate should agree within 20% relative percent difference (RPD). For SC DHEC a duplicate is prepared at a 10% frequency. The MS/MSD count towards this duplicate requirement.

9.7 Contingency

9.7.1 If due to a lab accident or to QC failures, a re-preparation and analysis are required for the sample and insufficient sample volume remains, the Project Manager must be alerted and will contact the client for direction on how to proceed.

9.7.2 If persistent contamination occurs in the laboratory, analysis must be halted until the source of the contamination can be identified and isolated. When the contamination issue is resolved, samples analysis may proceed.

9.7.3 Refer to the corresponding Data Review SOP (number will vary among sections) for information on how to handle reporting of data that are unacceptable or out-of-control.

9.7.4 Any other issues that potentially effect data quality should also be addressed with the Project Manager.

10.0 Calibration & Standardization

10.1 Prepare reagents and standards.

10.2 Set up manifold as shown in Attachment 1.

10.3 Input data system parameters for the method into Lachat.

10.4 Pump DI water through all reagent lines and check for leaks and smooth flow. Switch to reagents and allow the system to equilibrate until a stable baseline is achieved.

10.5 Load samples and standards into the autosampler. Input information required by the data system, such as concentration and replicates.

10.6 Calibrate the instrument by analyzing and reviewing the calibration curve before analyzing samples.

11.0 Procedure

Documentation must follow the requirements in QC SOP: Proper Documentation Procedures. Record all preparation information in the Hardness Preparation Log (**Attachment** 4)

11.1 Sample Preparation

11.1.1 Transfer 100 mL of well-mixed acid-preserved sample to a 250 mL beaker.

11.1.2 Add 5.0 mL of concentrated nitric acid and add a few boiling chips.

11.1.3 Cover the beaker with a watch glass and heat cautiously on a hot plate to near dryness (about 10 to 20 mL) before precipitation occurs. Bring to a slow boil.

11.1.4 Cool the solution and add another 5.0 mL of concentrated nitric acid. Cover and return to the hot plate and reflux with additional heat.

11.1.5 The digestion process is completed when the sample is a light-colored clear solution. If not, continue heating and adding acid until is completed. If samples are allowed to go to dryness during digestion, the entire process must be repeated.

11.1.6 Wash down the walls of the beaker with 5 mL DI water, and transfer the solution to a 100 mL volumetric flask. Repeat using another 5 mL DI water rinse. Dilute to the mark with DI water.

11.2 Lachat Procedure – System Notes

11.2.1 For information on system maintenance and troubleshooting, refer to the troubleshooting guide in the System Operations Manual.

11.2.2 After samples are analyzed, place the carrier and reagent lines in DI water. Pump water through the system for several minutes to remove any reagents in the lines. Remove the carrier and reagent lines from the water and pump air through the system until dry.

12.0 Data Analysis & Calculations

Calculations must be consistent with the QC SOP: Numerical Data Reduction.

12.1 Calculation of the mean or average of a set of values:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where: n = total number of values
x_i = each individual value used to calculate the mean
x = the mean of n

12.2 Calculation of the standard deviation of a set of values:

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n}\left(X_n - \overline{X}\right)^2}{n-1}}$$

12.3 Calculation of percent recovery:

12.3.1 LCS:

$$\%R = \frac{Amount\ found}{Amount\ spiked}\ x\ 100$$

12.3.2 Matrix spikes:

$$\%\,\mathrm{R} = \frac{Amount\ in\ spiked\ sample - Amount\ in\ unspiked\ (native)\ sample}{Amount\ spiked}\ x\ 100$$

12.4 Calculation of % RSD

$$\%RSD = \left(\frac{Standard\ deviation}{\overline{X}} \right) \times 100$$

12.5 Calculation of RPD

$$RPD = \frac{|Value\ 1 - Value\ 2|}{(Value\ 1 + Value\ 2)/2} x100$$

12.6 Calculation of %Difference (%D)

$$\%Diff = \frac{Value - \overline{Reference\ \ value}}{\overline{Reference\ \ value}} x\ 100$$

12.7 To calculate the concentration for inorganics analyses of Hardness (mg/L), CompuChem use the following calculations:

Concentration = [sample concentration (mg/L)] x [Dilution factor]

12.7 Calculating Dilutions

If a sample concentration exceeds the high level standard a dilution must be performed. Determine a level of dilution that will result in a value within the upper half of the calibration range. This is an acceptable dilution. A 10x dilution is performed using 1 mL sample plus 9 mL diluent for a total volume of 10 mL. It should be recorded on the run log as "10x (1 mL in 10 mL)."

13.0 Method Performance

This method was validated through in-house laboratory studies of method **detection limits** and precision and accuracy for single analyst. The data are retained by the QA department.

14.0 Pollution Prevention

The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 thing. **See SOP 12.1, Hazardous Waste Disposal, regarding laboratory procedures for recycling solvent waste streams.**

15.0 Waste Management

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Samples preserved with HCl, HNO_3, H_2SO_4, NaOH, and zinc acetate are hazardous and must be handled as hazardous waste

16.0 References

16.1 "Methods for Chemical Analysis of Water and Wastes" Method 130.1

16.2 Lachat AutoAnalyzer QuikChem Method 10-301-31-1-A, January, 1993.

16.3 Standard Methods for the Examination of Water and Wastewater, 20th (1998) Edition, Method 1080

16.4 New York State Analytical Services Protocol (NYSASP), 6/2000 plus revisions

16.5 QCSOP: Proper Documentation Procedures

16.6 QCSOP: Numerical Data Reduction

16.7 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477.

16.8 Hazardous Waste Management & Safety SOPs: "Hazardous Waste Disposal" and "Spill Control & Cleanup."

16.9 NELAC Standards, July 2003, plus revisions

16.10 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995.

16.11 New York State Environmental Laboratory Approval Program, Certification Manual, April 2005, plus revisions.

16.12 CompuChem Quality Manual, Revision **7**, Update 1, **12**/**13**/05, plus revisions

16.13 Sample Control SOP 4.1, "Receiving Samples"

16.14 Sample Control SOP 4.6, "Storing Samples"

16.15 Department of Defense Quality Systems Manual for Environmental Laboratories, Final Version 3, January 2006

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.1 Attachment 1 – Hardness Manifold diagram

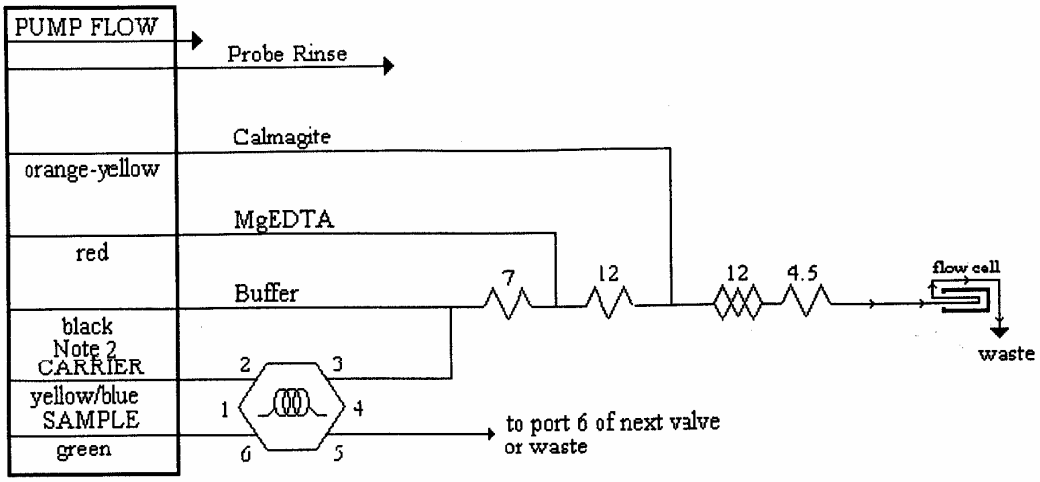
17.2 Attachment 2 – Hardness Standards/QC Preparation Log

17.3 Attachment 3 – Hardness Run Log Example

17.4 Attachment 4 – Hardness Preparation Log

Attachment 1

17.3. TOTAL HARDNESS MANIFOLD DIAGRAM



Carrier: **DI water**
Manifold Tubing: **0.8 mm (0.032 in) i.d.** This is **5.2 µL/cm**.
AE Sample Loop: 15 cm
QC8000 Sample Loop: 20.5 cm
Interference Filter: 520 nm

Apparatus: An injection valve, a 10 mm path length flow cell, and a colorimetric detector module is required.

4.5: **70** cm of tubing on a 4.5 cm coil support
7: **135** cm of tubing on a 7 cm coil support
12: **255** cm of tubing on a 12 cm alternating coil support

Note 1: PVC PUMP TUBES MUST BE USED FOR THIS METHOD.
Note 2: Remove stainless steel pins from the pump tube adaptor on carrier line.

Attachment 2

Standards/QC Preparation for Hardness on Lachat

Seq. File Name:_____

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Standards and Reagents Traceability*	Ref#:
Calcium Carbonate	7M1-14-1
Conc. Hydrochloric Acid	1M2-176-22
Conc. Nitric Acid	1M2-176-20
Ammonium Hydroxide	7M2-194-5 , LOT# A37066
Ammonium Chloride	1U(6)1-10-22
Calmagite	1U(6)1-7-6
Ethylenediamine tetraacetic acid, magnesium disodium salt	1U(6)1-7-5
2nd Source - Hardness ICV/LCS Solution TV=23.2	1U(6)1-10-14
REAGENT/STANDARD LOT NUMBER**	**PREPARATION INSTRUCTIONS**
Magnesium EDTA Solution – 0 6 0 9 0 5 – J M	Dissolve 0.20 g of ethylenediamine tetraacetic acid, magnesium disodium salt in 1 liter or 1 kg of DI water. Stir until dissolved. Degas with helium for one minute in a fume hood.
Buffer, pH 11.0 – 0 3 1 6 0 5 – J M	CAUTION: THIS REAGENT GIVES OFF DANGEROUS FUMES! STORE IN A TIGHTLY CLOSED CONTAINER. By Volume: In a fume hood, dissolve 67.6 g of ammonium chloride in 572 ml of concentrated ammonium hydroxide. Transfer to a 1-liter volumetric flask, and dilute to the mark with DI water. Invert three times. Degas with helium for one minute in a fume hood. By Weight: To a tared 1-liter container add 372 g of DI water, 514.8 g of concentrated ammonium hydroxide, and 67.6 g of ammonium chloride. Shake or stir until all solid material dissolves.
Calmagite Indicator – 1 1 2 4 0 5 – J M	Dissolve 0.50 g of calmagite in 500 ml of DI water by stirring for 30 minutes on a magnetic stirrer. The solution should be dark purple. Filter through rapid-flow qualitative filter paper. Filter reagent prior to any analysis thereafter. Degas with helium for one minute in a fume hood.
10% Ammonium Hydroxide – 0 1 24 05 jm	Add 10 mL ammonium hydroxide (NH_4OH) to 90 mL water. Do not degas.
1:1 HCl – 0 4 2 5 0 5 – J M	Add 200 mL concentrated hydrochloric acid (HCl) to 200 mL DI waster. Do not degas.
1:1 HNO3 – 0 4 2 5 0 5 – J M	Add 200 mL concentrated nitric acide (HNO3) to 200 mL DI waster. Do not degas.

Standard Solutions Prepared By: _____ Date: _____

Entered By: _____ Date: _____

Reviewed By: _____ Date: _____

*Ref# = Logbook ID, Page number, and item number from Materials Receipt Log **Standard Lot Number consists of standard ID, date prepared, and initials of preparer. 9/20/05 jad

The presence of the Chemist's/Analyst's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist/analyst together with the chemist's/analyst's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

Attachment 2 (continued)

Standards/QC Preparation for Hardness on Lachat

Seq. File Name:_____

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REAGENT/STANDARD LOT NUMBER**	PREPARATION INSTRUCTIONS
Calcium carbonate stock 1000 ppm – _0_2_2_4_0_5-J_M_	Place in a 500-ml Erlenmeyer flask flask: 1.0 g of dried calcium carbonate Add 1:1 HCl until solid has dissolved. Add 200 ml D.I. water and boil for a few minutes. Cool the solution. Adjust the pH to 5.4 with with 10% ammonium hydroxide. Transfer the solution to a 1 L volumetric flask Dilute to the mark with deionized water. Prepare fresh every six months or more often as needed.
Hardness 100 ppm – _0_7_0_6_0_5-J_M_	Place in a 100-ml volumetric flask: Add 2.0 ml of 1:1 HCl. Add 10.0 ml of calcium carbonate stock solution. Dilute to the mark with deionized water. Prepare fresh weekly or more often as needed.
Hardness 50 ppm – _0_7_0_6_0_5-J_M_	Place in a 100-ml volumetric flask: Add 2.0 ml of 1:1 HCl. Add 5.0 ml of calcium carbonate stock solution. Dilute to the mark with deionized water. Prepare fresh weekly or more often as needed.
Hardness 20 ppm – _0_7_0_6_0_5-J_M_ (CCV)	Place in a 100-ml volumetric flask: Add 2.0 ml of 1:1 HCl. Add 2.0 ml of calcium carbonate stock solution. Dilute to the mark with deionized water. Prepare fresh weekly or more often as needed.
Hardness 10 ppm – _0_7_0_6_0_5-J_M_	Place in a 100-ml volumetric flask: Add 2.0 ml of 1:1 HCl. Add 1.0 ml of calcium carbonate stock solution. Dilute to the mark with deionized water. Prepare fresh weekly or more often as needed.
Hardness 5 ppm – _0_7_0_6_0_5-J_M_	Place in a 100-ml volumetric flask: Add 2.0 ml of 1:1 HCl. Add 0.5 ml of calcium carbonate stock solution. Dilute to the mark with deionized water. Prepare fresh weekly or more often as needed.
ICV/LCS Solution 45.6 ppm – _0_7_0_6_0_5-J_M_	Place in a 100-ml volumetric flask: Add 2.0 ml of 1:1 HCl. Add 2.0 ml of second source calcium carbonate stock solution. Dilute to the mark with deionized water. Prepare fresh weekly or more often as needed.

Standard Solutions Prepared By: _____ Date: _____

Entered By: _____ Date: _____

Reviewed By: _____ Date: _____

**Standard Lot Number consists of standard ID, date prepared, and initials of preparer. 9/20/05:jad

The presence of the Chemist's/Analyst's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist/analyst together with the chemist's/analyst's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

Attachment 3

Hardness Run Log

CompuChem
A Division of Liberty Analytical Corp.

Analyst: Greg Pattison

File Name(s): 1119 Har 1

Date: 11/19/02

Case Name(s): ~~[illegible]~~ mdl's

Instrument ID: C2

Note: Manual Dilution Factor is not reflected in the sample results

Lachat Method 10-301-31-1-A
Method EPA 310.1

Cup Number	Sample ID	Sampling Date	Sampling Time	Manual	Result/Peak Area	Unit	Analyte Name	Comments
2	50	19-Nov-02	11:50:47	1	4941722	uv-s	Hardness	
3	20	19-Nov-02	11:51:48	1	2633165	uv-s	Hardness	
4	10	19-Nov-02	11:52:48	1	1424717	uv-s	Hardness	
5	5	19-Nov-02	11:53:49	1	725888	uv-s	Hardness	
6	0	19-Nov-02	11:54:50	1	88678	uv-s	Hardness	
13	ICV	19-Nov-02	11:57:11	1	68.551208	mg/L	Hardness	TV= 62.0
14	ICB	19-Nov-02	11:58:13	1	1.932722	mg/L	Hardness	
1	mdl1	19-Nov-02	11:59:14	1	4.264134	mg/L	Hardness	TV=5.0
2	mdl2	19-Nov-02	12:00:16	1	4.127292	mg/L	Hardness	
3	mdl3	19-Nov-02	12:01:17	1	4.236527	mg/L	Hardness	
4	mdl4	19-Nov-02	12:02:18	1	4.19249	mg/L	Hardness	
5	mdl5	19-Nov-02	12:03:18	1	4.170261	mg/L	Hardness	
6	mdl6	19-Nov-02	12:04:19	1	4.172279	mg/L	Hardness	
7	mdl7	19-Nov-02	12:05:19	1	4.126958	mg/L	Hardness	
2	CCV	19-Nov-02	12:06:20	1	53.73597	mg/L	Hardness	
6	CCB	19-Nov-02	12:07:21	1	1.944119	mg/L	Hardness	

Reviewed By: [signature] Date: 11-20-02

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Attachment 4

CompuChem, a division of Liberty Analytical Corp.

Hardness Preparation

Worksheet 1 P(5) Page __1___ of __1___

Analyst No.: _____ Date: 9/20/2005

Method EPA MCAWW 130.1 Batch No.: _____

CompuChem No.	Sample Type	Initial Vol (mL)	Final Volume (mL)	Dilution Factor	Comments

Reviewed By: _____ Date:_____

The presence of the Chemist's/Analyst's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist/analyst together with the chemist's/analyst's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

9/20/05:jad

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CompuChem
a division of Liberty Analytical Corporation
501 Madison Avenue
Cary, NC 27513

NELAP accredited

SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire block below (except effective date).

This is a new procedure _____ revised procedure ✓ outdated procedure (archive) _____

- Procedure Code: IP 604 SOP Section #: 3.5.14.3 Revision #: 2

SOP Title: Soil and Waste pH by Method 9045C (SW-846 + NYSASP)

Effective date: (QA fills in) 4-22-02

- Procedure prepared by: Diane C. Ellmore Date: 4-17-02
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) Date: 4-22-02
- Reason for change: Updated calibration steps
- This procedure meets the requirements of the following approved method references: Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods, SW846, 3rd Edition, Update III, 12/96, Method 9045C, 1/95; NELAC Standards, July 1, 1999, plus revisions

Procedure approved by Quality Assurance Representative: Date:
(Not needed if signed above)

Effective 1-1-96, on an annual basis, Lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary, indicate by your signature that the SOP has been reviewed.

Annual Review—Signature: _____ Date: 1-12-06

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Instrument Procedure 604: Soil and Waste pH by Method 9045C (SW-846 + NYSASP)

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Instrument Procedure 604: Soil and Waste pH by Method 9045C (SW-846 + NYSASP)

1.0 Scope and Application

Method 9045C is an electrometric procedure which has been approved for measuring pH in soils and waste samples. Wastes may be solids, sludges, or non-aqueous liquids. If waterH_2O is present, it must constitute less than 20% of the total volume of the sample. The sample is mixed with DI H_2Owater and the pH of the resulting sample. The sample is mixed with DI H_2Owater and the pH of the resulting aqueous solution is measured.

A method detection limit study is not required for this analysis.

Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

2.0 Summary of Method

The sample is mixed with DI water, and the pH of the resulting aqueous ???solution is measured.

3.0 Definitions

3.1 Reporting Units – Standard pH units

3.2 An SDG is defined by the following, whichever is more frequent:

- each 20 field samples received within a case, or
- each **7** calendar day period during which field samples in a case are received (**14** calendar days **if requested by the client)** beginning with the receipt of the first sample.

NOTE: The Army Corps of Engineers does not accept the SDG approach, unless the samples are prepared in a single batch. When a group of up to 20 field samples of similar matrices are prepared as one batch, method-specified QC samples such as a method blank, laboratory control sample, matrix spike, matrix spike duplicate, and matrix duplicate must also be prepared together at a rate of 5%. If samples

are batched together from different sites, project-specific QC must be processed.

3.3 Slope - Change in voltage output resulting from a decade change in the activity of the responding ion. Raw slope values do not provide a good measurements of the electrode's performance due to temperature dependence. The Model 50 reports slope values as temperature referenced to 25°C. This value reflects the condition of the ion selective electrode (ISE).

3.4 Efficiency Factor - Slope value for electrode divided by its theoretical value. Typical factors for properly functioning electrodes range from 0.90-1.05.

3.5 Efficiency - Efficiency factor of the electrode expressed as %. Properly functioning electrode in the Model 50 exhibit efficiencies between 90-105%.

4.0 Interferences

4.1 Samples with a very low or very high pH may give incorrect readings on the meter. For samples with a true pH >10, the measuredN/A pH may be incorrectly low. Strong acid solutions, with a true pH of <1, may give incorrectly high pH measurements.

4.2 Temperature fluctuations will cause measurement errors.

4.3 Errors will occur when the electrodes become coated. If an electrode becomes coated with an oily material that will not rinse free, it can be

- cleaned with an ultrasonic bath
- washed with a detergent followed by several rinses with DI water, then placed in a 1:1 HCl solution and rinsed again
- cleaned according to the manufacturer's instructions

5.0 Safety

Laboratory staff are encouraged to review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets for reagents used in the laboratory.

6.0 Equipment and Supplies

6.1 Fisher Scientific Model 50 pH/ISE meter.

6.2 Standard glass- body combination electrode

6.3 Beaker: 150mL plastic specimen cups

6.4 Thermometer or temperature sensor for automatic compensation.

6.5 Top loading or analytical balance capable of weighing 0.1g.

6.6 Magnetic stir plate and stir bars

7.0 Reagents and Standards

7.1 Reagent Water – All water used during preparation should be reagent-grade Type I with regard to resistivity or >10 megohm- cm (18th and 19th Editions of Standard Methods, Method 1080), and referred throughout this SOP as DI water.

7.2 Fisher certified **(or equivalent)** buffers: pH of 2.0, 4.0, 7.0, **and** 10.0

7.3 QC reference sample purchased from ERA with certificate of analysis.

8.0 Sample Collection, Preservation, and Storage

8.1 Samples should be stored at 4°C and should be analyzed as soon as possible.

9.0 Quality Control

9.1 After calibration and at a frequency of at least every 10 samples, analyze the pH 7.0 buffer as a calibration verification. Deviations of more than ± 0.10 pH units from the true value require recalibration and reanalysis of samples analyzed between the failing buffer and the preceding acceptable buffer.

9.2 Analyze an aqueous blank spike for each batch of samples. Obtain prepared solution and acceptance criteria from ERA. Record results and reference numbers in the pH Determination Logbook (Attachment 1). If acceptance criteria are not met, correct the problem, recalibrate and reanalyze the entire batch.

9.3 A duplicate sample should be analyzed with every 10 samples. Deviations of more than ± 0.10 pH units between duplicates require recalibration and reanalysis of all associated samples.

9.4 Efficiency determined at calibration should be between 90-105%.

10.0 Calibration and Standardization

10.1 The pH meter must be calibrated and recorded on the pH Determination Run Log before this analysis begins.

10.2 The value for each of the certified buffer solutions must be within +/- 0.05 pH units. Use fresh buffer solutions each time the pH meter is calibrated.

10.3 Calibrate the meter using either the auto recognition standardization method described below and in the Fisher Scientific Model 50 pH Meter Operating Instructions Manual. With this method, the meter automatically corrects the buffer value for the variation of buffer pH with temperature and it eliminates the need to key and enter a buffer value each time a standardization is performed. Temperature compensation at 25°C is provided, independent of whether an automatic temperature compensation (ATC) probe is connected.

Note: Multiple readings for each standard is requested in Method 9040B, however, the Fisher Scientific Model 50 pH Meter cannot calibrate using this process. Samples do have multiple readings performed per the method.

However, if temperature compensation with the ATC probe is not used , all buffers and samples should be at the same temperature.

Stir all buffers and samples with a magnetic stirrer while a measurement is being made.

10.3.1 From the main screen, press "**Standardize**".

10.3.2 Press **"2" to clear existing standards.**

10.3.3 Press **"Standardize" then press** "1" to update **standards.**

10.3.4 Place the electrode into pH 2.0 buffer and turn on the stirrer. **Type in the buffer value and press enter.** Immerse the electrode in a sufficient volume of solution to cover the sensing elements and allow the electrode to remain in the solution until a stable reading is obtained. Rinse the electrode thoroughly between determinations.

10.3.5 Remove the pH electrode from the pH 2.0 buffer and rinse the electrode thoroughly with DI water. Place the electrode into the pH 4.0 buffer repeating 10.3.4.

10.3.6 Repeat 10.3.5 for the pH 7.0 and 10.0 buffers.

10.4 Store the electrode in pH 7.0 buffer when not in use.

10.5 Check the slope and efficiency. Efficiency should be 90-105%.

11.0 Procedure

11.1 Weigh 20g of the soil sample in a 150 ml specimen cup, add 20ml of DI H_20, cover and stir the suspension for 5 minutes.

11.2 Allow the soil suspension to stand for 1 hour to allow most of the suspended soil to settle out from the suspension.

11.3 Immerse the electrode just below the suspension and record the pH and temperature of the sample in the pH Determination Run Log **(Attachment 1)**.

12.0 Data Analysis and Calculations

Calculations must be consistent with the QC SOP: Numerical Data Reduction.

13.0 Method Performance

Precision and accuracy for single analyst (Attachment 2). The data are retained by the QA department.

14.0 Pollution Prevention

The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 thing.

15.0 Waste Management

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and

controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Samples preserved with HCl, HNO_3, H_2SO_4, NaOH, or Zn Acetate are hazardous and must be neutralized before being disposed, or must be handled as hazardous waste.

Refer to the Hazardous Waste Management and Safety SOPs located in the lab.

16.0 References

16.1 "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods", SW846, 3rd Edition, Update III, 12/96, Method 9045C, 1/95

16.2 New York State Analytical Services Protocol (NYSASP), 6/2000, plus revisions

16.3 North Carolina DENR

16.4 QCSOP: Proper Documentation Procedures

16.5 QCSOP: Numerical Data Reduction

16.6 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477.

16.7 Hazardous Waste Management & Safety SOPs: "Hazardous Waste Disposal" and "Spill Control & Cleanup."

16.8 NELAC Standards, July 1, 1999, plus revisions

16.9 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995.

16.10 New York State Environmental Laboratory Approval Program, Certification Manual, October 15, 1999, plus revisions.

16.11 CompuChem Quality Manual, Revision 2, 10/26/01, plus revisions

16.12 Sample Control SOP 4.1, "Receiving Samples"

16.13 Sample Control SOP 4.6, "Storing Samples"

16.14 Fisher Scientific Model 50 pH Meter Operating Manual Revision D, 03/92

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.1 Attachment 1 – pH Determination Run Log

17.2 Attachment 2 – Single Analyst Capability Study

Attachment 1

CompuChem a division of Liberty Analytical Corp. Logbook 1 HH 2 Page ____ of ____

pH Determination Run Log

Method 150.1 (water) or 9045C (soil) (Circle one)

Fisher Scientific Model #50 Operator: _____

Date: SDG:

	2.00					
	4.00					
	7.00					
	10.00					
1	LCS ERA					±0.10 pH units
2						
3						
4						
5						
6						
7						
8						
9						
10						
	Check STD 7.00					±0.10 pH units
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
	Check STD 7.00					±0.10 pH units
		NA				

Because pH was not taken in the field, holding time (immediately after collection for 150.1 and 9045C) could not be met.

Reviewed By _____ **Date:** _____

The presence of the Chemist's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist together with the chemist's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

4/17/02:dce

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Attachment 2

Laboratory Name/North Carolina Certificate Number: CompuChem/79					
Analyst: Jenny Smith					
Method: pH in soil, Method 9045C					
Date	Sample ID	Std.Lot #	True Value	pH	Recovery
			pH		%
10/16/2001	LCS ERA	7M1-15-25	8.00	7.95	99
10/6/2001	LCS ERA	7M1-15-25	8.00	8.00	100
9/11/2001	LCS ERA	7M1-15-25	8.00	7.89	99
9/4/2001	LCS ERA	7M1-15-25	8.00	7.86	98
			Mean	7.9	99
			Std.deviation	0.062	0.78
			% RSD	0.79	0.79

CompuChem
a division of Liberty Analytical Corporation
501 Madison Avenue
Cary, NC 27513

SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire shaded area (except effective date).

This is a new procedure _____ revised procedure ✓ outdated procedure (archive) _____

- Procedure area, title, and SOP number: Section #: 3.5.19.1 Effective date: (QA fills in) 11/3/00
  IP610: Non-filterable Residue: Total Suspended Solids by MCAWW
- Procedure prepared by: Linda Carter Date: 10/12/00
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) Bob Mann Date: 10/12/00
- Reason for change: NELAC format changes; annual review
- This procedure meets the requirements of the following approved method references: Methods for Chemical Analysis of Water & Wastes, 3/83, Method 160.2; New York State Analytical Services Protocol, 10/95, NYSASP

Procedure approved by Quality Assurance Representative: Date:
(Not needed if signed above)

_____ _____

Effective 1-1-96, on an annual basis: Lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary, indicate by your signature that the SOP has been reviewed.

Annual Review—Signature: _____ Date: 4-17-02

Annual Review—Signature: _____ Date: 08/20/02

Annual Review—Signature: _____ Date:

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Instrument Procedure 610: Nonfilterable Residue; Total Suspended Solids, by MCAWW

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Instrument Procedure 610: Nonfilterable Residue; Total Suspended Solids, by MCAWW

1.0 Scope and Application

This method is used to determine total suspended solids in drinking, surface, and saline waters, **domestic and industrial wastes**.

A method detection limit is not applicable to this determination. The reporting limit is 1.0 mg/L and is adjusted based on the volume of sample used. This is discussed in detail below.

Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

2.0 Summary of Method

A **well-**mixed sample is filtered through a glass fiber filter disc (2.1 cm) and the non-filterable residue on the filter is dried to a constant weight at 103-105°C.

3.0 Definitions

3.1 Non-filterable residue - the solid mass retained by a glass fiber filter disc and dried to a constant weight at 103-105°C.

3.2 Method detection limit (MDL) – The minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR, Part 136, Appendix B.)

3.3 Reporting Limit – The laboratory reporting limit is based on the lowest multipoint calibration standard concentration. For some inorganic methods,

the reporting limit is based on the MDL, and is usually 4-8 times higher than the MDL.

If the low level standard concentration is not at least three times higher than the MDL value, the standard concentration is adjusted upward in order to achieve this minimal ratio. It may be adjusted higher than three times depending on the concentration range of the calibration curve and the ability to meet method linearity requirements

3.4 Reporting Units – mg/L

3.5 An SDG is defined by the following, whichever is more frequent:

- **each 20 field samples received within a case, or**
- **each 7 calendar day period during which field samples in a case are received (14 calendar days if requested by the client) beginning with the receipt of the first sample.**

NOTE: The Army Corps of Engineers does not accept the SDG approach, unless the samples are prepared in a single batch. When a group of up to 20 field samples of a similar matrix are prepared as one batch, method-specified QC samples such as a method blank, laboratory control sample, matrix spike, matrix spike duplicate, and matrix duplicate must also be prepared together at a rate of 5%. If samples are batched together from different sites, project-specific QC must be processed.

3.6 Constant weight – Weight obtained when weight loss is < 4% difference or < 0.5 mg (0.0005 g), whichever is less.

4.0 Interferences

4.1 Filtration apparatus, filter material, and washing and drying temperatures are specified because these variables have been shown to affect the results.

4.2 Samples high in dissolved solids, such as saline waters, brines, and some wastes, may be subject to a positive interference. Care must be taken in selecting the filtering apparatus so that washing the filter and any dissolved solids in the filter minimizes this potential interference.

5.0 Safety

Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous. During sample preparation safety glasses, gloves and lab coats are a minimum requirement. The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

Laboratory staff are encouraged to review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets (MSDS) for reagents used in the laboratory. The MSDS are located in the Quality Assurance department.

6.0 Equipment & Supplies

6.1 **"ProWeight Filters" pre-weighed 4.7 mm glass fiber filters catalog number F93447mm from Environmental Express, or equivalent**

6.2 Suction flasks

6.3 Drying oven--103-105°C

6.4 Dessicator

6.5 Analytical balance, capable of weighing to 0.1 mg

7.0 Reagents & Standards

7.1 Reagent water - All water used during preparation should be reagent-grade Type I with regard to resistivity of >10 megohm-**cm (18th and** 19th Editions of Standard Methods, Method 1080), and referred throughout this SOP as DI water.

8.0 Sample Collection, Preservation, & Storage

8.1 Samples are collected, preserved, and stored according to the tables in Sample Control SOP 4.1, "Receiving Samples" and 4.6, "Storing Samples." Sample holding times are also listed.

8.2 Preservation of the sample is not practical; analysis should begin as soon as possible. Refrigeration at 4°C, to minimize microbiological decomposition of solids, is recommended. The holding time is seven days.

8.3 Shake thoroughly to achieve homogeneity.

9.0 Quality Control

9.1 Analyze a method blank for every batch of up to 20 samples. The blank must measure less than 1 mg/L of non-filterable residue.

If the blank exceeds 1 mg/L, the entire sample batch associated with the blank must be re-prepared and reanalyzed.

9.2 At least one duplicate sample analysis should be performed for every 20 samples or for each SDG, whichever is more frequent. For NCDENR the duplicate frequency requirement is 1 in 20. The sample and duplicate should agree within a relative percent difference (RPD) of 20%.

If the sample and the duplicate do not agree within 20% RPD, the data may be reported and should be qualified.

9.3 A laboratory control sample (LCS) with every batch of up to 20 samples. The LCS is commercially available. Acceptable limits are 90-110% of the true value.

If the LCS recovery falls outside acceptance limits, the entire batch must be evaluated and repeated as needed.

10.0 Calibration & Standardization

10.1 Ensure the balance has been calibrated for the day prior to use following the procedure in Inorganic Sample Preparation Laboratory and Wet Chemistry SOP 9.3, "Analytical Balance Calibration and Maintenance."

11.0 Procedure

Documentation must follow the requirements in QC SOP: Proper Documentation Procedures. All fields must be completed in the Residue Determination Log (Attachment 1.) Because this logbook is also used for other residue determinations, "TSS" must be recorded in the right margin indicating which samples were analyzed by this residue method.

11.1 Preparation of glass fiber filter disc

11.1.1 Filters arrive in the laboratory pre-weighed, and dried. Upon arrival, remove filters (in tins) from the box and place in a dessicator for storage.

11.1.2 An initial weight is located on the tin. Remove the tin and weigh the filter. Record the weight on the Residue Determination Log.

Note: The filter weight does not include the tin.

11.2 Selection of sample volume

11.2.1 For a 4.7 mm diameter filter, filter 100 ml of sample. If the weight of captured residue is less than 1.0 mg, the sample must be increased to provide at least 1.0 mg of residue. Minimum field sample volume is 300 ml up to 1000 ml. Additional aliquots of sample may be added to the filter when increasing the sample amount to collect more residue.

Note: If other filter diameters are used, start with a volume of sample equal to 7ml/cm2 of filter area and collect at least 1.0 mg.

11.2.2 If greater than 200 mg are contained on the filter, a lesser sample volume must be used that results in a filter charged with 1-200 mg sample residue.

11.2.3 The reporting limit is adjusted based on the sample volume used. If there is not enough sample provided to filter 1000 ml, the reporting limit should be adjusted accordingly, and the value obtained is a qualified estimated value. The reporting limit for each sample is based on the volume of sample filtered. For example, a reporting limit of <4.0 mg/L would be reported if only 250 ml of sample was available for filtering. If one liter is filtered and the residue collected is <1.0 mg, the reporting limit is <1.0 mg/L.

11.2.4 The true value may vary with each lot of LCS solution purchased from the vendor. The volume of LCS solution filtered depends on the true value and must always yield >1.0 mg of residue charged to the filter.

11.2 TSS determination

11.2.1 Using forceps, remove filter from tin and assemble the filtering apparatus and begin suction. Wet the filter with a small volume of DI water to seat it against the fritted support.

11.2.2 Shake the sample vigorously and quantitatively transfer a 100 ml sample aliquot to the filter using a graduated cylinder.

Note: As noted above this volume may need to be adjusted and the initial volume can be varied depending on the appearance of the sample, i.e. if suspended solids are observed, turbidity, cloudiness, etc. increase the volume. Continue to add additional sample aliquots to the filter until at least 1.0mg residue is collected.

Remove all traces of water by continuing to apply the vacuum after the water has passed through.

11.2.3 Filter one liter of DI water for the method blank.

11.2.4 Filter 100-200 ml of the LCS solution. This volume may vary with each lot as discussed above.

11.2.5 Filter a sample duplicate.

11.2.6 With the suction on, wash the graduated cylinder, filter, non-filterable residue, and filter funnel wall with three 10 ml portions of DI water allowing complete drainage between washings. Remove all traces of water by continuing to apply the vacuum after the water has passed through.

Note: The total volume of the wash water used should equal approximately 2ml/cm^2. For a 4.7cm filter the total volume is 30 ml.

11.2.7 Carefully remove the filter from the support. Dry at least one hour at 103-105° C. Cool in a dessicator and weigh. Repeat the drying cycle until a constant weight is obtained (<4% difference or <0.5mg, i.e. 0.0005g, between successive weighings.) The drying procedure includes re-heating, re-dessicating and re-weighing.

11.2.8 If the filtration rates drop rapidly or if the filtration times exceeds 5-10 minutes, follow the steps below.

- **Use an unweighed filter affixed in the filter assembly. Add a known volume of sample to the filter funnel and record the time elapsed after selected volumes have passed through the filter.**

- **Use 25ml increments for timing. Continue recording the time and volume increments until the filtration rate drops rapidly.**

- **Plot the observed time versus volume filtered. Select the proper filtration volume as that just short of the time a significant change in filtration rate occurred.**

12.0 Data Analysis & Calculations

Calculations must be consistent with the QC SOP: Numerical Data Reduction.

12.1 Calculation of the mean or average of a set of values:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where: n = total number of values
x_i = each individual value used to calculate the mean
x = the mean of n

12.2 Calculation of the standard deviation of a set of values:

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n} \left(X_n - \overline{X}\right)^2}{n-1}}$$

12.3 Calculation of percent recovery:

12.3.1 LCS:

$$\%R = \frac{Amount\ found}{Amount\ spiked}\ x\ 100$$

12.3.2 Matrix spikes:

$$\%\,R = \frac{Amount\ in\ spiked\ sample - Amount\ in\ unspiked\ (native)\ sample}{Amount\ spiked}\ x\ 100$$

12.4 Calculation of % RSD

$$\%RSD = \left(\frac{Standard\ deviation}{\bar{X}}\right) \times 100$$

12.5 Calculation of RPD

$$RPD = \frac{|Value\ 1 - Value\ 2|}{(Value\ 1 + Value\ 2)/2} x100$$

12.6 Calculation of %Difference (%D)

$$\%Diff = \frac{Value - \overline{Reference\ \ value}}{\overline{Reference\ \ value}} x\ 100$$

12.7 Concentration for non-filterable residue

$$Non - filterable\ residue, mg/L = \frac{(A-B)*1000}{C}$$

Where: A = weight of filter (or filter and crucible) + residue in mg
B = weight of filter (or filter and crucible) in mg
C = ml of sample filter

13.0 Method Performance

This method was validated through in-house laboratory studies of method detection limits and precision and accuracy for single analyst (Attachment 2). The data are retained by the QA department.

14.0 Pollution Prevention

The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 thing.

15.0 Waste Management

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Samples preserved with HCl, HNO_3, or H_2SO_4 to pH <2 are hazardous and must be neutralized before being disposed, or must be handled as hazardous waste.

Refer to the Hazardous Waste Management and Safety SOPs located in the lab.

16.0 References

16.1 Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, Method 160.2.

16.2 Standard Methods for the Examination of Water and Wastewater, 18th Edition (1992) and 19th (1995) and 20th (1995) Edition upon promulgation, Method 1080

16.3 New York State Analytical Services Protocol (NYSASP), June 2000, plus revisions

16.4 QCSOP: Proper Documentation Procedures

16.5 QCSOP: Numerical Data Reduction

16.6 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477.

16.7 Hazardous Waste Management & Safety SOPs: "Hazardous Waste Disposal" and "Spill Control & Cleanup."

16.8 NELAC Standards, July 1, 1999, plus revisions

16.9 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995.

16.10 New York State Environmental Laboratory Approval Program, Certification Manual, October 15, 1999, plus revisions.

16.11 CompuChem Quality Manual, Revision 2, 10/26/01

16.12 Sample Control SOP 4.1, "Receiving Samples"

16.13 Sample Control SOP 4.6, "Storing Samples"

16.14 Code of Federal Register, 40 CFR, Part 136, "Guidelines for Establishing Test Procedures for Priority Pollutants"

16.15 Inorganic Sample Preparation Laboratory and Wet Chemistry SOP 9.3, "Analytical Balance Calibration and Maintenance."

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.1 Attachment 1 – Residue Determination Log

17.2 Attachment 2 – Single Analyst Capability Study

Attachment 1

CompuChem a division of Liberty Analytical Corporation
RESIDUE DETERMINATION LOG

Logbook No. 1 S(5) 5

Page _____ of _____

Circle one of the following:
Filterable Residue (TDS) EPA 160.1
Non-Filterable Residue (TSS) EPA 160.2
Total Residue (TS) EPA 160.3

Oven Temperature:	In	Out
TDS:		
TSS:		
TS:		

SDG(s):_____

Analyst:_____ Date:_____

Dish No.	CompuChem ID	Dish Tare - First Weight (g)	Dish Tare - Second Weight (g)	Dish Tare - Third Weight (g)	Sample Volume (L)	Weight - First Reading (g)	Weight - Second Reading (g)	Weight - Third Reading (g)	Net Residue (Final weight dish) (g)	Concentration Reported (net residue sample vol) (mg/L)	Comment
	LCSW										
	PBW										

LCS Acceptance Range = ±10%

LCS Lot No.:_____

Reviewed By:_____ Date:_____

4/10/02:dce

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Attachment 2

Laboratory Name/North Carolina Certificate Number: CompuChem/79					
Analyst: Jenny Smith					
Method: Non-Filterable Residue (TSS), Method 160.2					
Date	Sample ID	Std.Lot #	True Value	mg/l	Recovery
			mg/l		%
9/19/2001	LCSW	99111	46.70	45.00	96
9/17/2001	LCSW	99111	46.70	50.00	107
9/13/2001	LCSW	99111	46.70	51.00	109
9/11/2001	LCSW	99111	46.70	45.00	96
			Mean	48	102
			Std.deviatio	3.2	6.9
			% RSD	6.7	6.7

CompuChem
a division of Liberty Analytical Corporation
501 Madison Avenue
Cary, NC 27513

NELAP accredited

SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire block below (except effective date).

This is a new procedure _____ revised procedure ✓ outdated procedure (archive) _____

- Procedure Code: IP 609 SOP Section #: 3.5.19.2 Revision #: 8

SOP Title: Filterable Residue, Total Dissolved Solids, by MCAWW

Effective date: (QA fills in) 9/1/05

- Procedure prepared by: Judith Dozier Date: 9/1/05
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) Date: 9-1-05
- Reason for change: Updated for SC DHEC, Addition of Contigency Protocol to Section 9
- This procedure meets the requirements of the following approved method references: Methods for Chemical Analysis of Water & Wastes, March 1983 Method 160.1, New York State Analytical Services Protocol, NYSASP, June 2000

Procedure approved by Quality Assurance Representative: Date:
(Not needed if signed above)

Effective 1-1-96, on an annual basis: Lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary, indicate by your signature that the SOP has been reviewed.

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Instrument Procedure 609: Filterable Residue, Total Dissolved Solids, by MCAWW

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Instrument Procedure 609: Filterable Residue, Total Dissolved Solids, by MCAWW

1.0 Scope and Application

This method applies to drinking, surface, and saline waters. The practical range of the determination is 10 to 20,000 mg/L.

The method detection limit is shown in Attachment 1. The reporting limit is derived from the method at 10 mg/L.

Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

2.0 Summary of Method

A well-mixed sample is filtered through a glass fiber filter. The filtrate is evaporated and dried to a constant weight at 180° C.

3.0 Definitions

3.1 Filterable Residue - solids that will pass through a glass fiber filter and are then dried to a constant weight at 180° C.

3.2 Method detection limit (MDL) – The minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR, Part 136, Appendix B.)

3.3 Reporting Limit – The laboratory reporting limit is based on the lowest multipoint calibration standard concentration. For some inorganic methods, the reporting limit is based on the MDL, and is usually 4-8 times higher than the MDL.

If the low level standard concentration is not at least three times higher than the MDL value, the standard concentration is adjusted upward in order to achieve this minimal ratio. It may be adjusted higher than three times depending on the

concentration range of the calibration curve and the ability to meet method linearity requirements. An exception to this is for CLP methods where the MDL is only required to be lower than the reporting limit.

3.4 Reporting Units – mg/L

3.5 An SDG is defined by the following, whichever is more frequent:

- each 20 field samples received within a case, or
- each 7 calendar day period during which field samples in a case are received (14 calendar days if requested by the client) beginning with the receipt of the first sample.

NOTE: The Army Corps of Engineers **(US ACE) and SC DHEC** do not accept the SDG approach, unless the samples are prepared in a single batch. When a group of up to 20 field samples of a similar matrix are prepared as one batch, method-specified QC samples such as a method blank, laboratory control sample, matrix spike, matrix spike duplicate, and matrix duplicate must also be prepared together at a rate of 5% **for US ACE and 10% for SC DHEC**. If samples are batched together from different sites, project-specific QC must be processed.

3.6 SC DHEC – South Carolina Department of Health and Environmental Control

4.0 Interferences

4.1 Mineralized water containing large concentrations of calcium, magnesium, chloride, and/or sulfate may be hygroscopic and will require longer drying and desiccation time and rapid weighing.

4.2 Samples containing high concentrations of bicarbonate will require careful, and possibly prolonged, drying at 180° C to ensure that all bicarbonate is converted to carbonate.

4.3 Too much residue in the evaporating dish will crust over and entrap water that will not be driven off during drying. Total residue should be limited to about 200 mg.

5.0 Safety

Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous. During sample preparation safety glasses, gloves and lab coats are a minimum requirement. The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

Laboratory staff are encouraged to review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets for reagents used in the laboratory.

6.0 Equipment and Supplies

6.1 glass fiber filter discs - 4.7 cm or 2.1 cm, without organic binder

6.2 filter holder -membrane filter funnel or Gooch crucible adapter

6.3 suction flask - 500 **mL**

6.4 Gooch crucibles - 25 **mL** (if 2.1 cm is used)

6.5 evaporating dishes - porcelain, 100 **mL** volume (Vycor or platinum dishes may be substituted)

6.6 drying oven - 180° C ± 2° C

6.7 desiccator

6.8 analytical balance - capable of weighing to 0.1 mg.

7.0 Reagents and Standards

7.1 Reagent water - All water used during preparation should be reagent-grade Type I with regard to resistivity of >10 megohm-cm (**20**th Edition of Standard Methods, Method 1080), and referred throughout this SOP as DI water.

8.0 Sample Collection, Preservation, & Storag

8.1 Samples are collected, preserved, and stored according to the tables in Sample Control SOP 4.1, “Receiving Samples” and 4.6, “Storing Samples.” Sample holding times are also listed.

8.2 Analysis of the sample should begin as soon as possible since sample preservation is not practical. Refrigerate the samples at 4° C to reduce microbiological decomposition. The holding time is 7 days.

9.0 Quality Control

9.1 A method blank **(MB)** is analyzed with every batch of up to 20 samples. **SC DHEC requires a MB every 10 samples.**

9.1.1 The blank must measure less than 10 mg/L of filterable residue. If the blank exceeds 10 mg/L, the entire sample batch associated with the blank must be re-prepared and reanalyzed.

9.2 For every 20 samples or for each sample delivery group (SDG), whichever is more frequent, at least one duplicate sample analysis should be performed. The sample and duplicate should agree within 20% relative percent difference (RPD).

Note: For **SC DHEC** the duplicate frequency requirement is 1 in 10 samples.

9.2.1 If the sample and the duplicate do not agree within 20% relative percent difference (RPD), a Quality Assurance (QA) notice is required.

9.3 A laboratory control sample (LCS) is analyzed with every batch of up to 20 samples. **SC DHEC requires an LCS every 10 samples.** The LCS is purchased with a certificate of traceability to NIST.

9.3.1 Acceptance limits are 90 - 110% of the true value. If the LCS recovery falls outside acceptance limits, the entire batch must be evaluated and repeated as needed.

9.4 The balance calibration is checked at the end of each weighing sequence. This is done by weighing a class 1 weight and recording the result in the logbook (Attachment 2).

9.5 Contingency

9.5.1 If due to a lab accident or to QC failures a re-preparation and re-analysis are required for the sample and insufficient volume remains, the Project Manager must be alerted and will contact the client for directions on how to proceed.

9.5.2 If persistent contamination occurs in the laboratory, analyses must be halted until the source can be identified and isolated. When the contamination issue is resolved, sample analysis may proceed.

9.5.3 Refer to Data Review SOP 14.3.2.1 "Data Management: Wet Chemistry Data Review and Verification" for information on how to handle reporting of data that are unacceptable or out-of-control.

9.5.4 Any other issues that potentially affect data quality should also be addressed with the Project Manager.

10.0 Calibration and Standardization

10.1 Ensure the analytical balance has been calibration for the day prior to use. Refer to **Quality Control** SOP **13.17**, "Analytical Balance Calibration and Maintenance."

10.2 The balance, oven, and weight set serial numbers are recorded in the logbook for reference.

11.0 Procedure

11.1 Preparing glass fiber filter discs: Place the disc on the membrane filter apparatus or insert it into the bottom of a suitable Gooch crucible. While the vacuum is applied, wash the disc with three successive 20 **mL** volumes of distilled (DI) water. Remove all traces of water by continuing to apply the vacuum after the water has passed through. Discard the washings.

11.2 Preparing evaporating dishes: If volatile residue is to be measured, heat the clean dishes to 550° C ± 50° C for 1 hour in a muffle furnace. If only filterable residue is to be measured, heat the clean dishes to 180° C ± 2° C for 1 hour. Cool them in the desiccator and store until needed. Weigh immediately before use.

11.3 Assemble the filtering unit and begin suction. Shake the sample vigorously and use a 100 **mL** graduated cylinder to transfer rapidly 100 **mL** to the funnel. If the total filterable residue is low, a larger volume should be used. Sufficient volume of sample should be used to yield at least 10.0 mg of residue. Conversely, because excess residue in the dish may form a water-trapping crust, limit sample to no more than 200 mg.

11.4 Filter the sample through the glass fiber filter and rinse with three 10 **mL** portions of DI water. Continue to vacuum for about 3 minutes after filtration is complete to remove as much water as possible.

11.5 Transfer the volume of the sample to a weighed evaporation dish and evaporate to dryness.

11.6 To avoid splattering, place the sample in the oven set at ~ 98° C until the sample reaches dryness. Then increase the temperature to 180° C, being careful not to exceed 180° C. Dry the evaporated sample for at least 1 hr at 180° C ± 2° C and cool in a desic**c**ator. Weigh the dried sample. Repeat the drying procedure until a constant weight is obtained or until the weight loss is less than 0.5 mg. The drying procedure includes re-heating, re-desiccating, and re-weighing.

11.7 If the results are greater than 200 mg, a smaller volume must be filtered to obtain a result less than 200 mg. If the result is less than 10.0 mg, a larger volume, up to 1000 **mL**, must be filtered to obtain a result greater than 10.0 mg. If 1000 **mL** sample has less than 10.0 mg residue on the filter, the sample should be reported as < 10.0 mg/L.

If an entire liter must be filtered for a sample designated by the client as QC, an additional liter bottle would be needed by the laboratory to perform the duplicate analysis.

12.0 Calculation

Calculations must be consistent with the QC SOP: Numerical Data Reduction.

12.1 Calculation of the mean or average of a set of values:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where: n = total number of values
x_i = each individual value used to calculate the mean
x = the mean of n

12.2 Calculation of the standard deviation of a set of values:

$$Standard\ deviation = \sqrt{\frac{\sum_{i=1}^{n}\left(X_n - \overline{X}\right)^2}{n-1}}$$

12.3 Calculation of percent recovery:

12.3.1 LCS:

$$\%R = \frac{Amount\ found}{Amount\ spiked}\ x\ 100$$

12.3.2 Matrix spikes:

$$\%\ R = \frac{Amount\ in\ spiked\ sample - Amount\ in\ unspiked\ (native)\ sample}{Amount\ spiked}\ x\ 100$$

12.4 Calculation of % RSD

$$\%RSD = \left(\frac{Standard\ deviation}{\overline{X}}\right) \times 100$$

12.5 Calculation of RPD

$$RPD = \frac{|Value\ 1 - Value\ 2|}{(Value\ 1 + Value\ 2)/2} x100$$

12.6 Calculation of %Difference (%D)

$$\%Diff = \frac{Value - \overline{Reference\ value}}{\overline{Reference\ value}}\ x\ 100$$

12.7 Calculation of filterable residue concentration:

$$\text{filterable residue, mg/l} = \frac{(A-B) \times 1{,}000}{C}$$

where: A = weight of dish + residue in mg
B = weight of dish in mg
C = volume of sample in **mL**

13.0 Method Performance

This method was validated through in-house laboratory studies of method detection limits and precision and accuracy for single analyst (Attachment **3**). The data are retained by the QA department.

14.0 Pollution Prevention

The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 thing.

15.0 Waste Management

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Samples preserved with HCl, HNO_3, or H_2SO_4 to pH <2 are hazardous and must be neutralized before being disposed, or must be handled as hazardous waste.

Refer to the Hazardous Waste Management and Safety SOPs located in the lab.

16.0 References

16.1 Methods for Chemical Analysis of Water and Wastes, March 1983, Method 160.1

16.2 Standard Methods for the Examination of Water and Wastewater, 20th (1998) Editions, Method 1080

16.3 Code of Federal Register, 40 CFR, Part 136, "Guidelines for Establishing Test Procedures for Priority Pollutants"

16.4 New York State Analytical Services Protocol (NYSASP), 6/2000, plus revisions

16.5 QCSOP: Proper Documentation Procedures

16.6 QCSOP: Numerical Data Reduction

16.7 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477.

16.8 Hazardous Waste Management & Safety SOPs: "Hazardous Waste Disposal" and "Spill Control & Cleanup."

16.9 NELAC Standards, **July 2003**, plus revisions

16.10 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995.

16.11 New York State Environmental Laboratory Approval Program, Certification Manual, **April 2005**, plus revisions.

16.12 CompuChem Quality Manual, Revision **6**, **Update 1, 5/20/05**, plus revisions

16.13 Sample Control SOP 4.1, "Receiving Samples"

16.14 Sample Control SOP 4.6, "Storing Samples"

16.15 **Quality Control** SOP **13**.**17**, "Analytical Balance Calibration and Maintenance."

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.1 Attachment 1 – Method Detection Limit Study

17.2 Attachment 2 – Residue Determination Log

17.3 Attachment 3 –Single Analyst Capability Study

Attachment 1

Parameter	Method	Study	Rep#1	Rep#2	Rep#3	Rep#4	Rep#5	Rep#6	Rep#7	Rep#8	Mean	Amt.	S.Dev.	MDL	RptLim
(Water/Leachate)	Number	date	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Residue (TDS)	160.1	1/30/2003	15.0	16.0	15.0	15.0	13.0	15.0	12.0	16.0	14.6	15.0	1.408	4.2	10
Filterable															

Note: Attachment subject to change without notice.

Attachment 2

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Worksheek No. 1 S(5)

Filterable Residue (TDS) Method 160.1

Batch Number _____

Page __1___ of ___1____

SDG: _____ Oven Temp: (°C) | Temp In | Date | Time | Temp Out | Date | Time

Analyst No.: _____ Date: 9/1/2005

Cond	Dish No.	CompuChem No.	Sample Type	Dish Tare - First Weight (g)	Dish Tare - Second Weight (g)	Dish Tare - Third Weight (g)	Sample Volume (mL)	Weight - First Reading (g)	Weight - Second Reading (g)	Weight - Third Reading (g)	Net Residue (Final weight - dish) (g)	Results (net residue / sample vol) (mg/L)	Comment
					NA	NA	100		NA	NA	0.0000	0.0	
													TV =

LCS Acceptance Range = ±10% LCS TV= _____ LCS Reference No.: _____

_____ Date: _____ 7/30/04:dce

The presence of the Chemist's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist together with the chemist's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

Balance used for weights: Denver Instr Serial #B034903 S class weights for balance calibration:Serial #NCSN050 Fisher Oven Serial #472

Note: Attachment subject to change without notice.

Attachment 3

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Laboratory Name/North Carolina Certificate Number: CompuChem/79

Analyst: Matt Panning

Method: Total Suspended Solids, Method 160.2

Date	Sample ID	Std.Lot #	True Value ug/kg	mg/L	Recovery %
8/24/00	LCSW	ERA99101	50.3	54.00	107.4
9/22/00	WG5745-4	ERA99103	36.3	33.00	90.9
9/25/00	LCSW	ERA99103	36.3	33.00	90.9
9/27/00	WG5878-3	ERA99103	36.3	38.00	104.7
			Mean % Recovery		98.46
			Std.deviation		8.79
			% RSD		8.9

Note: Attachment subject to change without notice.

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SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire block below (except effective date).

This is a new procedure _____ revised procedure X outdated procedure (archive) _____

- Procedure Code: IP 612 SOP Section #: 3.5.22.1 Revision #: 2

SOP Title: Determination of Inorganic Anions by Ion Chromatography

Effective date: (QA fills in) 10/12/04

- Procedure prepared by: Robert E. McGuan Date: 10-12-04
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) Date: 10-12-04
- Reason for change: Incorporate SCDHEC requirements
- This procedure meets the requirements of the following approved method references: NY State Analytical Services Protocol (NYSASP) June 2000 plus revisions; NELAC Standards, June 2000, plus revisions; EPA/600/R-93-100 "Determination of Inorganic Anions by Ion Chromatography, Revision 2.1, August 1993, Method 300.0

Procedure approved by Quality Assurance Representative: Date:
(Not needed if signed above)

Effective 1-1-96, on an annual basis, Lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary indicate by your signature that the SOP has been reviewed.

ORIGINAL

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Instrument Procedure 612: Determination of Inorganic Anions by Ion Chromatography

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Instrument Procedure 612: Determination of Inorganic Anions by Ion Chromatography

1.0 Scope and Application

This method covers the determination of the following anions; nitrate-N, nitrite-N, bromide, sulfate, chloride, fluoride, and **ortho**phosphate-P in aqueous samples.

The laboratory reporting MDLs and reporting limits are given in attachment 1.

Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

2.0 Summary of Method

A small volume of sample is introduced into an ion chromatograph. The anions of interest are separated and measured using a system comprised of ion chromatography instrument, autosampler, and Omion IC software.

3.0 Definitions

3.1 Method detection limit (MDL) – The minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR, Part 136, Appendix B.)

3.2 Reporting Limit – The laboratory reporting limit is based on the lowest multipoint calibration standard concentration.

For some inorganic methods, the reporting limit is based on the MDL, and is usually 4-8 times higher than the MDL. This is referred to as the Practical Quantitation Limit (PQL). Values detected between the PQL and the instrument detection limit (IDL) are flagged and reported.

If the low level standard concentration is not at least three times higher than the MDL value, the standard concentration is adjusted upward in order to achieve this

minimal ratio. It may be adjusted higher than three times depending on the concentration range of the calibration curve and the ability to meet method linearity requirements.

3.3 Reporting Units – mg/L

3.4 An SDG is defined by the following, whichever is more frequent:

- each 20 field samples received within a case, or
- each 7 calendar day period during which field samples in a case are received (14 calendar days if requested by the client) beginning with the receipt of the first sample.

NOTE: The Army Corps of Engineers **(US ACE) and SC DHEC** do not accept the SDG approach, unless the samples are prepared in a single batch. When a group of up to 20 field samples of a similar matrix are prepared as one batch, method-specified QC samples such as a method blank, laboratory control sample, matrix spike, matrix spike duplicate, and matrix duplicate must also be prepared together at a rate of 5% **for US ACE and 10% for SC DHEC**. If samples are batched together from different sites, project-specific QC must be processed.

3.5 SC DHEC – South Carolina Department of Health and Environmental Control

4.0 Interferences

4.1 A direct chromatographic coelution may be solved by changing columns, eluent strength, modifying the eluent with organic solvents (if compatible with IC columns), changing the detection systems, or selective removal of the interference with pretreatment. Sample dilution will have little to no effect. Verify that these changes do not affect overall performance.

4.2 Samples that contain particles larger than 0.45 microns require filtration to prevent damage to instrument columns and flow systems.

4.3 Chloride

4.3.1 Substances that reduce iron (III) to iron (II) and mercury (III) to mercury (II) (eg. sulfite, thiosulfate)

4.3.2 Halides, which also form strong complexes with mercuric ion (e.g., Br^-,I^-), give a positive interference.

4.4 Sulfate

4.4.1 Silica in concentrations over 500 mg/L will interfere.

4.5 Nitrate and Nitrite

4.5.1 Low results would be obtained for samples that contain high concentrations of iron, copper, or other metals.

4.5.2 Sample turbidity may interfere. Remove turbidity first by filtration with 0.45 um pore diameter membrane filter prior to analysis.

4.6 Fluoride

4.6.1 The polyvalent cations, Si^{4+} , Al^{3+} ,and Fe^{3+} interfere by forming complexes with fluoride.

4.7 **Orthop**hosphate-**P**

4.7.1 Concentrations of ferric iron >50 mg/L will cause a negative interference.

4.8 Bromide

4.8.1 Iron, manganese, and organic matter can cause interference.

5.0 Safety

Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous. During sample preparation, glasses, gloves and lab coats are a minimum requirement. The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

Laboratory staff are encouraged to review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets (MSDS) for solvents and reagents used in the laboratory. The MSDS are located in the Quality Assurance department.

6.0 Equipment and Supplies

6.1 Ion chromatograph – Omnion IC

6.2 Autosampler – ASX 500 series XYZ autosampler

6.3 Syringes equipped with 0.2 micron filters

6.4 Sample vials

7.0 Reagents and Standards

Preparation of all reagents and standards is documented in the Reagent/Standard/QC Preparation Logbook (attachment 2). The final volume of reagent or standard may vary from that listed in the SOP as long as the concentrations remain consistent.

7.1 Reagent Water-All water used during preparation should be reagent-grade Type I with regard to resistivity of > 10 megohm-cm (**20**th Edition of Standard Methods, Method 1080), and referred throughout this SOP as DI water.

7.2 Regenerant solution

7.2.1 In a 1L volumetric flask partially filled with DI water, add 14 mL of sulfuric acid and dilute to volume.

7.3 Eluent stock sodium bicarbonate solution (100mM)

7.3.1 Dissolve 8.40 g of sodium bicarbonate into DI water in a 1 L volumetric flask.

7.4 Eluent stock sodium carbonate solution (100mM)

7.4.1 Dissolve 10.60 g of sodium carbonate into DI water in a 1 L volumetric flask.

7.5 Eluent working solution (2mM sodium bicarbonate and 2.6mM sodium carbonate)

7.5.1 Add to 20 mL of stock sodium bicarbonate solution and 26 mL of stock sodium carbonate solution and dilute in a 1 L volumetric flask with DI water.

7.6 Stock A Calibration Standard – commercially purchased

7.6.1 Nitrite at 50 ppm concentration

7.7 Stock B Calibration Standard – commercially purchased

7.7.1 Fluoride, Bromide, Nitrate, and **ortho**phosphate at 50 ppm concentration

7.7.2 Chloride at 500 ppm concentration

7.7.3 Sulfate at 1000 ppm concentration

7.8 Working Standard A (High calibration standard)

20 ml of stock A & B standards are added to a 200 ml flask and diluted to volume with DI water to generate the concentrations given on the table below. This standard serves as the high standard in the instrument calibration. **This standard is prepared fresh weekly.**

Fluoride	Chloride	Nitrite	Nitrate	Bromide	Phosp.	Sulfate
5 ppm	50 ppm	5 ppm	5 ppm	5 ppm	5 ppm	100 ppm

7.9 Calibration Standards

In addition to working standard A, six additional standards are prepared for the instrument calibration. These calibration standards are diluted from stock A & B standards. Additional standard preparation instructions are given in the Reagent/Standard/QC Preparation Logbook (attachment 2). The concentration of each standard is listed on the table below. All standard concentrations are in ppm. **These standards are prepared fresh weekly.**

Fluoride	Chloride	Nitrite	Nitrate	Bromide	Phosp.	Sulfate
3	30	3	3	3	3	60
1	10	1	1	1	1	20
0.4	4	0.4	0.4	0.4	0.4	8
0.1	1	0.1	0.1	0.1	0.1	2
0.05	0.5	0.05	0.05	0.05	0.05	1
0.01	0.1	0.01	0.01	0.01	0.01	0.2

7.10 Initial Calibration Verification (ICV) Stock Standard

Separate stock standard is purchased for the ICV. The ICV concentration for each parameter is listed on the table below. All standard concentrations are in ppm.

Fluoride	Chloride	Nitrite	Nitrate	Bromide	Phosp.	Sulfate
500	2000	500	500	500	500	2000

7.11 ICV Working Standard

The ICV stock standard is diluted to prepare the working standard. The concentration for each parameter is listed on the table below.

Fluoride	Chloride	Nitrite	Nitrate	Bromide	Phosp.	Sulfate
2.5 ppm	20 ppm	2.5 ppm	2.5 ppm	2.5 ppm	2.5 ppm	20 ppm

7.12 Continuing Calibration Verification (CCV) and Laboratory Control Sample (LCS)

The CCV and LCS are the same standard. The CCV/LCS is prepared from working standard A. The CCV/LCS is diluted to half the concentration of standard A. The concentrations are listed on the table below.

Fluoride	Chloride	Nitrite	Nitrate	Bromide	Phosp.	Sulfate
2.5 ppm	25 ppm	2.5 ppm	2.5 ppm	2.5 ppm	2.5 ppm	50 ppm

7.12 Matrix Spike (MS)/ Matrix Spike Duplicate (MSD)

The MS/MSD is spiked only for the parameters of interest. The MS/MSD are spiked at the concentrations given on the table below. The MS/MSD are prepared by diluting the ICV stock standard to the appropriate spiking level.

Fluoride	Chloride	Nitrite	Nitrate	Bromide	Phosp.	Sulfate
5 ppm	40 ppm	5 ppm	5 ppm	5 ppm	5 ppm	40 ppm

The spiked sample has a 5x dilution performed resulting in a result 1/5 the value given on the table above.

8.0 Sample Collection, Preservation, and Storage

8.1 Samples are obtained from the Custodian out of storage. If refrigerated, samples should be allowed to come to room temperature prior to sample preparation. After preparation, they are returned to the Custodian for long-term storage and disposal.

8.2 Samples are collected, preserved, and stored according to the tables in Sample Control SOP 4.1, "Receiving Samples" and 4.6, "Storing Samples." Samples should be received unpreserved and analyzed within the holding time requirements for the parameter of interest. A summary of the holding times are given below.

Parameter	Holding Times
Chloride	28 days
Fluoride	28 days
Nitrate-N	48 hours
Nitrite-N	48 hours
Orthophosphate-P	48 hours
Bromide	28 days
Sulfate	28 days

9.0 Quality Control

9.1 After instrument calibration, the correlation coefficient must be determined to be 0.995 or better before sample analysis can begin. An initial calibration verification (ICV) and initial calibration blank (ICB) must be analyzed. The ICV standard is a second source standard. It may be diluted to achieve a concentration near the calibration mid-point. The ICV must fall within 90-110% of the true value. The absolute ICB value must not be greater than the reporting limit.
If these control limits cannot be met, determine and correct the problem, recalibrate and reanalyze until all control limits can be met. If instrument problems are suspect, notify your supervisor, document the problem in the maintenance log (attachment 3), put an "out of service tag" on the instrument, and notify the instrumentation repair personnel.

9.2 A continuing calibration verification (CCV) and a continuing calibration blank (CCB) must be analyzed at a 10% frequency throughout the analytical run and analyzed at the end. The CCV is a mid-range calibration standard.

The control limits the CCV are 90-110% of the true value. The CCB must not contain a value above the reporting limit. In the event of a CCV/CCB failure,

determine and correct the problem, recalibrate the instrument, and reanalyze all affected samples.

9.3 A method blank should be analyzed with every 20 samples or for each sample delivery group (SDG), whichever is more frequent. **For SC DHEC, analyze the blank every 10 samples.** The method blank value must not be greater than the reporting limit. If the blank exceeds the reporting limit, the run is stopped, the problem is determined and corrected, the instrument is re-calibrated, and any affected samples are reanalyzed.

9.4 A laboratory control sample (LCS) must be prepared with every preparation batch of up to 20 samples. **For SC DHEC, analyze the LCS every 10 samples.** The term "blank spike" may be used interchangeably. A dilution may be required to achieve a concentration near the calibration mid-point. The result of the LCS must fall within the statistical control limits of 90-110% of the "true" value. If, after analysis, you find that the LCS falls outside these control limits, the analysis must be then evaluated and it must be determined if an instrument problem exists. If so, then correct the problem, recalibrate and reanalyze the entire batch.

9.5 For every 20 samples or each SDG, whichever is more frequent, a matrix spike/matrix spike duplicate (MS/MSD) analysis must be performed. An aliquot of the stock standard is used to spike the original to achieve the appropriate spike amount. If the spike is not within **80**-12**0**% recovery limits and the sample result does not exceed 4x the spike added, matrix interference is suspected. Verify this by respiking another aliquot of the sample.

If the control limits still cannot be met, then a quality assurance notice is required to indicate that a matrix interference is present. If the relative percent difference (RPD) between the MS/MSD exceeds control limits of 20%, a quality assurance notice is required. Samples identified as field blanks should not be used for MS/MSD analysis.

9.6 The **SC DHEC** requires a 10% duplicate frequency and may be satisfied with the MS/MSD.

9.7 All preventive and routine maintenance as mentioned above is recorded in the instrument run log. Major maintenance is recorded in the maintenance log (attachment 3).

9.8 A method detection limit study should be performed every six months or when significant changes to the instrument occur. The MDL is performed for all analytes at approximately two to three times the instrument detection limit.

10.0 Calibration and Standardization

10.1 After preparing reagents and standards and setting up and priming the instrument, load the working standards in the XYZ sampler tray in order from highest to lowest. Follow steps given in section 11.0 to perform the calibration.

11.0 Procedure

Documentation must follow the requirements in QC SOP: Proper Documentation Procedures.

11.1 Initializing IC

11.1.2 Place carrier, regenerant, and eluent lines in appropriate solutions.

11.1.3 Turn on computer and IC.

11.1.4 Push initialize button. Initialization will take approximately five minutes. The button light will change from red to orange to green once initialization is complete.

11.1.5 Mode button should be set to PSI. The PSI range is typically 900-1200.

11.1.6 The conductivity detector gain factor is set at 1.

11.1.7 Press Run button. This will start the pump.

11.1.8 Load calibration standards and samples onto the autosampler. Each standard and sample must be syringe filtered through a 0.2 micron filtered before being added to the sampling vial.

11.2 Computer sequence

11.2.1 Double click on IC5000 icon.

11.2.2 Click ok on Omnion IC screen. This will initialize the auto sampler.

11.2.3 From the Data System screen, click on IC5000.

11.2.4 Click on File, then new batch. The system will ask “Save current batch file?” Answer yes. A new batch screen will appear.

11.2.5 On the new batch screen complete the following fields.

11.2.6 To choose method, click on blue folder to right. Choose 5_300a1.met file by double clicking.

11.2.7 Leave the data path field as is appears on the screen.

11.2.8 Leave the sample ID column empty.

11.2.9 The file name is the current date, for example, 111901. If multiple runs are performed on a given day follow the date will an alphabet sequence, for example, 111901a, 111901b, etc. Follow the date with a decimal and then (001), for example, 111901b.(001).

11.2.10 Leave sample amount as 1, ISTD amount as 0, and dilution factor as 1. Enter the total number of standards, QC and samples in the number of runs field.

11.2.11 Click ok. This will make the batch table.

11.3 Completing batch table

11.3.1 Click on the run type cell and choose calibration. Follow this process for all standards associated with the instrument calibration

11.3.2 Scroll across to the Level 1 column. The calibration standards are entered from high to low. This column should start at 1 for the high standard and increase with each lower standard used. If standard concentrations deviate from those stated in this SOP, contact the laboratory supervisor.

11.3.3 After the calibration information, type the QC and CompuChem numbers down the run type column.

11.3.4 Enter the sample IDs associated with the QC and CompuChem numbers in the sample ID column.

11.3.5 All other column information will appear on the screen with appropriate information already entered.

11.3.6 Click on File, Save batch as, and saves autosampler table as the file name assigned earlier, for example, 111901a. The file type is *.seq.

NOTE: This step is very important because the system will not analyze a batch that has not been saved.

11.3.7 Once the batch is saved, click on the green run batch arrow icon button on the top toolbar.

11.3.8 Click yes. The batch acquisition screen will appear. The current batch name will appear, if not click on folder to choose correct batch. Check confirm overwriting existing file option. Start run # will be first and end run # will be last. Then click start.

11.4 Instrument Run

11.4.1 The autosampler will start and the instrument calibration will begin. The run time is approximately 12 minutes per sample.

11.4.2 Once the calibration curve is completed, it can be reviewed. Click on Method, review peak calibration curve. Review the calibration is acceptable for each parameter of interest.

11.4.3 Generate instrument run log (attachment 4) for inclusion in final report.

11.4.4 Place the eluent in the DI water and shut down the IC and computer.

12.0 Data Analysis and Calculations

Calculations must be consistent with the QC SOP: Numerical Data Reduction.

12.1 Calculation of the mean or average of a set of values:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where: n = total number of values
x_i = each individual value used to calculate the mean
x = the mean of n

12.2 Calculation of the standard deviation of a set of values:

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{n} \left(X_n - \overline{X}\right)^2}{n-1}}$$

12.3 Calculation of percent recovery:

12.3.1 LCS:

$$\%R = \frac{Amount\ found}{Amount\ spiked}\ x\ 100$$

12.3.2 Matrix spikes:

$$\%\ R = \frac{Amount\ in\ spiked\ sample - Amount\ in\ unspiked\ (native)\ sample}{Amount\ spiked}\ x\ 100$$

12.4 Calculation of % RSD

$$\%RSD = \left(\frac{Standard\ deviation}{\overline{X}}\right) \times 100$$

12.5 Calculation of RPD

$$RPD = \frac{|Value\ 1 - Value\ 2|}{(Value\ 1 + Value\ 2)/2} x100$$

12.6 Calculation of %Difference (%D)

$$\%Diff = \frac{Value - \overline{Reference\ value}}{\overline{Reference\ value}}\ x\ 100$$

12.7 Calculating Dilutions

If a sample concentration exceeds the high level standard a dilution must be performed. Determine a level of dilution that will result in a value within the upper half of the calibration range. This is an acceptable dilution. A 10x dilution is performed using 1 mL sample plus 9 mL diluent for a total volume of 10 mL. It should be recorded on the run log as "10x (1 mL in 10 mL)."

13.0 Method Performance

This method was validated through in-house laboratory studies of method (Attachment 1) and precision and accuracy for single analyst (Attachment 5). The data are retained by the QA department.

14.0 Pollution Prevention

The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 thing.

15.0 Waste Management

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Samples preserved with HCl, HNO_3, H_2SO_4, NaOH, Zn acetate are hazardous and must be neutralized before being disposed, or must be handled as hazardous waste. Refer to the Hazardous Waste Management and Safety SOPs located in the lab.

16.0 References

16.1 "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods", SW846, 3rd Edition, Update III, 12/96

16.2 EPA/600/R-93-100, "Determination of Inorganic Anions by Ion Chromatography", Revision 2.1, August 1993, Method 300.0

16.3 Standard Methods for the Examination of Water and Wastewater, 20th (1998) Edition, Method 1080

16.4 IC5000 User Manual, Doc#2129, Rev E, April, 1, 2000

16.5 Code of Federal Register, 40 CFR, Part 136, "Guidelines for Establishing Test Procedures for Priority Pollutants"

16.6 New York State Analytical Services Protocol (NYSASP), 6/2000, plus revisions

16.7 QCSOP: Proper Documentation Procedures

16.8 QCSOP: Numerical Data Reduction

16.9 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477.

16.10 Hazardous Waste Management & Safety SOPs: "Hazardous Waste Disposal" and "Spill Control & Cleanup."

16.11 NELAC Standards, **approved May 2001**, plus revisions

16.12 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995.

16.13 New York State Environmental Laboratory Approval Program, Certification Manual, October 15, 1999, plus revisions.

16.14 CompuChem Quality Manual, Revision **4**, 12/1**0**/0**3**, plus revisions

16.15 Sample Control SOP 4.1, "Receiving Samples"

16.16 Sample Control SOP 4.6, "Storing Samples"

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.1 Attachment 1 – Method Detection Limit Study

17.2 Attachment 2 – Reagent/Standard/QC Preparation Log

17.3 Attachment 3 – Instrument Maintenance Log

17.4 Attachment 4 – Example Instrument Run Log

17.5 Attachment 5 – Initial Demonstration of Capability

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Attachment 1

Parameter	Method	Study	Rep#1	Rep#2	Rep#3	Rep#4	Rep#5	Rep#6	Rep#7	Rep#8	Mean	Amt.	S.Dev.	MDL	RptLim
(Water/Leachate)	Number	date	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Bromide	300.0/300.1	11/20/2002	0.013	0.015	0.013	0.014	0.016	0.015	0.016	0.013	0.014	0.010	0.0013	0.0039	0.10
Chloride	300.0/300.1	11/20/2002	0.208	0.251	0.246	0.221	0.287	0.357	0.174	0.220	0.246	0.200	0.056	0.17	3.0
Fluoride	300.0/300.1	11/20/2002	0.016	0.016	0.014	0.015	0.014	0.017	0.017	0.015	0.016	0.010	0.00120	0.0036	0.10
Nitrate-N	300.0/300.1	11/20/2002	0.012	0.012	0.012	0.012	0.013	0.012	0.013	0.012	0.012	0.010	0.00046	0.0014	0.050
Nitrite-N	300.0/300.1	11/20/2002	0.014	0.014	0.016	0.014	0.014	0.014	0.014	0.016	0.015	0.010	0.00093	0.0028	0.050
Phosphate-P	300.0/300.1	11/20/2002	0.014	0.010	0.014	0.007	0.013	0.013	0.011	0.013	0.012	0.010	0.0024	0.0072	0.01
Sulfate	300.0/300.1	2/8/02	0.274	0.261	0.261	0.259	0.258	0.260	0.258	0.260	0.261	0.10	0.0052	0.016	5.0

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Attachment 2

Reagent /Standards/QC Preparation for IC Page 1 of 2 File Seq. Number:_____
CompuChem a division of Liberty Analytical Corp. WORKSHEET 1 W(7)

STANDARDS AND REAGENTS TRACEABILITY*	REF#:
Stock A Calibration Standard - Nitrite (50 ppm)	
Stock B Calibration Standard - Fluoride (50 ppm), Bromide (50 ppm), Nitrate (50 ppm), Phosphate, (50 ppm), Chloride (500 ppm), Sulfate (1000 ppm)	
ICV/MS/MSD Stock Standard - Fluoride (500 ppm), Bromide (500 ppm), Nitrate (500 ppm), Nitrite (500 ppm), Phosphate, (500 ppm), Chloride (2000 ppm), Sulfate (2000 ppm)	
Sulfuric acid	
Sodium bicarbonate	
Sodium carbonate	
REAGENT LOT NUMBER**	**PREPARATION INSTRUCTIONS**
Regenerant solution – 0 1 0 8 0 4 – J M	In a 1L volumetric flask partially filled with DI water, add 14 mL of sulfuric acid and dilute to volume.
Eluent stock sodium bicarbonate soln. (100mM) – 0 1 0 8 0 4 – J M	Dissolve 8.40 g of sodium bicarbonate into DI water in a 1 L volumetric flask.
Eluent stock sodium carbonate soln. (100mM) – 0 1 0 8 0 4 – J M	Dissolve 10.60 g of sodium carbonate into DI water in a 1 L volumetric flask.
Eluent working solution – 0 1 0 8 0 4 – J M	Add to 20 mL of stock sodium bicarbonate solution and 26 mL of stock sodium carbonate solution and dilute in a 1 L volumetric flask with DI water.
STANDARD LOT NUMBER**	**PREPARATION INSTRUCTIONS**
ICV Working Standard - Fluoride (2.5 ppm), Bromide (2.5 ppm), Nitrate (2.5 ppm), Nitrite (2.5 ppm), Phosphate, (2.5 ppm), Chloride (20 ppm), Sulfate (20 ppm) – 0 1 0 8 0 4 – J M	Place in a 100-ml volumetric flask: 1 ml of ICV Stock Standard Dilute to the mark with deionized water.
Working Standard A - Fluoride (5 ppm), Bromide (5 ppm), Nitrate (5 ppm), Nitrite (5 ppm), Phosphate, (5 ppm), Chloride (50 ppm), Sulfate (100 ppm) – 0 1 0 8 0 4 – J M	Place in a 200-ml volumetric flask: 20 ml of Stock A & B Calibration Standard Dilute to the mark with deionized water.
CCV/LCS - Fluoride (2.5 ppm), Bromide (2.5 ppm), Nitrate (2.5 ppm), Nitrite (2.5 ppm), Phosphate, (2.5 ppm), Chloride (25 ppm), Sulfate (50 ppm) – 0 1 0 8 0 4 – J M	Place in a 100-ml volumetric flask: 50 ml of Working Standard A Dilute to the mark with deionized water.

Standard Solutions Prepared By: _____ Date: _____

Entered By: _____ Date: _____

Reviewed By: _____ Date: _____

*Ref# = Logbook ID, Page number, and item number from Materials Receipt Log
**Standard Lot Number consists of standard ID, date prepared, and initials of preparer.

12/9/03:dce

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Attachment 2 (Continued)

Reagent /Standards/QC Preparation for IC Page 2 of 2
CompuChem a division of Liberty Analytical Corp. WORKSHEET 1 W(7)

STANDARD LOT NUMBER**	PREPARATION INSTRUCTIONS
Standard 1 - Fluoride (5 ppm), Bromide (5 ppm), Nitrate (5 ppm), Nitrite (2.5 ppm)m Phosphate, (5 ppm), Chloride (50 ppm), Sulfate (100 ppm) – 0 1 0 8 0 4 – J M	Use Working Standard A listed above.
Standard 2 - Fluoride (3 ppm), Bromide (3 ppm), Nitrate (3 ppm), Nitrite (3 ppm), Phosphate, (3 ppm), Chloride (30 ppm), Sulfate (60 ppm) – 0 1 0 8 0 4 – J M	Place in a 50-ml volumetric flask: 3 ml of Stock A & B Calibration Standard Dilute to the mark with deionized water.
Standard 3 - Fluoride (1 ppm), Bromide (1 ppm), Nitrate (1 ppm), Nitrite (1 ppm), Phosphate, (1 ppm), Chloride (10 ppm), Sulfate (20 ppm) – 0 1 0 8 0 4 – J M	Place in a 50-ml volumetric flask: 1 ml of Stock A & B Calibration Standard Dilute to the mark with deionized water.
Standard 4 - Fluoride (0.4 ppm), Bromide (0.4 ppm), Nitrate (0.4 ppm), Nitrite (0.4 ppm), Phosphate, (0.4 ppm), Chloride (4 ppm), Sulfate (8 ppm) – 0 1 0 8 0 4 – J M	Place in a 50-ml volumetric flask: 0.4 ml of Stock A & B Calibration Standard Dilute to the mark with deionized water.
Standard 5 - Fluoride (0.1 ppm), Bromide (0.1 ppm), Nitrate (0.1 ppm), Nitrite (0.1 ppm), Phosphate, (0.1 ppm), Chloride (1 ppm), Sulfate (2 ppm) – 0 1 0 8 0 4 – J M	Place in a 50-ml volumetric flask: 0.1 ml of Stock A & B Calibration Standard Dilute to the mark with deionized water.
Standard 6 - Fluoride (0.05 ppm), Bromide (0.05 ppm), Nitrate (0.05 ppm), Nitrite (0.05 ppm), Phosphate, (0.05 ppm), Chloride (0.5 ppm), Sulfate (1 ppm) – 0 1 0 8 0 4 – J M	Place in a 50-ml volumetric flask: 0.05 ml of Stock A & B Calibration Standard Dilute to the mark with deionized water.
Standard 7 - Fluoride (0.01 ppm), Bromide (0.01 ppm), Nitrate (0.01 ppm), Nitrite (0.01 ppm), Phosphate, (0.01 ppm), Chloride (0.1 ppm), Sulfate (0.2 ppm) – 0 1 0 8 0 4 – J M	Place in a 50-ml volumetric flask: 0.01 ml of Stock A & B Calibration Standard Dilute to the mark with deionized water.

Standard Solutions Prepared By: _____ Date: _____

Entered By: _____ Date: _____

Reviewed By: _____ Date: _____

*Ref# = Logbook ID, Page number, and item number from Materials Receipt Log
**Standard Lot Number consists of standard ID, date prepared, and initials of preparer.

12/9/03:dce

The presence of the Chemist's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist together with the chemist's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

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Attachment 3

CompuChem A division of Liberty Analytical Corp. Logbook 1 U(7) 1

Inorganics Lab Instrument Service: Ion Chromatography

Operator: _____ Page ____ of ____

Date: _____ Time: _____ □AM □PM

Explanation of Problem

Total time instrument down: _____ Job complete? □yes □no

Explanation of corrective action

Reviewed By:_____ Date: _____

11/16/01:dce

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Attachment 4

Lachat IC 5000 RunLog

Case Name(s): P1810 QI1884

CompuChem
A Division of Liberty Analytical Corp.

Analyst: G. Pattison

Method: c:\omnionic\methods\ic5000\5_300a1.met

Date: 1-8-02

Date	Time	Sample Id	File Name	Fluoride	Chloride	Nitrite-N	Bromide	Nitrate-N	Phosphate-P	Sulfate
12/12/01	11:24:30	Standard 1	c:\omnionic\data\cal1212.001	5	50	5	5	5	5	100
12/12/01	11:39:29	Standard 2	c:\omnionic\data\cal1212.002	3	30	3	3	3	3	60
12/12/01	11:54:28	Standard 3	c:\omnionic\data\cal1212.003	1	10	1	1	1	1	20
12/12/01	12:09:26	Standard 4	c:\omnionic\data\cal1212.004	0.4	4	0.4	0.4	0.4	0.4	8
12/12/01	12:24:25	Standard 5	c:\omnionic\data\cal1212.005	0.1	1	0.1	0.1	0.1	0.1	2
12/12/01	12:39:23	Standard 6	c:\omnionic\data\cal1212.006	0.05	0.5	0.05	0.05	0.05	0.05	1
12/12/01	12:54:22	ICV (NO3 PO4)	c:\omnionic\data\cal1212.007	0	46.671	0	0	4.749	1.508	0.155
12/12/01	13:09:20	ICV (CL F SO4)	c:\omnionic\data\cal1212.008	0.861	44.129	0	0	0	0.078	11.667
12/12/01	13:24:18	ICV (NO2 BR)	c:\omnionic\data\cal1212.009	0	0.245	0.171	0.342	0	0	0.186
12/12/01	13:39:16	ICB	c:\omnionic\data\cal1212.010	0	0.255	0.022	0	0	0.026	0.151
12/12/01	13:54:13	CCV	c:\omnionic\data\cal1212.011	2.448	24.517	2.416	2.448	2.384	2.39	52.54
12/12/01	14:09:11	CCB	c:\omnionic\data\cal1212.012	0	0.195	0	0	0	0.043	0.149

Reviewed by: [signature]

Date: 1-09-02

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Attachment 5

Laboratory Name/North Carolina Certificate Number: CompuChem/79					
Analyst: Paul Cvetich					
Method: PO_4-P, Method 300.0/300.1					
Date	Sample ID	Std.Lot #	True Value	mg/l	Recovery
			mg/l		%
11/27/2001	WG14382-4	ICLCS-112601-PC	0.500	0.462	92
11/27/2001	WG14431-4	ICLCS-112601-PC	0.500	0.458	92
11/27/2001	LCSW	ICLCS-112601-PC	0.500	0.434	87
11/27/2001	LCSW	ICLCS-112601-PC	0.500	0.439	88
			Mean	0.45	90
			Std.deviation	0.014	2.8
			% RSD	3.1	3.1

Laboratory Name/North Carolina Certificate Number: CompuChem/79					
Analyst: Paul Cvetich					
Method: Bromide, Method 300.0/300.1					
Date	Sample ID	Std.Lot #	True Value	mg/l	Recovery
			mg/l		%
11/27/2001	WG14382-4	ICLCS-112601-PC	0.500	0.497	99
11/27/2001	WG14431-4	ICLCS-112601-PC	0.500	0.512	102
11/27/2001	LCSW	ICLCS-112601-PC	0.500	0.499	100
11/27/2001	LCSW	ICLCS-112601-PC	0.500	0.512	102
			Mean	0.51	101
			Std.deviation	0.0081	1.6
			% RSD	1.6	1.6

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Attachment 5 (Continued)

Laboratory Name/North Carolina Certificate Number: CompuChem/79					
Analyst: Paul Cvetich					
Method: Nitrate-N, Method 300.0/300.1					
Date	Sample ID	Std.Lot #	True Value	mg/l	Recovery
			mg/l		%
11/27/2001	WG14382-4	ICLCS-112601-PC	0.500	0.508	102
11/27/2001	WG14431-4	ICLCS-112601-PC	0.500	0.522	104
11/27/2001	LCSW	ICLCS-112601-PC	0.500	0.505	101
11/27/2001	LCSW	ICLCS-112601-PC	0.500	0.524	105
			Mean	0.51	103
			Std.deviation	0.0096	1.9
			% RSD	1.9	1.9

Laboratory Name/North Carolina Certificate Number: CompuChem/79					
Analyst: Paul Cvetich					
Method: Nitrite-N, Method 300.0/300.1					
Date	Sample ID	Std.Lot #	True Value	mg/l	Recovery
			mg/l		%
11/27/2001	WG14382-4	ICLCS-112601-PC	0.500	0.456	91
11/27/2001	WG14431-4	ICLCS-112601-PC	0.500	0.466	93
11/27/2001	LCSW	ICLCS-112601-PC	0.500	0.465	93
11/27/2001	LCSW	ICLCS-112601-PC	0.500	0.468	94
			Mean	0.46	93
			Std.deviation	0.0053	1.1
			% RSD	1.1	1.1

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Attachment 5 (Continued)

Laboratory Name/North Carolina Certificate Number: CompuChem/79					
Analyst: Paul Cvetich					
Method: Chloride, Method 300.0/300.1					
Date	Sample ID	Std.Lot #	True Value	mg/l	Recovery
			mg/l		%
11/27/2001	WG14382-4	ICLCS-112601-PC	5.000	4.238	85
11/27/2001	WG14431-4	ICLCS-112601-PC	5.000	4.329	87
11/27/2001	LCSW	ICLCS-112601-PC	5.000	4.351	87
11/27/2001	LCSW	ICLCS-112601-PC	5.000	4.287	86
			Mean	4.30	86
			Std.deviation	0.050	1.0
			% RSD	1.2	1.2

Laboratory Name/North Carolina Certificate Number: CompuChem/79					
Analyst: Paul Cvetich					
Method: Sulfate, Method 300.0/300.1					
Date	Sample ID	Std.Lot #	True Value	mg/l	Recovery
			mg/l		%
11/27/2001	WG14382-4	ICLCS-112601-PC	10.00	9.819	98
11/27/2001	WG14431-4	ICLCS-112601-PC	10.00	9.731	97
11/27/2001	LCSW	ICLCS-112601-PC	10.00	9.888	99
11/27/2001	LCSW	ICLCS-112601-PC	10.00	9.887	99
			Mean	9.83	98
			Std.deviation	0.074	0.74
			% RSD	0.76	0.76

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Attachment 5 (Continued)

Laboratory Name/North Carolina Certificate Number: CompuChem/79					
Analyst: Paul Cvetich					
Method: Fluoride, Method 300.0/300.1					
Date	Sample ID	Std.Lot #	True Value	mg/l	Recovery
			mg/l		%
11/27/2001	WG14382-4	ICLCS-112601-PC	0.500	0.458	92
11/27/2001	WG14431-4	ICLCS-112601-PC	0.500	0.461	92
11/27/2001	LCSW	ICLCS-112601-PC	0.500	0.455	91
11/27/2001	LCSW	ICLCS-112601-PC	0.500	0.457	91
			Mean	0.46	92
			Std.deviation	0.0025	0.50
			% RSD	0.55	0.55

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CompuChem
a division of Liberty Analytical Corporation

501 Madison Avenue
Cary, NC 27513

NELAP accredited

SOP DOCUMENTATION FORM

This form must accompany all new and revised Standard Operating Procedures (SOPs) when you turn them in to Quality Assurance for review. Please fill out the entire block below (except effective date).

This is a new procedure _____ revised procedure __√__ outdated procedure (archive) _____

- Procedure Code: IP 802, 809 SOP Section #: 3.6.2.2 Revision #: 12

SOP Title: Effective date: (QA fills in)

Analysis of Soil Samples for Total Organic Carbon (TOC) by SW-846 And Lloyd Kahn 1/13/03

- Procedure prepared by: Diane C. Ellmore Date: 8/26/02
- Procedure approved by: (If the manager prepared the SOP, a qualified second party should sign) Date: 1-13-03
- Reason for change: Adding Lloyd Khan method requirements
- This procedure meets the requirements of the following approved method references:

New York State Analytical Services Protocol (NYSASP), June 2000, plus revisions; NELAC Standards, June 2000, plus revisions; SW846, 3rd Edition, Update III, Method 9060; Lloyd Khan Method, July 1988

Procedure approved by Quality Assurance Representative: Date:
(Not needed if signed above)

Effective 1-1-96, on an annual basis: Lab managers are required to review lab practices and revise the SOP if necessary. If no revision is necessary, indicate by your signature that the SOP has been reviewed.

Annual Review—Signature: _____ Date: 8·31·05

Annual Review—Signature: _____ Date: _____

Annual Review—Signature: _____ Date: _____

Instrument Procedure 802 **and 809**: Analysis of Soil Samples for Total Organic Carbon (TOC) by SW-846 **and Lloyd Kahn**

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Instrument Procedure 802 **and 809**: Analysis of Soil Samples for Total Organic Carbon (TOC) by SW-846 **and Lloyd Kahn**

1.0 Scope and Application

Soil and sediment samples are analyzed with a Dohrman DC-180 TOC analyzer. The instrument converts any organic carbon to carbon dioxide (CO_2) by catalytic combustion. The carbon dioxide is measured directly with a non-dispersive infrared detector. The instrument is capable of measuring TOC up to the linear limit of 16,000 mg/kg (Table 1).

The current method detection limit (MDL) and reporting limit are shown in Attachment 1. **A reporting limit of 100 mg/Kg is required for the Lloyd Kahn method.**

Staff members performing the procedures described in this SOP are responsible for reading, understanding, and complying with the SOP requirements. Supervisors are responsible for directing the analyst to the controlled SOP, and providing adequate explanation of the material contained therein.

This procedure is restricted to use by or under the supervision of analysts experienced in the instrumentation or preparative methods and who have demonstrated the ability to generate acceptable results through QC samples and analyst capability studies.

2.0 Summary

TOC in soil is composed of a variety of organic compounds in various oxidation states. A high temperature combustion method is used to measure TOC in soil. The sample is acidified to remove inorganic carbon, and introduced to a combustion oven (800°C) where all carbonaceous matter is oxidized to carbon dioxide. The carbon dioxide is bubbled through an acidified liquid and then routed through a mist trap to remove water and scrub out any corrosive species formed. The gas is swept to a linearized non-dispersive infrared detector which is specific for carbon dioxide measurement.

Samples are required to be analyzed in quadruplicate by the method. When run in quadruplicate, both the average and the range are reported. If the client requests otherwise, quadruplicate analyses may not be performed.

3.0 Definitions

3.1 Method detection limit (MDL) – The minimum concentration of an analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR, Part 136, Appendix B.)

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3.2 Reporting Limit – The laboratory reporting limit is based on the lowest multipoint calibration standard concentration. For some inorganic methods, the reporting limit is based on the MDL, and is usually 4-8 times higher than the MDL.

3.3 Reporting Units – mg/Kg

3.4 An SDG is defined by the following, whichever is more frequent:

- each 20 field samples received within a case, or
- each 7 calendar day period during which field samples in a case are received (14 calendar days if requested by the client) beginning with the receipt of the first sample.

NOTE: The Army Corps of Engineers does not accept the SDG approach, unless the samples are prepared in a single batch. When a group of up to 20 field samples of a similar matrix are prepared as one batch, method-specified QC samples such as a method blank, laboratory control sample, matrix spike, matrix spike duplicate, and matrix duplicate must also be prepared together. If samples are batched together from different sites, project-specific QC must be processed.

4.0 Interferences

4.1 The volatiles can be lost during sample blending, particularly if temperature is allowed to rise.

4.2 Avoid contaminated glassware, plastic containers, and rubber tubing.

5.0 Safety

Appropriate protective equipment and clothing must be used under the assumption that all samples are potentially hazardous. Safety glasses, gloves and lab coats are a minimum requirement. The persistent presence of noxious odors may be indicative of failure of the laboratory ventilation system and must be reported to a supervisor or manager.

Laboratory staff are encouraged to review the Chemical Hygiene Plan for general safety policies, and Material Safety Data Sheets for reagents used in the laboratory.

6.0 Equipment & Supplies

6.1 Total organic analyzer--Dohrmann Model DC-180 with boat sampling module or equivalent

6.2 Analytical balance capable of weighing to 0.001g for weighing samples and preparation of standards

6.3 Hamilton syringe, 10 µL or 50 µL

6.4 Glassware – Prepare by handwashing with a non-phosphate biodegradable detergent, then rinsing three times with DI water.

6.4.1 100 ml volumetric flasks

6.4.2 volumetric pipettes

7.0 Reagents & Standards

Record all reference numbers and required information on the QC/Standards Preparation and Traceability for Total Organic Carbon in Soil Logbook (Attachment 2).

7.1 Reagent Water-All water used during preparation should be reagent-grade Type I with regard to resistivity of > 10 megohm-cm (18th and 19th Editions of Standard Methods, Method 1080), and referred throughout this SOP as DI water.

7.2 Carrier gas: purified oxygen, carbon dioxide free, and containing less than 1 ppm hydrocarbon.

7.3 Quartz Wool (Used as soil media for standards and instrument blank)

7.4 Sulfuric acid (20%)-reagent grade – Add 200 ml of concentrated sulfuric acid to one liter of DI water.

7.5 Phosphoric acid – 1:1 by volume solution used for Lloyd Kahn procedure

7.**6** 2,000 ppm Stock Calibration Standard

7.6.1 Potassium hydrogen phthalate (KHP), reagent grade, 2,000 ppm. This aqueous standard is purchased from Tekmar-Dohrman and is used as the primary stock standard.

7.**7** 10,000 ppm Stock Standard

7.**7**.1 Potassium hydrogen phthalate (KHP), reagent grade, 10,000 ppm. A commercially available (through Inorganic Ventures or ERA, for example) second source aqueous standard.

7.**8** 1,000 ppm Continuing Calibration Verification (CCV) Standard

7.**8**.1 The concentration of the **continuing** calibration standard is 1,000 ppm. This standard is prepared by diluting 50 ml of the 2,000 ppm stock standard (section 7.5) in a 100 ml volumetric flask with DI water. Prepare fresh monthly.

7.**9** 100 ppm Low Range (Reporting Limit) Standard (LRS)

7.**9**.1 A 100 ppm standard is prepared by diluting 1.00 mL of the 10,000 ppm stock standard (section 7.6) in a 100 mL volumetric flask with DI water. This low range standard is used to verify the instrument calibration at the reporting limit. Prepare fresh monthly.

7.**10** 1,000 ppm Initial Calibration Verification (ICV) and Laboratory Control Sample (LCS)

7.**10**.1 The concentration of the ICV/LCS is 1,000 ppm. This standard is prepared by diluting 10 ml of the 10,000 ppm stock standard (section 7.6) in a 100 ml volumetric flask with DI water. Prepare fresh monthly.

7.1**1** Matrix Spike

7.1**1**.1 The matrix spike and matrix spike duplicate (MS/MSD) are spiked using the 10,000 ppm stock standard (section 7.6). The initial sample result is obtained. Based upon this result, the sample is then spiked at 1 to 5 times the sample concentration.

8.0 Sample Collection, Preservation, & Storage

8.1 Samples are collected, preserved, and stored according to the tables in Sample Control SOP 4.1, “Receiving Samples” and 4.6, “Storing Samples.” Sample holding times are also listed.

8.2 Soil samples are not preserved. They are refrigerated at 4°C in amber glass containers with TFE lined caps. Samples must be analyzed within 28 days of sampling.

9.0 Quality Control

9.1 The ICV is run immediately after the instrument is calibrated with a separate source KHP standard. Acceptance criteria are ± 10% of the true value.

9.1.1 If the ICV fails, reanalyze. If it still fails, re-calibrate and reanalyze.

9.2 An initial calibration blank (ICB) is run after the ICV. This result must not be greater than the reporting limit. If it falls above the reporting limit, the calibration must be repeated using clean glassware.

9.3 The acceptance criteria for the 100 ppm LRS (reporting limit standard) is +/- 20%. The LRS is analyzed immediately after the ICB.

9.4 The LCS and prep blank (PB) have the same acceptance criteria as the ICV/ICB.

9.5 A CCV/CCB are run after every 10 samples and at the end of the sequence. Acceptance criteria are the same as the ICV/ICB. If the CCV or CCB fails, the previous 10 samples must be reanalyzed.

9.6 Analyze a MS/MSD every 20 samples. Acceptance criteria for sample spikes are a recovery between 75 and 125% and a relative percent difference of $\leq$ 20%. If the sample spike acceptance criteria are not met and the blank spike recovery is acceptable, a sample matrix effect is indicated and the batch is in control. In these instances of confirmed matrix interference, the results are reported and qualified.

10.0 Calibration & Standardization

10.1 Instrument calibration consists of a single point standard and a blank per the manufacturer specifications.

10.1.1 From the Main Menu, select “CALIBRATION MODE” by pressing [2] followed by [4]. To enter the ID number press [2], [2], [6], then hit [YES].

10.1.2 Verify that the “SYRINGE CALIBRATION MODE” shows a value other than zero. "7.8E-02" is usually displayed here.

10.1.3 Select “PRINT CALIBRATION FACTORS” by pressing [9] to make a hard copy of the current calibration factors in case the factor for the syringe mode is needed later in the process.

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10.1.4 From the "ANALYSIS MODES" menu press [+/-] then [2] and finally [3], then select "SYRINGE MODE."

10.1.5 Answer "YES" to the question "BOAT INLET (Y/N)?"

10.1.6 Position the sample boat under the septum injection port and place quartz wool into the sample boat.

10.1.7 Inject 40 µl of the 2,000 ppm calibration standard (section 7.5) onto the quartz wool.

10.1.8 Press "RUN." Enter the ID number, then enter the mg weight (40 µl of aqueous KHP standard is equivalent to 40 mg weight); then press "ENTER."

10.1.9 Slowly push the boat into the combustion tube during the period "INJECT NOW."

10.1.10 When the run is complete, pull out the boat and position it under the hatch port for cooling down to room temperature about one minute.

10.1.11 When the integration is completed answer "YES" to the question "CONTINUE (Y/N)?" Enter the mg weight, then repeat steps 10.1.7, 10.1.8, and 10.1.9.

10.1.12 After triplicate injections of the same standard have been completed and results are reproducible (within ± 2%), answer "NO" to the question "CONTINUE (Y/N)?" to obtain the statistics (average and standard deviation). The instrument calculates the statistics and displays the results.

10.1.13 If the percent standard deviation is not within 2%, check for error and troubleshoot the instrument, then repeat steps 10.1.7-10.1.8.

10.1.14 When a passing calibration is obtained, from the "CALIBRATION MODES" menu select [+/-] then [2] and [4] in order. Select "UPDATE CALIBRATION" by pressing [5].

10.1.15 Enter the standard concentration used, then press "ENTER." Observe that a new CAL factor for the syringe mode (boat inlet) is updated. Press"9" to print out the updated calibration factors.

10.2 Pipette Calibration

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10.2.1 Ensure pipettes have been calibrated at the required frequency before use according to Inorganics SOP 9.1, "Calibrating Automatic Pipettes in the Inorganics Laboratory."

10.3 Balance Calibration

10.3.1 Ensure the balance has been calibrated for the day prior to use following Quality Control SOP 13.17, "Analytical Balance Calibration and Maintenance."

11.0 Procedure

Documentation must follow the requirements in QC SOP: Proper Documentation Procedures. Record all information on the Total Organic Carbon **logbook (Attachment 2).**

11.1 Discard any foreign objects such as sticks, stones, and leaves. Thoroughly mix the sample, reducing any clumps, with a metal spatula in a plastic weighing boat to create a homogeneous, representative sample.

11.2 Complete the calibration procedure. Remove the sample boat add a tuft of quartz wool, then place it on the analytical balance. Tare the balance and transfer 10 to 40 mg of soil sample to the boat.

11.3 Add one drop of 20% sulfuric acid to the top of the sample in the boat. **For Lloyd Kahn samples, add 1:1 phosphoric acid.** Allow the sample to stand at room temperature for 3-5 minutes or until effervescence ceases.

11.4 Place the sample boat into the hatch port. Close the hatch, and allow the detector baseline to stabilize. Press "RUN." Enter the sample ID, press "ENTER." Enter the sample weight in mg, and press "ENTER."

11.5 Slowly push the boat into the combustion tube during the period "INJECT NOW." When the run is complete, pull out the boat and position it under the hatch port.

11.6 After completion of the integration, press "NO" for the next sample. If the samples are required to be analyzed in quadruplicate (quad) method, press "YES" to continue and repeat steps 11.2 through 11.6. **One in twenty Lloyd Kahn samples are performed in quad.**
A RSD of 20% must be achieved for quad samples or the analysis must be repeated.

11.7 Instrument Linear Range

11.7.1 Linear range is a function of the detector electronics and sample size. The concentrations of a sample may not be higher than the concentrations shown in Table 1 for each sample weight.

Table 1: Sample Size and Maximum Concentration for Linear Range

Sample Size (mg)	Dynamic Linear Range Concentration in ppm
5	16,000
10	8,000
20	4,000
40	2,000

11.7.2 For example, if a 20 mg sample has a concentration above 4,000 ppm, the sample should be analyzed at a lower weight.

If the concentration of a soil sample exceeds 16,000 ppm with a 5 mg sample weight, or whenever the detector panel meter needle goes past 100% deflection, then the sample result may be non-linear and is invalid. When this occurs, report the result as >16,000 ppm and insert the appropriate QA Notice.

If the sample needs to be anayzed at a weight less than 10 mg, silica gel should be added to the sample to bring it to a weight of 10 mg.

11.7.2.1 Calculating Dilutions

- Determine a level of dilution that will result in a value within the upper half of the calibration range. This is an acceptable dilution.

- For example, 7.0 mg silica gel mixed with 2.9 mg sample yields a dilution factor of 3.41. A 10 mg aliquot of this mixture is transferred to the boat. It should be recorded on the run log as "3.41x (7.0 mg silica gel + 2.9 mg sample)."

12.0 Data Analysis & Calculations

Calculations must be consistent with the QC SOP: Numerical Data Reduction.

12.1 The DC-180 TOC Analyzer automatically calculates the concentration of organic carbon. When carbon is detected, an electronic peak is generated and sent to the DC-180's computer where its area is calculated. The amount of carbon in the sample is determined by comparing the peak area obtained for the sample to the peak area established for the 2000 ppm standard. A 40 µl aliquot of 2000 ppm potassium hydrogen phthalate calibration standard, and the peak area stored in memory for that standard, corresponds to 80 µg of carbon.

Remembering that ppm = ng/µl = µg/ml = mg/L,

(40 µl) x (2000 ng/µl) = 80,000 ng = 80 µg Carbon

$$\text{Thus, } 2000 \text{ ng/µl} = \frac{80{,}000 \text{ ng of Carbon}}{40 \text{ µl}} = 2000 \text{ ppm}$$

12.2 When calculating the concentration of a soil sample, volume in the above equation is substituted by weight as shown below:

Remembering that ppm = ng/mg = ug/g = mg/kg

(40 mg) x (2000 ng/mg) = 80,000 ng = 80 ug

$$\text{Thus, } 2000 \text{ ng/mg} = 2000 \text{ ppm} = \frac{80{,}000 \text{ ng}}{40 \text{ mg}}$$

These calculations take place within the DC-180 TOC analyzer so that only the final result in ppm is printed out on the display and output printer.

12.3 The concentration of TOC in soil is determined using the following equation:

$$\text{C of TOC} = \frac{\text{peak area of sample}}{\text{peak area from calibration}} * \text{C of standard}$$

where: C = concentration in mg/kg

12.4 Calculation of the mean or average of a set of values:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where: n = total number of values
x_i = each individual value used to calculate the mean
x = the mean of n

12.5 Calculation of the standard deviation of a set of values:

$$Standard\ deviation = \sqrt{\frac{\sum_{i=1}^{n}\left(X_n - \overline{X}\right)^2}{n-1}}$$

12.6 Calculation of percent recovery:

12.6.1 LCS:

$$\%R = \frac{Amount\ \ found}{Amount\ spiked}\ x\ 100$$

12.6.2 Matrix spikes:

$$\%\ R = \frac{Amount\ in\ spiked\ \ sample\ -\ Amount\ in\ unspiked\ (native)\ sample}{Amount\ spiked}\ x\ 100$$

12.7 Calculation of % RSD

$$\%RSD = \left(\frac{Standard\ deviation}{\overline{X}}\right)\ \times\ 100$$

12.8 Calculation of RPD

$$RPD\ =\ \frac{|Value\ 1\ -\ Value\ 2|}{\left(Value\ 1\ +\ Value\ 2\right)/2}\ x100$$

13.0 Method Performance

This method was validated through in-house laboratory studies of method detection limits (Attachment 1) and precision and accuracy for single analyst (Attachment **3**). The data are retained by the QA department.

14.0 Pollution Prevention

The solvents used in this procedure pose little threat to the environment when recycled and managed properly. 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 thing.

15.0 Waste Management

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Samples preserved with H_2SO_4 to pH <2 are hazardous and must be neutralized before being disposed, or must be handled as hazardous waste.

Refer to the Hazardous Waste Management and Safety SOPs located in the lab.

16.0 References

16.1 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846; 3rd Edition, 9/86, Method 9060, modified for soils, based on the Dohrman Operator's Manual "Boat Sampling" section.

16.2 New York State Analytical Services Protocol (NYSASP), June 2000, plus revisions

16.3 QCSOP: Proper Documentation Procedures

16.4 QCSOP: Numerical Data Reduction

16.5 "Less is Better: Laboratory Chemical Management for Waste Reduction," American Chemical Society Department of Government Relations and Science Policy, 1155 16th Street, N.W., Washington DC, 20036, (202) 872-4477.

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16.6 Hazardous Waste Management & Safety SOPs: "Hazardous Waste Disposal" and "Spill Control & Cleanup."

16.7 NELAC Standards, **June 2000** , plus revisions

16.8 QA-G6: Guidance for the Preparation of Standard Operating Procedures for Quality-Related Operations EPA/600/R-96/027, November 1995.

16.9 New York State Environmental Laboratory Approval Program, Certification Manual, October 15, 1999, plus revisions.

16.10 CompuChem Quality Manual, Revision **3**, 1**2**/**19**/0**2**, plus revisions

16.11 Inorganics SOP 9.1, "Calibrating Automatic Pipettes in the Inorganics Laboratory."

16.12 Sample Control SOP 4.1, "Receiving Samples" and 4.6, "Storing Samples."

16.13 Quality Control SOP 13.17, "Analytical Balance Calibration and Maintenance."

16.14 Lloyd Kahn Method, "Determination of Total Organic Carbon in Sediment," July 1988, modified for soils

17.0 Attachments as Tables, Diagrams, Flowcharts & Validation Data

17.1 Attachment 1 - Method Detection Limit (MDL) Study

17.2 Attachment 2 –Total Organic Carbon – Sample Prep & Analysis Log – Soil

17.3 Attachment 3 – Single Analyst Capability Study

Attachment 1

Parameter	Method	Study	Rep#1	Rep#2	Rep#3	Rep#4	Rep#5	Rep#6	Rep#7	Rep#8	Rep#9	Mean	Amt.	S.Dev.	MDL	Report
(in Waste/Soil)	Number	date	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	Limit
																mg/kg
TOC	9060	2/7/02	148	152	166	142	153	143	144	*	NA	150	100	8.48	27	100

Attachment 2

CompuChem a division of Liberty Analytical Corp. Logbook 6 FF 2

TOTAL ORGANIC CARBON- Sample Prep & Analysis Log - Soil

Method: 9060 or Lloyd Khan (Circle one) **Page _____ of _____**

Analyst: _____ **Date:** _____ **SDGs:** _____

Standards / Reagents	Preparation Instructions / Reference Numbers
2,000 ppm TOC Stock Calibration Std. (primary source)	Ref #:
10,000 ppm TOC Stock Std. & MS/MSD Std. (second source)	Ref #:
20% Sulfuric Acid (9060 only)	Ref #:
1:1 Phosphoric Acid (Lloyd Khan only)	Ref #:
1,000 ppm CCV - ___ ___ ___ ___ ___ ___ - ___ ___	50 ml of 2,000 ppm stock into a 100 ml volumetric flask. Dilute to mark with DI water. Made fresh monthly.
1,000 ppm ICV & LCS - ___ ___ ___ ___ ___ ___ - ___ ___	10 ml of 10,000 ppm stock into a 100 ml volumetric flask. Dilute to mark with DI water. Made fresh monthly.
100 ppm LRS - ___ ___ ___ ___ ___ ___ - ___ ___	1 ml of 10,000 ppm stock into a 100 ml volumetric flask. Dilute to mark with DI water. Made fresh monthly.

	CCN	Vol mg	Instrument Reading / (Result mg/Kg)	Dilution	Corrected Conc. (mg/Kg)*	Comments / Acceptance Criteria
	2000 mg/Kg	Calibration % Std Dev = _____ (Acceptance range = ±2%)				
	2000 mg/Kg					
	2000 mg/Kg					
	ICV, TV=1000 mg/Kg					**±10%**
	ICB					**<100 mg/Kg**
	LRS, TV=100 mg/Kg					**±20%**
1	PB					**<100 mg/Kg**
2	LCS, TV=1000 mg/Kg					**±10%**
3						
4						
5						
6						
7						
8						
9						
10						
	CCV, TV=1000 mg/Kg					**±10%**
	CCB					**<100 mg/Kg**
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
	CCV, TV=1000 mg/Kg					**±10%**
	CCB					**<100 mg/Kg**

***Quad results are the average of four instrument readings. The Corrected Conc. column remains blank unless the Quad analysis or a dilution is performed.**

Reviewed By: _____ **Date:** _____

The presence of the Chemist's employee ID number, or signature, on this run log attests that strict compliance with the method's SOP has occurred. Any SOP deviations require documentation by the responsible chemist together with the chemist's initials and the initials of the lab supervisor and a QA department representative, signifying approval of the deviation.

7/11/02:dce

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Attachment 3

Analyst Capability Study

Laboratory Name/North Carolina Certificate Number: CompuChem/79					
Analyst: Jenny Smith					
Method: TOC, Method 9060					
Date	Sample ID	Std.Lot #	True Value mg/L	mg/L	Recovery %
9/4/2001	WG12505-4	SC01025	10000	9520	95.20
9/5/2001	WG12505-6	SC01025	10000	9250	92.50
9/6/2001	WG12505-8	SC01025	10000	10000	100.00
9/7/2001	WG12505-10	SC01025	10000	9440	94.40
			Mean	9553	
			Std.deviatio	319	
			% RSD	3.3	

CATION EXCHANGE CAPACITY BY SW-846 METHOD 9081

1.0 SCOPE AND APPLICATION

1.1 Method 9081 is applicable to most soils, including calcareous and noncalcareous soils. The method of cation-exchange capacity by summation (Chapman, 1965, p. 900; see Paragraph 10.1) should be employed for distinctly acid soils.

2.0 SUMMARY OF PROCEDURE

2.1 The soil sample is mixed with an excess of sodium acetate solution, resulting in an exchange of the added sodium cations for the matrix cations. Subsequently, the sample is washed with isopropyl alcohol. An ammonium acetate solution is then added, which replaces the adsorbed sodium with ammonium. The concentration of displaced sodium is then determined by ICAP 61E.

3.0 INTERFERENCES

3.1 Interferences can occur during analysis of the extract for sodium content. Thoroughly investigate the chosen analytical method for potential interferences.

4.0 APPARATUS AND MATERIALS

4.1 VOA Vial: 45-mL

4.2 Rotary TCLP Extractor

4.3 Volumetric flask: 100-mL

4.4 Centrifuge

4.5 Pan Balance #2, capable of weighing 0.01g

4.5.1 The balance is checked for calibration according to Procedure # 09-QS-0010.I

4.6 Graduated Cylinders

5.0 REAGENTS

5.1 Sodium acetate (NaOAc), 1.0 N: Dissolve 136 g of NaOAc in water and dilute it to 1,000 mL. The pH of this solution should be 8.2. If needed, add a few drops of acetic acid or NaOH solution to bring the reaction of the solution to pH 8.2.

5.2 Ammonium acetate (NH_4OAc), 1 N: Dilute 114 mL of glacial acetic acid (99.5%) with water to a volume of approximately 1 liter. Then add 138 mL of concentrated ammonium hydroxide (NH_4OH) and add water to obtain a volume of about 1,980 mL. Check the pH of the resulting solution, add more NH_4OH, as needed, to obtain a pH of 7, and dilute the solution to a volume of 2 liters with water.

5.3 Reagent water. All references to water in this method refer to reagent water, as defined in Chapter One of EPA SW-846.

5.4 Isopropyl alcohol: 99%. ACS Grade. Available from Fisher or VWR.

6.0 SAMPLE COLLECTION, PRESERVATION AND HANDLING

6.1 All samples must be collected using a sampling plan that addresses the considerations discussed in EPA SW-846 Chapter 13.

6.2 Samples should be collected in plastic or glass containers. All containers must be thoroughly cleaned and rinsed.

7.0 PROCEDURE

7.1 Weigh 4 g of medium- or fine-textured soil or 6 g of coarse-textured soil and transfer the sample to a 45-ml VOA vial. (A fine soil has >50% of the particles <0.074 mm, medium soil has >50% >0.425 mm, while a coarse soil has more than 50% of its particles >2 mm.

7.2 Add 33 mL of 1.0 N NaOAc solution, cap the vial, rotate in the TCLP extractor for 20 minutes, and centrifuge it until the supernatant liquid is clear.

7.3 Decant the liquid, and repeat Paragraph 7.2 three more times.

7.4 Add 33 mL of 99% isopropyl alcohol, cap the vial, rotate in the TCLP extractor for 20 minutes, and centrifuge it until the supernatant liquid is clear.

7.5 Repeat the procedure described in Paragraph 7.4 two more times.

7.6 Add 33 mL of NH_4OAc solution, cap the vial, rotate in the TCLP extractor for 20 minutes, and centrifuge it until the supernatant liquid is clear. Decant the washing into a 100-mL volumetric flask.

7.7 Repeat the procedure described in Paragraph 7.6 two more times.
7.8 Dilute the combined washing to the 100-mL mark with ammonium acetate solution and determine the sodium concentration by following the SOPs for EPA Method 3010 and EPA Method 6010B.

8.0 QUALITY CONTROL

8.1 Each person using this procedure is required to comply with the formal quality control program specified by AAL. The minimum requirements of this program consist of an initial demonstration of capability, and the periodic analysis of laboratory reagent blanks, fortified blanks and other laboratory solutions as a continuing check on performance. The laboratory, through the analyst, is required to maintain performance records that define the quality of the data that are generated.

8.1.1 Method blank. Reagent blank analysis must be performed at the following frequency: Every twenty (20) samples of similar concentration and/or sample matrix or whenever samples are extracted and analyzed by the same procedure at same time, whichever is more frequent. The concentration of the method blank of any analyte of interest should not exceed the laboratory established practical quantitation limit (PQL).

8.1.2 Method Duplicate (MD). A second aliquot of the sample shall be taken through the entire analytical process. RPD will be calculated and compared to laboratory generated control limits.

8.1.3 Out of control situations must be documented in the appropriate Quality Non Conformance (QNF) form. See the appropriate SOP for completion of this form. Appendix A contains a copy of this form.

9.0 HEALTH AND SAFETY REQUIREMENTS

9.1 Health and Safety: Safety glasses and latex type gloves must be worn at all times when dealing with any chemicals, samples, or reagents. A lab coat is also highly recommended. Close-toed shoes and clothing that covers the legs (no shorts or dresses) must be worn at all times an analyst is working in the laboratory.

9.2 The toxicity or carcinogenicity of each reagent used in this method has not been fully established. Each chemical should be regarded as a health hazard and exposure should be as low as reasonably possible. All health and safety concerns for these and any other

chemicals are listed in the Material Safety Data Sheets (MSDS) provided by the supplier or manufacturer of these chemicals. A copy of any MSDS is available for review at any time.

10.0 DATA REPORTING

10.1 Report results to two significant digits. For example, if the result is less than 1, report the result as “0.08”.

10.2 When taking duplicate measurements, average the two readings

10.3 The estimated RL for this test method is 0.5 meq/100g.. Periodically, this limit is updated. See Appendix E and F for the MDL values for Water and Soil.

11.0 FILE MAINTENANCE

11.0 Data from this test is stored in logbooks. When the logbooks are complete, they are returned to the QA Manager. The Initial Calibration Verification, the analysis log book for waters and soils are given in Appendix B, Appendix C and Appendix D respectively.

11.1 The QA Manager “retires” the logbook and issues new ones.

11.2Data is entered into LIMS by the analyst performing the work

12.0 INSTRUMENT MAINTENANCE

12.1 Instrument logbooks. Instrument logbooks must be completed each time that any maintenance is performed upon the instrument.

Each instrument logbook must have a cover page that includes the following information.

Equipment name. Example: GC-5
Manufacturers name. Example: Hewlett Packard 6890 GC
Serial Number. Example: 13226589A
Date Received. Example: 11/01/00
Date Placed into Service. Example: 11/05/00

12.2 Routine Maintenance: Typical routine maintenance consists of keeping the system clean.

12.3 Non-routine maintenance: Typical non-routine maintenance consists of replacement of circuit boards and or replacement of photomultiplier tubes on the spectrophotometer.

13.0 METHOD PERFORMANCE

13.1 The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The reporting limit RL is defined as the concentration of a substance that is above the level of uncertainty. Due to the nature of this analysis, no MDL study can be performed.

14.0 POLLUTION MANAGEMENT

14.1 All laboratory analysis generates wastes. Some wastes can be hazardous such as acidic wastes, alkaline wastes, cyanide wastes, metal-bearing wastes, and organic wastes.

14.2 Some wastes are generated because of the test procedure such as organic extractions and acid digestions.

14.3 The following procedures should be adhered to when disposing of hazardous wastes.

14.1.1. Wastes with pH levels above 12 or less than 4 should be neutralized prior to disposal.

14.1.2. Wastes with other pH levels may be directly discharged into the sinks.

14.1.3 Cyanides must be destroyed by chlorination prior to disposal.

14.4 When disposing of laboratory wastes, the waste disposal log must be completed. To complete this log, supply the following information.

Sample Number
Method of disposal and treatment prior to disposal
Date of sample disposal
Name of person performing the disposal duty

15.0 DEFINITIONS

15.1 Primary Grade –A dry chemical that has been dried at 250°C for 4 hours cooled and stored in a desiccator.

15.2 LCS - Laboratory Control Sample. A known amount of sought for analyte is added to distilled water or clean soil and the concentration is measured after all procedures are applied to the sample. The resulting determined concentration must fall within test specified limits.

15.3 DI water- Deionized water

15.4 RSD – Relative Standard Deviation

15.5 MS- Matrix Spike. Procedure where a known amount of sought for analyte is added to a sample and the resulting concentration measured. The recovery is defined as the measured result of the spiked sample less the concentration of the same analyte in the unspiked sample multiplied by 100 percent.

15.6 MSD- Matrix Spike Duplicate.

15.7 CCV - Continuing calibration verification standard. Must be varied throughout the daily runs, that is the concentration must be low, middle, and sometimes at the upper end of the calibration curve.

15.8 ICV – Initial calibration verification standard. This standard must be prepared from a second source than that used for the calibration curve. That is, it must be from a different manufacturer or lot that the calibration standard.

15.9 LCSD - Laboratory Check Sample Duplicate

15.10 <CR> - Carriage return key

15.11 Cyanide - cyanide ion and complex cyanides converted to hydrocyanic acid (HCN) by. evolution in a reflux system of a mineral acid in the presence of magnesium ion

16.0 REFERENCES

16.14 Test Methods for the Evaluating Solid Waste, Physical Chemical Methods, April 1998, Method 9081, “CATION-EXCHANGE CAPACITY OF SOILS (SODIUM ACETATE)”.

Appendix A
Laboratory Quality Communication Form

	Accura Analytical Laboratory, Inc. *Environmental Analytical Services* 6017 Financial Drive Norcross, GA 30071	Laboratory Quality Communication Form Document No.: 14-QS-005.F Revision/Date : No. 00/Effective: 02/01/01 Page No.: 1 of 1

[ ] Departmental Corrective Action [ ] Quality Notice [ ] Temporary Method Deviation
Notice

Tracking Number:

Reported By: Date Reported:

Department: Metals Proj #(s): Case No.: SDG:
Analysis:

Discrepancy:

Resolution Assigned to (circle one): Migdalia Alvarado John Amirtham David Fuller Anthony Gatch
Duane Johnson John Peterson Camden Robinson Shaker Reddy Michael Trinidad

Resolution:

Resolution recorded by: _____ Date: _____

Copied to (circle one): David Fuller Anthony Gatch Michael Trinidad Shaker Reddy

QA Comments:

QA Review by: _____ Date: _____

OXIDATION-REDUCTION POTENTIAL BY ASTM METHOD 1498

1.0 SCOPE AND APPLICATION

1.1 This procedure covers the apparatus and procedure for the electrometric measurement of oxidation-reduction potential (ORP) in waters or a slurry of soil matrices.

2.0 SUMMARY OF PROCEDURE

2.1 This procedure is designed to measure the ORP which is defined as the electromotive force between a noble metal electrode and a reference electrode when immersed in a solution. The ORP electrodes are inert and measure the ratio of the activities of the oxidized to the reduced species in the process reactions.

2.2 For aqueous solutions, the electrodes are placed into the solution and a direct measurement is obtained. For soils, a slurry of the soil sample mixed in a 1:1 ratio with DI water is made, with a direct reading taken from the electrodes once placed in the slurry.

3.0 INTERFERENCES

3.1 The ORP electrodes are generally not subject to solution interference from color, turbidity, colloidal matter, and suspended matter.

4.0 APPARATUS AND MATERIALS

4.1 pH meter, capable of reading in mV.

4.2 Reference electrode, a silver-silver chloride, with a constant potential.

4.3 Oxidation-Reduction electrode, a noble metal electrode, typically a platinum electrode.

4.4 Magnetic stirrer and stir bars.

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. These are purchased from an approved vendor such as VWR Scientific or Fisher Scientific. Laboratory personnel should monitor the expiration dates of all reagents and dispose of any that have expired.

5.2 Deionized (DI) water, analyzed before use to ensure no interferences are present. Made by passing tap water through ion exchange tanks, monitored and

maintenanced by U.S. Filter Water Systems.

5.3 1N NaOH, add 40g of NaOH pellets to 1L DI water.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 Samples should be analyzed as soon as possible after collection.

7.0 PROCEDURE

7.1 Allow the meter to warm up thoroughly, at least 2-3 hours.

7.2 Verify the sensitivity of the electrodes by noting the change in mV reading when the test solution is altered. The ORP will increase when the pH of the test solution decreases and the ORP will decrease if the test solution pH is increased. Place the sample in a clean glass beaker and agitate the sample. Insert the electrodes and note the ORP or mV reading. Add a small amount of 1N NaOH and note the value of the ORP. If the ORP does not respond as above when the caustic is added, the electrodes should be cleaned and the above procedure repeated.

7.3 Waters and aqueous solutions:

7.3.1 After the meter has been checked for sensitivity, wash the electrodes with DI water.

7.3.2 Place the sample in a clean, glass beaker and insert the electrodes.

7.3.3 Insert a magnetic stir bar and place on the stirrer to agitate the sample while obtaining the reading.

7.3.4 Measure successive portions of the sample until two successive portions differ by no more than 10mV.

8.0 QUALITY CONTROL

8.1 Each person using this procedure is required to comply with the formal quality control program specified by AAL. The minimum requirements of this program consist of an initial demonstration of capability, and the periodic analysis of laboratory reagent blanks, fortified blanks, and other laboratory solutions as a continuing check on performance. The laboratory, through the analyst, is required to maintain performance records that define the quality of the data that are generated. Detailed quality assurance procedures can be found in SOP# QA-01000, “Quality Assurance Manual,” Section 5. Subsequent sections define portions of the quality control program.

8.1.1 A Method Blank (MB) is not practical for this analysis. In that regard, the MB is not required.

8.1.2 A Laboratory Control Spike (LCS) is not practical for this analysis. In that regard, the LCS is not required.

8.1.3 A sample duplicate (Dup) must be analyzed with every batch. The RPD for the two samples must be within the guidelines specified in the Quality Assurance Manual.

8.2 Out of control situations must be documented in the appropriate Quality Non Conformance (QNF) form. See the appropriate SOP for completion of this form. Appendix A contains a copy of this form.

8.3 Documentation of data. Document and record all analytical sequence, standard preparation, instrument maintenance, and any procedural deviations in appropriate logbooks.

8.4 Initial demonstration of capability. An initial demonstration of capability is not practical with this analysis.

9.0 HEALTH AND SAFETY REQUIREMENTS

9.1 Health and Safety: Safety glasses and latex type gloves must be worn at all times when dealing with any chemicals, samples, or reagents. A lab coat is also highly recommended. Close-toed shoes and clothing that covers the legs (no shorts or dresses) must be worn at all times an analyst is working in the laboratory.

9.2 All health and safety concerns for any chemicals are listed in the Material Safety Data Sheets (MSDS) provided by the supplier or manufacturer of these chemicals. A copy of any MSDS is available for review at any time.

9.3 Proper disposal of all wastes is essential. Containers are provided for all waste according to the type. The waste disposal SOP discusses the disposal of various laboratory wastes in detail.

10.0 DATA REPORTING

10.1 Report results to three significant digits. For example, if the result is less than 10, report the result as “9.90”.

10.2 When taking duplicate measurements, report both in Xenco. It will average the two and determine the RPD.

10.3 Current MDLs for all parameters may be found in Section 5 of SOP# QA-01000, “Quality Assurance Manual”.

10.4 As per NELAC Chapter 5, Appendix D.1.4.(a), a detection limit study is not required for any component for which spiking solutions or quality control samples are not available.

11.0 FILE MAINTENANCE

11.1 Data from this test is stored in logbooks. When the logbooks are complete, they are stored in banker boxes for 5 years.

11.2 New logbooks are either created or retired through the QA Manager. Copy of the pH calibration and run logbook are given in Appendix B and Appendix C respectively.

11.3 Data is entered into the LIMS by the analyst performing the work

12.0 INSTRUMENT MAINTENANCE

12.1 Instrument logbooks. Instrument logbooks must be completed each time that any maintenance is performed upon the instrument.

12.2 Each instrument logbook must have a cover page that includes the following information.

Equipment name.	Example: GC-5
Manufacturers name.	Example: Hewlett Packard 6890 GC
Serial Number.	Example: 13226589A
Date Received.	Example: 11/01/00
Date Placed into Service.	Example: 11/05/00

12.3 Routine Maintenance: Typical routine maintenance consists of keeping the system clean.

12.4 Non-routine maintenance: Typical non-routine maintenance consists of repair to the drying oven.

13.0 METHOD PERFORMANCE

13.1 The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The reporting limit RL is defined as the concentration of a substance that is above the level of uncertainty. The concentrations listed in the table in Section VIII were obtained using reagent water. Similar results can be achieved using representative wastewaters. The MDL actually achieved is a given analysis will vary depending on instrument sensitivity and matrix effects.

13.2 Forty four analysts in twenty laboratories analyzed six synthetic water samples containing exact increments of hydrogen hydroxyl ions, with the following results.

pH Units	Standard Deviation pH Units	Accuracy as Bias %	Accuracy as Bias pH Units
3.5	0.10	-0.29	-0.01
3.5	0.11	-0.00	

7.1	0.20	+1.01	+0.07
7.2	0.18	-0.03	-0.002
8.0	0.13	-0.12	-0.01
8.0	0.12	+0.16	+0.01

13.3 In a single laboratory using surface water samples at an average pH of 7.7, the standard deviation was 0.1.

14.0 POLLUTION MANAGEMENT

14.1 All laboratory analysis generates wastes. Some wastes can be hazardous such as acidic wastes, alkaline wastes, metal bearing wastes, and organic wastes.

14.2 Some wastes are generated because of the test procedure such as organic extractions and acid digestions.

14.3 The following procedures should be adhered to when disposing of hazardous wastes.

14.1.1. Wastes with pH levels above 12 or less than 4 should be neutralized prior to disposal.
14.1.2. Wastes with other pH levels may be directly discharged into the sinks.

14.1.3. SOP Waste Disposal and SOP Sample Receiving further discuss methods for disposal of samples and waste materials.

14.4 When disposing of laboratory wastes, the waste disposal log must be completed. To complete this log, supply the following information.

Sample Number
Method of disposal and treatment prior to disposal
Date of sample disposal
Name of person performing the disposal duty

15.0 DEFINITIONS

15.1 Primary Grade –A dry chemical that has been dried at 250°C for 4 hours cooled and stored in a desiccator.

15.2 LCS - Laboratory Control Check Standard. A known amount of sought for analyte is added to distilled water or clean soil and the concentration is measured after all procedures are applied to the sample. The resulting determined concentration must fall within test specified limits.

15.3 DI water- Deionized water

15.4 RSD – Relative Standard Deviation

15.5 MS- Matrix Spike. Procedure where a known amount of sought for analyte is added to a sample and the resulting concentration measured. The recovery is defined as the measured result of the spiked sample less the concentration of the same analyte in the unspiked sample multiplied by 100 percent.

15.6 MSD- Matrix Spike Duplicate.

15.7 CCV - Continuing calibration verification standard. Must be varied throughout the daily runs, that is the concentration must be low, middle, and sometimes at the upper end of the calibration curve.

15.8 ICV – Initial calibration verification standard. This standard must be prepared from a second source than that used for the calibration curve. That is, it must be from a different manufacturer or lot that the calibration standard.

15.9 LCSD - Laboratory Check Standard Duplicate

15.10 <CR> - Carriage return key

16.0 REFERENCES

16.1 ORION Expandable Ionanalyzer Instruction Manual, 1989.

16.2.1 ASTM procedure “Standard Practice for Oxidation-Reduction Potential of Water” Method Number D 1498-93.

Appendix A
Laboratory Quality Communication Form

	Accura Analytical Laboratory, Inc. *Environmental Analytical Services* 6017 Financial Drive Norcross, GA 30071	Laboratory Quality Communication Form Document No.: 14-QS-005.F Revision/Date : No. 00/Effective: 02/01/01 Page No.: 1 of 1

[ ] Departmental Corrective Action [ ] Quality Notice [ ] Temporary Method Deviation Notice

Tracking Number:

REPORTED BY: DATE REPORTED:

DEPARTMENT: METALS PROJ #(S): CASE NO.: SDG: ANALYSIS:

Discrepancy:

Resolution Assigned to (circle one): Migdalia Alvarado John Amirtham David Fuller Anthony Gatch John Peterson Camden Robinson Shaker Reddy Michael Trinidad

Resolution:

Resolution recorded by: _____ Date: _____

Copied to (circle one): David Fuller Anthony Gatch Michael Trinidad Shaker Reddy

QA Comments:

QA Review by: _____ Date: _____

Appendix B

ACCURA ANALYTICAL LABORATORY, INC.

Environmental Analytical Services

DAILY CALIBRATION OF pH METER AND CONDUCTIVITY METER
Daily Reading of pH and Conductivity of DI Water

Lot #'s:

pH 7.00 Standard:_____
pH 4.00 Standard:_____
pH 10.00 Standard:_____
Check Std must be ± 0.1 of true value or restandardize

1000uMHOS/cm Cond. Std.:_____
100uMHOS/cm Cond. Std.:_____
10uMHOS/cm Cond. Std.:_____
100uMHOS/cm ICV Cond. Std.:_____

		Conductivity Standards (uMHOS/cm)			ICV	DI H_2O	Temp.	pH Standards Calibration			Check	DI H_2O	Slope
Date	Analyst	1000	100	10	100	Cond.	°C	4.00	7.00	10.00	4 or 10	pH	pH Calib.

Appendix C

ACCURA ANALYTICAL LABORATORY, INC.

Environmental Analytical Services

pH, Oxidation-Reduction Potential, and Conductivity Log
EPA 150.1, 9040A, 9045C for pH
EPA 120.1, 9050 for Conductivity
ASTM D1498-93 for Oxidation-Reduction Potential

Date	Analyst	AAL #	Matrix	pH			Temp °C	Time	Conductivity (uMHOS/cm)				ORP (mV)	Comments
				Sample	Dup	% RPD			ICV	Sample	Dup	% RPD		

Note: see pH and Conductivity Calibration Log Book for calibration and lot #'s
ORP = Oxidation-Reduction Potential

STANDARD OPERATING PROCEDURE

for

PERCHLORATE IN WATER, SOILS AND SOLID WASTES USING HIGH PERFORMANCE LIQUID CHROMATOGRAPHY/ELECTROSPRAY IONIZATION/MASS SPECTROMETRY (HPLC/ESI/MS) FOR DoD

SOP No.: HPLC-DoDPerchlorate
Revision: 1

June 30, 2006

Approved by: _____ _____
Supervisor Date

_____ _____
QA Coordinator Date

_____ _____
Laboratory Manager Date

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Annual review of this SOP has been performed and the SOP still reflects current practice.
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DOCUMENT CONTROL

NUMBER: _____

Initials: _____ Date:_____

1. SCOPE AND APPLICATION

1.1. This SOP is compliant with the DoD Perchlorate Handbook (March 2006) and the DOD Standard Operating Procedure for the Analysis of Perchlorate in Water, Soils, and Solid Wastes using High Performance Liquid Chromatography/Electrospray Ionization/Mass Spectrometry (HPLC/ESI/MS). This method is for the determination of perchlorate in drinking water, groundwater, surface water, wastewater, soil, sediment and sludge using reverse phase high performance liquid chromatography (HPLC) coupled with electrospray ionization (ESI) mass spectrometry (MS). Other matrices (example – biota) may be applicable to this method if the lab demonstrates the acceptability of the matrix.

1.2. The reporting limits listed below are for guidance only. Reporting Limits are highly matrix-dependent and not always achievable.

Matrix	Reporting Limit
Water	0.20 ug/L
Soil	2.0 ug/kg
Biota	To be determined
Milk	To be determined

2. METHOD SUMMARY

Solids are first extracted prior to analysis using an acetic acid solution. Extracts are filtered. An appropriate volume of the sample or sample extract is introduced into a HPLC/MS instrument. Perchlorate is separated by HPLC from the sample matrix, partially fragmented via negative electrospray ionization and detected by MS using mass-to-charge (m/z) ratios 83, 85 and 89. Quantitation is performed using m/z 83 and internal standard calibration. Isotopically-labeled perchlorate ($Cl^{18}O_4^-$), m/z 89, serves as the internal standard. The 83/85 isotopic ratio reflects the isotopic ratio of naturally occurring $^{35}Cl/^{37}Cl$ and is used for additional confirmation of perchlorate identification.

3. DEFINITIONS

3.1. **Preparation Batch**: a group of 20 or fewer samples of the same matrix prepared together on the same day. See ADM-BATCH for more information.

3.2. **Analytical Batch**: a group of 20 or fewer samples analyzed together. See ADM-BATCH for more information.

3.3. **Internal Standards –** Internal standards are analytes which are similar to the analytes of interest but which are not found in the samples. The chosen internal standards are used to calibrate the instrument's response.

3.4. **Continuing Calibration Verification (CCV):** standard analyzed at a routine frequency throughout the sequence to establish the instrument is meeting calibration criteria. DoD names the first daily CCV an ICV.

3.5. **Independent Calibration Verification (ICV) or Second Source Calibration Verification (SSCV):** standard analyzed from a source that is different than that used to calibrate the instrument. The ICV is a check on the purity and accuracy of the calibration standards and can be used in preparing matrix spike solutions for spiking of QA/QC samples.

3.6. **Relative Percent Difference (RPD):** measure of the relative difference between two values. See QAM.

3.7. **Method Detection Limit (MDL) -** also called LoD (Limit of Detection): a statistically derived value representing the lowest level of target analyte that may be measured by the instrument with 99% confidence that the value is greater than zero.

3.8. **Method Reporting Limit (MRL):** The minimum amount of a target analyte that can be measured and reported quantitatively. The MRL is equivalent to Practical Quantitation Level (PQL), reporting limit, and Limit of Quantitation (LoQ).

3.9. **QA/QC Samples**: Samples added to a sample preparation batch, or an analytical batch to provide quality assurance checks on the analysis.

3.9.1. **Duplicate Sample (DUP):** a laboratory duplicate. The duplicate sample is a separate sample aliquot that is processed in an identical manner as the sample proper.

3.9.2. **Laboratory Control Sample (LCS):** a method blank that has been fortified with the analyte of interest. Used to verify laboratory performance.

3.9.3. **Method Blank (MB):** a laboratory blank that is used to check that reagents and equipment are free of target analytes. The Method Blank follows the same preparative techniques as samples. Unless stated in project specific data quality objectives, reagents are considered free of target analyte contamination if the level detected in the Method Blank is less than the ½ MRL.

3.9.4. **Matrix Spike Sample (MS):** a duplicate sample aliquot that has been fortified with the analyte of interest. Used to observe the effects of the sample matrix on target analyte recovery.

3.9.5. **Matrix Spike Sample/ Matrix Spike Duplicate Sample (MS/MSD):** matrix spike samples prepared in duplicate. It is used to evaluate method precision and matrix effects.

4. INTERFERENCES

4.1. Solvents, reagents, glassware, and other sample processing hardware may yield artifacts and/or interferences to sample analysis. All of these materials must be demonstrated to be free from interferences under the conditions of the analysis by analyzing method blanks.

4.2. All reagent solutions and samples (including QC samples) should be filtered through a minimum 0.45-µm nominal pore size membrane or frit to remove particulates and prevent damage to the instrument, columns and flow systems. Filters specifically designed for IC or HPLC applications should be used.

4.3. Hydrogen sulfate ion $H^{34}SO_4^-$, formed from a minor sulfur isotope, is commonly present in samples. $H^{34}SO_4^-$ elutes before perchlorate but at high concentrations can tail into the retention time of the perchlorate peak and elevate its baseline at m/z 99. Quantitation of perchlorate based on m/z 83 and 89 avoids this potential interference from $H^{34}SO_4^-$.

4.4. Contamination by carryover can occur when high level samples immediately precede samples containing significantly lower levels of contamination. This contamination often comes from the autosampler. Running instrument blanks after samples that are suspected to contain high levels of target analyte can minimize this. Repeat any samples which are suspected to have contamination by carry-over.

4.5. Glassware must be scrupulously cleaned. Glassware should be rinsed as soon as possible after use with the last solvent used. This should then be followed by detergent washing with hot water and rinses with tap water and organic-free reagent water. After washing, the glassware should then be drained, dried, and heated in a laboratory oven at 130°C for two to three hours before reuse. Solvent rinses with acetonitrile may be substituted for the oven heating. After drying and cooling, glassware should then be stored in a clean environment to prevent accumulation of dust or other contaminants

5. SAFETY

5.1. The toxicity or carcinogenicity of each reagent used in this procedure may not be precisely defined. Material safety data sheets (MSDS) are available on each solvent and standard and should be reviewed as part of employee training.

5.2. Personal protective clothing (safety glasses, gloves and lab coat) are recommended when prepping samples, handling standards, or performing maintenance on pressurized systems.

5.3. The use of pressurized gases is required for this procedure. Care should be taken when moving cylinders. All gas cylinders must be secured to a wall or an immovable counter with a chain or a cylinder clamp at all times. Sources of flammable gases (e.g., pressurized hydrogen) should be clearly labeled.

5.4. The proper use of syringes and glass pipettes should be part of employee training. Care should be taken to avoid personal injury as a result of improper handling techniques.

5.5. Refer to the Safety Manual for further discussion of general safety procedures and information.

6. SAMPLE COLLECTION, CONTAINERS, PRESERVATION, AND STORAGE

6.1. Water samples should be collected in purchased, pre-cleaned 125-mL polyethylene bottles.

6.2. For solids, collect samples in purchased clean, 4-oz amber glass jars.

6.3. Prepare solid extracts within 28 days of sample acquisition

6.4. Analyze samples and extracts within 28 days of collection and/or preparation

6.5. Care should be taken to avoid temperature extremes during shipment and storage

6.6. Samples will be refrigerated to 0-6°C upon sample login

6.7. For sample handling see SMO-GEN SOP.

7. APPARATUS AND EQUIPMENT

7.1. Volumetric flasks, 100-mL and other sizes as needed.

7.2. Automatic precision pipetters and disposable tips - 10-10,000 µL capacity or gas tight syringes.

7.3. Disposable autosampler vials, 2mL capacity.

7.4. Disposable plastic centrifuge tubes - 50 mL and 20 mL scintillation vials.

7.5. Disposable plastic micro-beakers.

7.6. Sample bottles - polyethylene or glass of sufficient volume to allow replicate analyses.

7.7. Disposable PTFE 0.45-µm, surfactant-free, membrane syringe filters.

7.8. Glass 5-mL luer-lock syringes or equivalent.

7.9. SPE Cartridges - C_{18} (2000 mg) chromatography columns or equivalent for extract solution cleanup.

7.10. High Performance Liquid Chromatograph/Mass Spectrometer - An analytical system combining a high performance liquid chromatograph for separation of the sample components, electrospray ionization interface and mass spectrometer for fragmentation and detection of sample components. Agilent LC/MS. See Appendix A of the Quality Assurance Manual for specific parts and serial numbers.

7.10.1. High Performance Liquid Chromatograph – The instrument contains a programmable solvent delivery system and all required accessories including injection loop, analytical columns, purging gases, etc. The chromatographic system must be capable of interfacing with a mass spectrometer.

7.10.2. Electrospray ionization (ESI) source – The ESI source generates gas phase ions of perchlorate from the liquid phase.

7.10.3. Mass Spectrometer – A quadrupole mass analyzer, Agilent 1100 LC/MS quadrupole mass spectrometer. Instrument tuning and instrument conditions are based on the manufacturer's instructions. Tuning is not required prior to daily analyses. Tuning parameters are available from the instrument manufacturer, along with mass tuning solutions and instructions on how to optimize the mass spectrometer.

7.10.4. Analytical column – 4 mm x 250 mm, peptides-impregnated, reverse-phase HPLC column. K' (Prime) Technologies, Inc. KP-RPPX250 column or equivalent.

7.10.5. Data system capable of performing analyte signal acquisition, peak integration, instrument calibration and analyte quantification

7.11. Analytical balance, capable of ±0.0001 g accuracy.

7.12. Centrifuge - capable of 5000 rpm and/or generating g-force of such strength as needed for providing adequate separation of a solid suspension and thus yielding a clear supernatant for sample injection and analysis.

8. PREVENTIVE MAINTENANCE

8.1. A maintenance log will be kept documenting maintenance performed on the analytical system. Log entries will include the date maintenance was performed, symptoms of the problem, serial numbers of major equipment upgrades or replacements (defined as any non-consumable part essential to operation), phone logs from technical support contacts, a description of the maintenance performed, a description of the check performed (attach standard data to logbook) to assure the system has returned to acceptable levels of operation, and the analyst's initials.

8.2. Any major maintenance performed on the instrument must be recorded in a maintenance log and must include the date, the person performing , the type and the outcome of the maintenance. Also include a data file number of a chromatogram exhibiting acceptable chromatography.

8.3. Routine maintenance such as changing columns, fresh mobile phase, changing guard columns or inlet filters is noted in the run log.

9. STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

9.1. Reagents – follow guidelines for storage and expiration in ADM-DATANTRY. Follow appropriate reagent check procedures in ADM-CTMN.

9.1.1. Acetonitrile, CH_3CN – HPLC grade or equivalent

9.1.2. Acetic acid (glacial), CH_3CO_2H

9.1.3. UPDI water-HPLC grade: prepared by taking Ultra-Pure-De-Ionized water from the VOA lab Millipore polishing system and filtering through a 0.45u nylon filter using a sidearm flask and vacuum. Used for preparing all reagents, mobile phases, standards, and blanks. May also use purchased HPLC grade water – Fisher W5-4.

9.2. **Standards Preparation General Information and Disclaimers**

9.2.1. All Standards for this analysis are prepared in UPDI-HPLC grade water.

9.2.2. All of the preparation instructions are general guidelines. Other technical recipes may be used to achieve the same results. Example – a 20 mg/L standard may be made by adding 1 mL of 200 mg/L to 10 mLs or may be made by adding 4 mL of 50 mg/L to 10 mLs. The preparation depends upon the final volume needed and the initial concentration of the stock. Reasonable dilution technique is used.

9.2.3. The initial calibration curve given is typical, but also subject to variation due to detection levels needed. A minimum of six calibration standards is recommended as well as a blank standard. The lowest concentration level shall be at or below the reporting level. The remaining levels should define the working linear range of the analytical system.

9.2.4. Vendors and vendors' products are sometimes listed for the ease of the analyst using this SOP, but products and purchased concentrations are examples only and subject to change at any time. All purchased standards are certified by the vendor. Certificates of Analysis are kept in the department until the standards are no longer being used – at which time they are filed with QA. Certificates of Analysis are available upon request. Purchased standards are routinely checked against an independent source for both analyte identification and analyte concentration.

9.2.5. All Standards must be traceable using the CAS lot system (ADM-DATANTRY).

9.3. Stock standard solution (1000 mg/L ClO_4^-) - This solution is purchased commercially as a certified standard. Stock standards may be stored at room temperature for a period of up to 12 months. Expiration dates should be clearly specified on the label.

9.4. Intermediate Standard (1.0 mg/L ClO_4^-) – Dilute 100 uL of 1000 mg/L Intermediate standard solution to 100 mL with UPDI-HPLC water. Working standard may be stored

at room temperature for up to 1 month. Expiration dates should be clearly specified on the label.

9.5. Calibration standards – Prepare by adding various amounts of the 1.0 mg/L intermediate standard solution to UPDI-HPLC water directly in scintillation vials. Spike each calibration standard with 20uL of internal standard spiking solution and 50 uL of glacial acetic acid. The final internal standard concentration is exactly the same (i.e. 2.0 µg/L $Cl^{18}O_4^-$) for each calibration standard.

Calibration Concentration (ug/L)	Volume (uL) of 1.0 mg/L ClO_4^- working std	Final Volume (mL)
0	0	10
0.10	1.0	10
0.20	2.0	10
0.50	5.0	10
1.00	10.0	10
2.00	20.0	10
5.00	50.0	10
10.0	100.0	10

9.6. Internal standard stock solution (8 mg/L $Cl^{18}O_4^-$) – Purchased commercially. Store at room temperature. Expires per manufacturer's indications or 6 months if no other indication is given.

9.7. Internal standard spiking solution (approximately 1000 µg/L $Cl^{18}O_4^-$) - Dilute 0.625 mL of the 8 mg/L internal standard stock solution to 5.0 mL with UPDI-HPLC water.

9.7.1. Each standard and sample is spiked with 20 µL of internal standard spiking solution per 10 mL of sample or standard to obtain a final internal standard concentration of approximately 2 µg/L $Cl^{18}O_4^-$. An alternate internal standard concentration may be used provided that it falls within the same concentration range as the external calibration curve.

9.8. HPLC Mobile Phase – Prepare by combining 527 mL acetonitrile, 468 mL reagent water and 5 mL acetic acid.

9.9. Second Source Standard – The second source standard is purchased at 1000 mg/L from a different manufacturer than the Stock standard solution. Expires per manufacturer's indications or 6 months if no other indication is given.

9.10. Independent Calibration Verification Standard (ICV) or DoD Second Source Calibration Verification (SSCV): The ICV is prepared from the second source standard at a concentration level within the calibration range of the method. Prepare fresh each use. Add acetic acid in proportion to the samples and calibration standards.

9.11. Continuing Calibration Verification Standard (CCV): The CCV is prepared from the intermediate standard solution at a concentration level within the calibration range of the method. Prepare fresh each use. Add acetic acid in proportion to the samples and calibration standards.

9.12. LODV – A standard prepared at a concentration 2 times the MDL.

9.13. LCS/MS Spiking Solution (1 mg/L) – Dilute 100 uL of the 1000 mg/L Second Source Perchlorate Standard to 100 mL with UPDI-HPLC. Use this to spike the MS and the LCS. Store at room temperature. Expires in 6 months.

9.14. Laboratory Control Sample (LCS) (0.2 ug/L) – Dilute 2.0 uL of 1 mg/L LCS/MS solution to 10 mL UPDI-HPLC water. Process as a sample.

9.15. Interference Check Sample (ICS) (0.2 ug/L) –

9.15.1. ICS Matrix preparation - 1000 mg/L each of chloride, sulfate, carbonate by dissolving 1.648g NaCl +1.479g Na_2SO_4 +1.0589g Na_2CO_3 in DI and diluting to 1000ml.

9.15.2. ICS – prepared upon use - spike 10 mL of the ICS matrix with 2.0 uL of 1 mg/L perchlorate standard (second source = LCS/MS Spiking Solution) to monitor anion interference. Process as a sample.

9.16. MS Water (0.2 ug/L) **–** Add 2.0 uL of 1.0 mg/L spiking solution to 10 mL of water sample or UPDI-HPLC. Process as a sample.

9.17. The LCS/MS for Soil - Add 2.0 uL of 1.0 mg/L spiking solution to 1 g of Ottawa sand or soil sample. Process as a sample

9.18. The LCS/MS for biota, and milk is under development.

9.19. MB – Process an analyte-free matrix as a sample. Use DI for water samples, and Ottawa sand for soil samples. The MB for biota and milk is under development.

9.20. Tuning Standard – a proprietary mix from Agilent. Use, store, and discard as per manufacturer's instructions.

10. RESPONSIBILITIES

It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. Final review and sign-off of the data is performed by the department supervisor or designee.

11. PROCEDURE

11.1. Be sure the analysts performing the test have a current IDC or CDC (see section 19). Be sure the instrument has a current MDL study (see section 14 and ADM-MDL).

11.2. Sample Preparation

11.2.1. Water Sample Preparation

11.2.1.1. Dispense 10.0 mL of sample or standard into a 20 mL disposable scintillation vial.

11.2.1.2. Add 50 µL of internal standard spiking solution and 50 µL of acetic acid to the sample tube, cap and shake until mixed well. The final concentration of internal standard in the sample must be exactly the same as that in the calibration standards

11.2.1.3. Filter the sample solution using a plastic syringe fitted with a 0.45-µm PTFE membrane filter. Dispense the sample into an autosampler vial for analysis.

11.2.2. Solid Sample Preparation

11.2.2.1. Weigh 1 g of solid sample, recording the weight to 0.01 g into a 15 mL centrifuge tube.

11.2.2.2. Add 10 mL of UPDI-HPLC water, 20 µL of internal standard spiking solution and 50 µL of acetic acid to the sample tube. Vortex the mixture, followed by sonication (ultrasonic bath) for a minimum of 10 minutes, followed by additional vortexing.

11.2.2.3. Centrifuge the sample for 5 minutes, if necessary, to separate the solids from the extract solution.

11.2.2.4. Filter the supernatant extract solution using a plastic syringe fitted with a 0.45-µm PTFE membrane filter. Dispense the extract sample into an autosampler vial for analysis. NOTE: The final concentration of internal standard in the sample extract must be exactly the same as that in the calibration standards.

11.2.2.5. If large quantities of organic contaminants are not believed to be present in the solid sample extract (i.e. supernatant extract is relatively clear and not highly colored), proceed to instrument analysis. If necessary, however, a cleanup step using a C_{18} column may be performed to remove organic contaminants from the supernatant extract solution.

11.2.2.5.1. Activate the C_{18} cartridge column by pushing approximately 5 mL of methanol through the column, followed by 5 mL of UPDI-

HPLC water. A flow rate of approximately 0.5 mL/min is recommended. Care should be taken not to let the column become dry.

11.2.2.5.2. Pull approximately 6 mL of the supernatant extract solution through the activated column. Use vacuum, if necessary.

11.2.2.5.3. Discard the first 2 mL of eluted sample extract. The initially eluted sample extract is discarded because it is diluted by the solution remaining in the column following the activation process.

11.2.2.5.4. Collect the remaining eluted sample extract (approximately 4 mL) in a clean container. Filter the sample extract using a plastic syringe fitted with a 0.45-µm membrane filter. Dispense the extract sample into an autosampler vial for analysis. Quantitative recovery of the eluted extract sample is not necessary because there is no dilution or concentration of the sample.

11.3. Instrument Set-up

11.3.1. Instrument conditions for analysis are set to optimize response and separation of the analytes. Analysts are advised to adjust the HPLC systems to particular analytical needs. Once optimized, the same conditions are to be used for analysis of all standards, client samples, and QC samples. The current system uses the conditions in Table 1. Actual instrument conditions are optimized and recorded in the instrument daily run log.

11.3.2. Mass Calibration –

- Frequency – Upon instrument setup and as needed (QC failures, large ion mass deviations, major instrument maintenance, tune won't meet criteria)
- Acceptance Criteria – the calibration range must bracket the ion masses of interest without greatly exceeding the range. The most recent mass calibration must be used for an analytical run and the same mass calibration must be used for all data files in an analytical run. Mass calibration must e verified by acquiring a full scan continuum mass spectrum of a perchlorate stock standard. Perchlorate ions should be within ±0.3 *m/z* of mass 99, 101, and 107.
- Corrective action – Correct the problem and recalibrate if the mass calibration fails.

11.3.3. Retention Time

11.3.3.1. Window width establishment – for each analyte and internal standard

11.3.3.1.1. Retention time windows are determined for each column on which analysis is performed and updated upon installation of a new column. Samples may be analyzed on a new column for which formal retention times windows have not been established based on absolute retention time of the compound and a default retention time window of ±0.10 minutes. However, prior to reporting the data, the retention time windows must be established. If the windows are different, update the method and reprocess the data.

11.3.3.1.2. Analyze three non-consecutive standards over a 72 hour period. The retention time windows are ± three times the standard deviation of the average of the three standards. If the standard deviation is zero, a default window of ±0.10 minutes will be used.

11.3.3.2. Retention time position establishment – The absolute position of the retention time is set at the retention time of the midpoint standard of the calibration curve.

11.3.4. Interference Threshold study –

- Frequency – at initial setup and when major changes occur in the method's operating procedures (addition of cleanup procedure, column changes, mobile phase changes).

- Acceptance Criteria – Measure the threshold of common suppressors (chloride, sulfate, carbonate, bicarbonate) that can be present in the system without affecting the quantitation of perchlorate. The threshold is the concentration of the common suppressors where perchlorate recovery falls outside an 85-115% window.

11.4. Initial Calibration

11.4.1. Start up entire HPLC system and allow baseline response to settle.

11.4.2. All injections of standards and samples and associated QC are to be the same. 25 uL injections are used.

11.4.3. The first sample through the system should be an instrument blank. This blank is simply an injection of UPDI-HPLC and internal standard. As the first injection of the day, this helps to further settle the baseline and equilibrate the system.

11.4.4. A pre-curve blank is run to check for system and reagent cleanliness. Any potentially interfering peaks should be noted. This blank is prepared alongside the calibration standards.

11.4.5. Follow ADM-ICAL – if there are discrepancies between ADM-ICAL and this SOP, follow this SOP.

11.4.6. Process a minimum of 6 calibration standards and a blank (as described in Section 9). The calibration standards are pH adjusted, but not filtered.

11.4.7. Analyte responses are tabulated and recorded in the integration software. The low point in the ICAL (initial calibration) must be at or below the MRL (method reporting limit).

11.4.8. Calibration Curve - Establish the initial calibration curve using an internal Calibration by linear regression . Plot the area ratio response $\frac{(A_s)(C_{is})}{A_{is}}$ for each standard against the concentration C_s using the internal standard calibration method using the equation of a line (y=mx+b).

The curve must not be forced through zero. The acceptance criterion for the calibration curve is a correlation coefficient of 0.995 or higher.

11.4.9. The concentration corresponding to the absolute value of the calibration curve's Y-intercept must be ≤ LOD.

11.4.10. All of the ICAL criteria must be acceptable before samples may be analyzed.

11.4.11. Routinely, after the high point of the curve, a blank is run to prove that there is no carry-over from the autosampler. It should be noted if there are any target hits above ½ of the MRL.

11.4.12. Verify the calibration by analyzing an independent calibration verification standard. Acceptance criteria for the ICV is 90-110% recovery.

11.5. Analytical Sequence:

11.5.1. Daily tune verification – the daily tune is performed according to the proprietary standard instructions from Agilent®.

11.5.2. Samples immediately following an initial calibration and ICV may skip the system blank and the opening CCV.

11.5.3. Analyze a system blank to establish that the instrument is free of contamination. Unless stated in project specific data quality objectives, the system is considered free of contamination if the level detected is less than ½ of the method reporting limit.

11.5.4. Analyze an opening CCV. If this is acceptable, analyze up to 10 client samples and associated batch QC (MB, LCS, DUP, MS). Analyze another CCV. This pattern is continued until the sequence is complete, or a CCV fails to meet acceptance criteria. End the run with a CCV. All samples must be bracketed by acceptable CCVs.

11.6. Evaluation of the Analytical Sequence

11.6.1. Check that CCVs were acceptable and interspersed throughout the sequence at the proper frequency. Discussion of CCV acceptance is given in Section 12.

11.6.2. Check LCS and MS/MSD samples against acceptance criteria. Acceptance criteria and corrective action are listed in Section 12.

11.6.3. Check that the ICS is within acceptance criteria to accept the batch. Frequency, acceptance criteria and corrective action are listed in Section 12.

11.7. Evaluation of Sample Analysis

11.7.1. Examine solution concentrations of target analytes in the samples. If the concentration is greater than the high calibration standard, reanalyze the sample at a dilution. As a general rule, dilutions should be performed to keep target analytes in the upper half of the calibration range. See ADM-DIL.

11.7.2. Check for possible carryover. Pay particular attention to situations where samples containing low levels of target analyte were analyzed one or two injections after samples containing levels of target analyte near or over the high end of the calibration range. Reanalyze as needed to confirm.

11.7.3. Check peak integrations. Where possible, all integrations should be performed consistent with integration of the corresponding calibration standards and with ADM-INT.

11.7.4. Monitor the mass ratio between ions 83/85. The ion ratio should fall within the established window of 2.3-3.8. If criteria not met, the sample(s) must be repeated.

Reextract using cleanup procedures or alternative techniques to confirm the presence of perchlorate such as post spikes or dilutions to reduce the interference. Qualify the data and discuss in the case narrative as necessary.

12. QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

12.1. Calibration Criteria: Calibration criteria is given in section 11.

12.2. Method Blank:

- Frequency - Process one MB with each preparation batch of 20 or fewer samples. The MB should be carried through all stages of sample preparation and analysis.
- Acceptance Criteria - The result of the MB must be less than ½ the reporting limit.
- Corrective Action - If it is not, determine the source of the contamination and reprep and reanalyze the associated samples.

12.3. Reagent blanks –

- Frequency – prior to calibration and after each batch is analyzed. When perchlorate concentrations in the samples are over the linear range, any samples which follow the overrange sample will be repeated if the sample concentrations were greater than ½ the RL.
- Acceptance Criteria – must be less than ½ RL.
- Corrective Action – reanalyze reagent blanks until no carryover is observed (<1/2 MRL). Reanalyze all samples processed since the contaminated blank. If the closing reagent blank fails, reanalyze all samples since the last clean reagent blank.

12.4. MS –

- Frequency - Prepare one MS (or MS/MSD pair) with each batch of 20 or fewer samples of the same matrix.
- Acceptance Criteria - The limit for the water and soil is 75-125% of the true value.
- Corrective Action - If recovery of MS fails on a sample batch the samples are acceptable only if the LCS meets acceptance criteria. If the LCS passes, but the MS fails, report the MS recoveries and note outliers in the case narrative.

12.5. LCS –

- Frequency - Prepare one LCS with each batch of 20 or fewer samples of the same matrix.
- Acceptance Criteria (recovery) - The limit for the water and soil LCS is 85-115%. The limits for biota and milk are under development.
- Corrective Action - If the LCS fails on a sample batch, reprep and reanalyze the sample batch. If a duplicate LCS was run with the batch and one LCS was slightly out, but the other LCS was in, the data is accepted.

12.6. DUP/MSD Precision –

- Frequency - Precision for each prep batch of 20 or fewer samples of the same matrix must be established by either analyzing a sample in duplicate (DUP) or analyzing a MS in duplicate (MSD).
- Acceptance Criteria – (for all samples above the reporting limit), the RPD value between samples or MS/MSD results must not exceed 20%.
- Corrective Action - examine the chromatograms and benchsheets for potential matrix interferences. Reanalyze the pair if deemed appropriate. The outlying RPD should be mentioned in the Case Narrative so that data may be flagged appropriately.

12.7. The SSCV (ICV) is discussed in Section 11.

12.8. CCV –

- Frequency – bracketing every 10 or fewer samples
- Acceptance Criteria - All samples must be bracketed by an acceptable CCV. The acceptance limit is 85-115% of the true value.
- Corrective Action - If the CCV does not meet acceptance criteria, correct the problem and achieve an acceptable CCV. Recalibration may be necessary. All samples bound by the unacceptable CCV must be reanalyzed with acceptable QC.

12.9. Internal standard area response verification:

- Frequency – The IS is added to every sample, spiked sample, standard, instrument blank, and method blank
- Acceptance Criteria - The internal standard area counts for each sample and QC standard must be monitored throughout the analysis and the IS area must be within ±50% of the ICAL.
- Corrective Action - If the internal standard area counts exceed ± 50% that of the ICAL, rerun the sample at increasing dilutions until the acceptance criteria are met. If the criteria cannot be met with dilution, the interference are suspected and the sample must be reprepared using additional pretreatment steps. Thoroughly document corrective action in the case narrative.

12.10. Internal standard and Target retention times

- Frequency – IS is added to every sample, spiked sample, standard, instrument blank, and method blank.
- Acceptance Criteria – The RRT (relative retention time) must be 0.98-1.02. Calculate the RRT in a sample by dividing the retention time of the perchlorate ion by the retention time of the internal standard.
- Corrective Action – Thoroughly document in the case narrative.

12.11. MDL – see section 14 and ADM-MDL.

12.12. LODV

- Frequency – before and directly after every analytical batch of samples. It may be run more frequently to reduce reanalysis rate.
- Acceptance criteria – the recovery must be within 30% of the true value. Exception – any samples with concentrations above the MRL may be reported.
- Corrective Action – if there are samples below the MRL, correct the problem, obtain a compliant LODV and reanalyze affected samples.

12.13. ICS

- Frequency – one ICS is extracted with every batch of 20 or fewer samples. At least one ICS must be analyzed daily.
- Acceptance Criteria – the recovery must be within 30% of the true value.
- Corrective action – Correct the problem and reanalyze all samples associated with a failed ICS.

13. DATA REDUCTION AND REPORTING

13.1. Identify perchlorate in the sample chromatograms:

13.1.1. Compare the retention times of the ClO_4^-, m/z 83, peak and the internal standard $Cl^{18}O_4^-$, m/z 89, peak. The retention times should not vary by more than 0.1 minutes.

13.1.2. Evaluate the relative abundances of the m/z 83 and 85 ions in the chromatogram. To confirm the presence of perchlorate, the 83/85 peak area counts ratio should be 2.3-3.8. Repeat the samples if ratio criteria not met or flag the data as estimated and discuss in the case narrative.

13.2. Calculate the perchlorate concentration for each sample using the internal standard calibration. Use m/z 83 and 89 from the internal standard for quantitation. Calculate the concentration of each of the sample matrices as follows:

13.2.1. Water Samples

$$\text{Concentration } (\mu g/L) = \frac{\left[\frac{A_s C_{is}}{A_{is}} - b\right] D}{m}$$

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 concentrated sample extract in µg/L.
D = Dilution factor, if the sample or extract was diluted prior to analysis. If no dilution was made, D=1. The dilution factor is always dimensionless.
m = Slope of the line
b = The y intercept.

13.2.2. Solid Samples

$$\text{Final Result } (\mu g/kg\ ClO_4^-) = \frac{(C)(V)(D)}{M}$$

Where:
C = Concentration in extract (µg/L ClO_4^-)
V = Volume of sample extract used for analysis (mL)
D = Dilution factor (if needed)
M = Mass of initial sample extracted (g)

13.3 Report samples "as received" – do not adjust for Dry Weight.

13.4 Adjustments to the Method Reporting Limit - MRLs are elevated for insufficient sample volume, matrix interference, and dilutions.

13.5 Data Review: Data is reviewed according to ADM-DREV.

14. METHOD PERFORMANCE

14.1. MDL study – refer to ADM-MDL for more information. If there are conflicts between ADM-MDL and this SOP, this SOP is to be followed.

14.1.1. Design - The MDL study must be performed in the matrix of interest using a standard at a concentration that is 1 to 10 times the estimated MDL value. The standard is taken through the entire preparation and analysis procedure.

14.1.2. Frequency - A full MDL study must be conducted at initial setup and subsequently once per 12 month period and when major changes occur in the method's operating procedures (addition of cleanup procedures, column changes,

mobile phase changes). If no changes have been made to the method, quarterly MDL verification checks (see below) may be performed in lieu of the yearly MDL study.

14.1.3. Acceptance criteria – The study must produce an MDL value which is no more than 10 times lower than the spike level (10x rule). The calculated MDL must be 3 times less than the reporting limit. The MDL must be verified by an acceptable MDL verification check (see below) prior to the analysis of samples.

14.1.4. Corrective Action –

14.1.4.1. If the MDL study does not meet the 10x rule, adjust the spike concentration and repeat the study.

14.1.4.2. If the MDL is not 3 times less than the reporting limit, correct the problem and repeat the MDL study or raise the reporting limit accordingly.

14.1.4.3. If the MDL verification check fails, see below.

14.2. MDL verifications checks –

14.2.1. Concentration – the MDL verification check is a low-level spike at approximately 2 times the MDL taken through the entire preparation process.

14.2.2. Frequency – with each new MDL study prior to the analysis of samples and quarterly if an annual study will not be performed.

14.2.3. Acceptance criteria – must produce a signal at least 3 times the instrument's noise level. Recovery should be within 30% of its true value.

14.2.4. Corrective action – run the MDL verification check at a higher level or re-perform the MDL study. If the MDL verification check is run at a higher level, the reported MDL must be adjusted higher (1/2 the spike concentration of the acceptable check).

14.3. File the MDL study and the MDL check with the QA office.

14.4. Demonstration of Capability is performed upon instrument set-up , whenever a new analyst begins independent analysis, and annually thereafter according to ADM-TRANDOC and section 19 below. The documentation of this method performance is retained by the Quality Assurance office.

15. WASTE MANAGEMENT AND POLLUTION PREVENTION

Standards are prepared on an as-needed basis in small quantities and minimum sample volumes are used during analysis. All expired standards are disposed of as hazardous and hazardous samples are disposed of either as acidic aqueous waste or as hazardous aqueous waste depending on their analytes' concentrations. These tasks are turned over to staff qualified and equipped for disposal. See SMO-SPLDIS for more discussion.

16. CORRECTIVE ACTIONS FOR OUT OF CONTROL DATA

If data is produced that is out of control, the samples are to be re-analyzed with in-control QA whenever possible. See corrective actions in Section 12 of this SOP and in the applicable Figures in Section 12 of the Quality Assurance Manual.

17. CONTINGENCIES FOR HANDLING OUT OF CONTROL OR UNACCEPTABLE DATA

If data is produced that is out of control and is not to be re-analyzed due to sample volume restrictions, holding times, or QC controls can not be met, follow the procedures in Section 15 of the Quality Assurance Manual.

18. REFERENCES

DoD Standard Operating Procedure for the Analysis of Perchlorate in Water, Soils and Solid Wastes using High Performance Liquid Chromatography/Electrospray Ionization/ Mass Spectrometry (HPLC/ESI/MS), July 2006.

DoD Perchlorate Handbook, March 2006.

19. TRAINING OUTLINE

19.1. Read the most current SOP. Demonstrate a general understanding of the methodology and chemistry. Follow policies in ADM-TRANDOC.

19.2. Observe Sample Preparation and Analysis. Follow HPLC Training Plan Form.

19.3. Participate in the methodology, documentation, and data reduction with guidance.

19.4. Demonstrate Competency by performing the analysis independently. Analyze four replicates of the LCS. If recovery is within acceptable limits, complete Training Plan Form, IDC certificate and summary spreadsheet and file with QA. An IDC study must be successfully performed before the new analyst may analyze samples independently. Continued demonstration of Capability is performed annually by analyzing a PE, blind, or new 4 replicate study.

20. METHOD MODIFICATIONS

- None

21. INSTRUMENT- SPECIFIC ADDENDUM

Instrument manuals are located near the instrument.

22. ATTACHMENTS

- Table 1: Recommended Instrument Settings.

23. CHANGES FROM PREVIOUS REVISION

These changes are additions and corrections to Revision 0 and are not changes in procedure since 6/28/06.

- 7.7, 11.2.1.3, 11.2.2.4 - Added that syringe filters are PTFE.
- 9-Eliminated preparation and use of 0.10 mg/L intermediate standard solution – all ICAL standards are being prepared from the 1.0 mg/L intermediate standard. The ICAL standards are being made to 10 mL in a scintillation vial instead of to 1.6 mL in an autosampler vial.
- Throughout – the volume of internal standard used for each standard and sample is 20 uL instead of 50 uL.
- 9-ICS - The perchlorate is spiked into the ICS matrix at the time of use instead of when the bulk matrix is prepared.
- 11.2.2.2 – The solid samples are sonicated in an ultrasonic bath – not with disrupter horns (method 3550) as previously stated.
- 11.4.8 + 13.2.1– The equation for response factor was eliminated and the equation of a line was added. The sample calculation was changed accordingly.
- 12.7 – The terminology “ICV” was changed to “SSCV (ICV)”
- 12.10 – clarified by adding “target” to the title
- 13.1.2 – Eliminated wording about establishing a window of acceptable ratios for the relative abundances of the m/z ions since the window is fixed by DoD.

TABLE 1

EXAMPLE HPLC/MS INSTRUMENT SETTINGS

Autosampler

Injection Volume:	25 µL

Analytical Column

Column Temperature:	30 ºC

HPLC Pump

Flow Rate:	0.5 mL/min
Run Time:	13.0 min

Mobile Phase:

52.7% CH_3CN/ 46.8% H_2O / 0.5% CH_3CO_2H

Mass Spectrometer

Ionization Mode:	Electrospray
Polarity:	Negative

SIM Parameters:

SIM Ion	Fragmentor	Gain (EMV)	Actual Dwell
83	200 V	3.0	392 msec
85			392 msec
89			392 msec

Spray Chamber:

Gas Temperature	Drying Gas (N_2)	Nebulizer Pressure
320 ºC	12.0 L/min	50 psig

Capillary voltage:

Negative
1450 V

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

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
GCFID								1.1.3.1
GCFID								1.1.3.2
GC/MS – VOA								1.2.3.4
GC/MS – VOA								1.2.3.5
GC/MS – VOA								1.2.4.2
GC/MS – SVOA								2.4.4.3
GCECD– Pest								2.1.2.3
GCECD - PCB								2.1.2.4
GC/HPLC								2.3.2.4
HPLC/EIS/MS								HPLC-DoDPerchlorate
ICP/AES - Metals								3.1.1.4
pH Meter								3.5.14.3
ORP								09WC-14981.I
CEC								09WC-9081.I
DC-180 TOC Analyzer								3.6.2.2
TSS								3.5.19.1
TDS								3.5.19.2
Hardness								3.5.7.1
IC, Lachat								3.5.22.1

[1]Specific information for each instrument is found in the attached CD, Attachment A of this QAPP.

QAPP Worksheet #26
Sample Handling System

Sample Collection, Packaging, and Shipment

Sample Collection (Personnel/Organization): Project Field Team. Field SOPs are found in Attachment 1.

Sample Packaging (Personnel/Organization): Project Field Team. Field SOPs are found in Attachment 1.

Coordination of Shipment (Personnel/Organization): Field Team Leader. Stephen Brand/CH2M HILL.

Type of Shipment/Carrier: Overnight/Fed Ex

Sample Receipt and Analysis

Sample Receipt (Personnel/Organization): Contracted laboratory/To be determined

Sample Custody and Storage (Personnel/Organization): Contracted laboratory/To be determined

Sample Preparation (Personnel/Organization): Contracted laboratory/To be determined

Sample Determinative Analysis (Personnel/Organization): Contracted laboratory/To be determined

Sample Archiving

Field Sample Storage (No. of days from sample collection): See Worksheet 19.

Sample Extract/Digestate Storage (No. of days from extraction/digestion): See Worksheet 19.

Sample Disposal

Personnel/Organization: Contracted laboratory/To be determined

Number of Days from Analysis: After submission, the laboratory will keep samples 90 days and the sample extracts for a minimum of 60 days.

QAPP Worksheet #27
Sample Custody Requirements

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

Samples will be collected by field team members under the supervision of the field team leader. As samples are collected, they will be placed into containers and labeled, as outlined below. Labels will be taped to the jar to ensure they do not separate. Samples will be cushioned with packaging material and placed into coolers containing enough ice to keep the samples below 4°C until they are received by the laboratory. The chain of custody (COC) will be placed into the cooler as well. Coolers will be shipped to the laboratory via FedEx, with the airbill number indicated on the COC (to relinquish custody). Upon delivery, the laboratory will log in each cooler and report the status of the samples.

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

The project-specific laboratory will provide laboratory SOPs for the project-specific work plan.

Sample Identification Procedures:

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

Chain-of-Custody Procedures:

Chains of custody will include, at a minimum, laboratory contact information, client contact information, sample information, and relinquished by/received by information. Sample information will include sample ID, date/time collected, number and type of containers, preservative information, analysis method, and comments. The chain of custody will also have the sampler's name and signature. The chain of custody will link location of the sample from the field logbook to the laboratory receipt of the sample. The laboratory will use the sample information to populate the LIMS database for each sample.

CHAIN OF CUSTODY FORM

Project Site	AOC E				Number of Containers	Analysis Requested												Project No.
Project Manager	Brett Doerr																	
Contact Tel No.	757-289-9246 (Adrienne Jones)																	Lab Batch/SDG ID
Contact Address	4350 W. Cypress Street, Suite 600, Tampa, FL 33607																	
Lab Name																		Lab Tel No./Fax No.
Lab Contact																		
Lab Address																		
Item	Sample ID	Station ID	Matrix	Date & Time Collected		MET_SO/GN	PCB_SO	PEST_SO	SVOC_SO	TL_SO	TOC_SO	TPH_SO_DRO/ORO	TPH_SO_GRO	VOC_SO	GRAIN_SIZE	TPH_W_GRO	VOC_W	Comments
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
Sampled By:				Date/Time:		Custody Seal: Y / N				Relinquished By:								Date/Time:
Shipped Via: UPS FedEx Hand Other (Please specify):																		
Samples Temperature and Condition Upon Receipt (for lab's use):																		
Received By:				Date/Time:		Custody Seal: Y / N				Relinquished By:								Date/Time:
Received By:				Date/Time:		Custody Seal: Y / N				Relinquished By:								Date/Time:
Remarks:																		

QAPP Worksheet #28-1
QC Samples Table

Matrix	Soil/Sediment
Analytical Group	Volatile Organic Compounds
Concentration Level	Low/Medium
Sampling SOP[1]	A-6, G-5
Analytical Method/SOP Reference[2]	EPA CLP SOM01.1
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per 12-hour period in which samples are analyzed	must meet all internal standard and deuterated monitoring compound criteria; all target compound < CRQL, except DCM, acetone and 2-butanone < 2x CRQL	If contaminated, find and eliminate source of contamination. Reanalyze.	LQAO	contamination/bias	must meet all internal standard and deuterated monitoring compound criteria; all target compound < CRQL, except DCM, acetone and 2-butanone < 2x CRQL
Instrument Blank	analyze after high concentration sample	must meet all internal standard and deuterated monitoring compound criteria; all target compound < CRQL	reanalyze	LQAO	contamination/bias	must meet all internal standard and deuterated monitoring compound criteria; all target compound < CRQL
Matrix spike/Matrix spike duplicate	if requested, per SDG or per 20 field samples in an SDG; per concentration level	must meet relative RT criteria; should meet advisory % recovery and RPD criteria in SOM01.1 SOW	no further action necessary; investigate repeated failures	LQAO	precision/accuracy	must meet relative RT criteria; should meet advisory % recovery and RPD criteria in SOM01.1 SOW
Storage Blank	1 per SDG, after all sample in the SDG have been analyzed	same as method blank	reanalyze	LQAO	conatimination/bias	same as method blank

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-2
QC Samples Table

Matrix	Soil/Sediment
Analytical Group	Semivolatile Organic Compounds
Concentration Level	Low/Medium
Sampling SOP[1]	A-1, A-2, A-5, G-5
Analytical Method/SOP Reference[2]	EPA CLP SOM01.1
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per extraction batch not to exceed 20 field samples	must meet internal standard and DMC criteria; all target compounds <CRQL, except bis-(2-ethylhexyl)phthalate < 5x CRQL	If contaminated, find and eliminate the source. If internal or DMC fail acceptance criteria; reanalyze. If surrogates continue to fail, re-extract and reanalyze along with all associated samples	LQAO	contamination/bias	must meet internal standard and DMC criteria; all target compounds <CRQL, except bis-(2-ethylhexyl)phthalate < 5x CRQL
Matrix spike/Matrix spike duplicate	If requested, per SDG or per 20 field samples within an SDG; per concentration level	must meet relative RT criteria; should meet advisory spike recovery and RPD criteria in the SOM01.1 SOW	no further action necessary; investigate repeated failures	LQAO	precision/accuracy	must meet relative RT criteria; should meet advisory spike recovery and RPD criteria in the SOM01.1 SOW

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer
DMC = Deuterated Monitoring Compound

QAPP Worksheet #28-3
QC Samples Table

Matrix	Soil/Sediment
Analytical Group	Organochlorine Pesticides
Concentration Level	Low
Sampling SOP[1]	A-1, A-2, A-5, G-5
Analytical Method/SOP Reference[2]	EPA CLP SOM01.1
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per extraction batch not to exceed 20 field samples	all target compounds < CRQL; surrogates must be within RT windows; surrogate recoveries must be within 30-150%	If contaminated, find and eliminate the source. If acceptance criteria not met, reanalyze. If acceptance criteria still not met re-extract and reanalyze along with all associated samples.	LQAO	contamination/bias	all target compound < CROL; surrogates must be within RT windows; surrogate recoveries must be within 30-150%
Sulfur Blank	1 per batch of samples on which sulfur cleanup is performed	all target compounds < CRQL; surrogates must be within RT windows; surrogate recoveries must be within 30-150%	If contaminated, find and eliminate the source. If acceptance criteria not met, reanalyze. If acceptance criteria still not met re-extract and reanalyze along with all associated samples.	LQAO	contamination/bias	all target compound < CRQL; surrogates must be within RT windows; surrogate recoveries must be within 30-150%
Instrument Blank	1 to initiate each 12-hour analytical sequence	surrogates must be within RT windows; all target compounds CRQL	reanalyze	LQAO	contamination/bias	surrogates must be within RT windows; all target compoundsCRQL
Laboratory Control Sample	1 per SDG or 20 field samples	surrogates must be within RT windows; surrogate recoveries must be with 30-150%;spike recoveries must meet criteria in SOM01.1 SOW	If acceptance criteria not met, reanalyze. If acceptance criteria still not met re-extract and reanalyze along with all associated samples.	LQAO	accuracy	surrogates must be within RT windows; surrogate recoveries must be with 30 150%;spike recoveries must meet criteria in SOM01.1 SOW
Matrix spike/Matrix spike duplicate	per 20 field samples	surrogates must be with in RT windows; should meet advisory spike % recovery and RPD acceptance criteria in the SOM01.1 SOW	no further action necessary; investigate repeated failures	LQAO	precision/accuracy	surrogates must be with in RT windows; should meet advisory spike % recovery and RPD acceptance criteria in the SOM01.1 SOW

[1] Reference number from QAPP Worksheet #21.
[2] LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-4
QC Samples Table

Matrix	Soil/Sediment
Analytical Group	Polychlorinated Biphenyls
Concentration Level	Low
Sampling SOP[1]	A-1, A-2, A-5, G-5
Analytical Method/SOP Reference[2]	EPA CLP SOM01.1
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per extraction batch not to exceed 20 field samples	all target compounds < CRQL; surrogates must be within RT windows; surrogate recoveries must be within 30-150%	If contaminated, find and eliminate the source. If acceptance criteria not met, reanalyze. If acceptance criteria still not met re-extract and reanalyze along with all associated samples.	LQAO	contamination/bias	all target compounds < CROL; surrogates must be within RT windows; surrogate recoveries must be within 30-150%
Sulfur Blank	1 per batch of samples on which sulfur cleanup is performed	all target compounds < CRQL; surrogates must be within RT windows; surrogate recoveries must be within 30-150%	If contaminated, find and eliminate the source. If acceptance criteria not met, reanalyze. If acceptance criteria still not met re-extract and reanalyze along with all associated samples.	LQAO	contamination/bias	all target compounds < CRQL; surrogates must be within RT windows; surrogate recoveries must be within 30-150%
Instrument Blank	1 to initiate each 12-hour analytical sequence	surrogates must be within RT windows; all target compounds CRQL	reanalyze	LQAO	contamination/bias	surrogates must be within RT windows; all target compounds CRQL
Laboratory Control Sample	1 per SDG or 20 field samples	surrogates must be within RT windows; surrogate recoveries must be with 30-150%;spike recoveries must meet criteria in SOM01.1 SOW	If acceptance criteria not met, reanalyze. If acceptance criteria still not met re-extract and reanalyze along with all associated samples.	LQAO	accuracy	surrogates must be within RT windows; surrogate recoveries must be with 30-150%;spike recoveries must meet criteria in SOM01.1 SOW
Matrix spike/Matrix spike duplicate	per 20 field samples	surrogates must be within RT windows; should meet advisory % recovery and RPD acceptance criteria specified in the SOM01.1 SOW	no further action necessary; investigate repeated failures	LQAO	precision/accuracy	surrogates must be within RT windows; should meet advisory % recovery and RPD acceptance criteria specified in the SOM01.1 SOW

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-5
QC Samples Table

Matrix	Soil/Sediment
Analytical Group	Explosives
Concentration Level	Medium
Sampling SOP[1]	A-1, A-2, A-5, G-5
Analytical Method/SOP Reference[2]	SW-846 8330
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per extraction batch not to exceed 20 field samples	no target compounds > the reporting limit; surrogate recovery must be within the limits of 38-155%	If contaminated, find and eliminate the source. If acceptance criteria not met, reanalyze. If acceptance criteria still not met re-extract and reanalyze along with all associated samples.	LQAO	contamination/bias	no target compounds > the reporting limit; surrogate recovery must be within the limits of 38-155%
LCS	1 per extraction batch not to exceed 20 field samples	surrogate recovery must be within the limits of 38-155%; spike recovery limits must be within the range of 50-150%	reextract and reanalyzed associated samples	LQAO	accuracy/bias	surrogate recovery must be within the limits of 38-155%; spike recovery limits must be within the range of 50-150%
MS/MSD	if requested, 1 per 20 field samples in an SDG	spike recovery limits are 50-150%; RPD limts are 30%	Evaluate LCS; may report with qualifier	LQAO	precision/accuracy	spike recovery limits are 50-150%; RPD limts are 30%

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-6
QC Samples Table

Matrix	Soil/Sediment
Analytical Group	Explosives
Concentration Level	Medium
Sampling SOP[1]	A-1, A-2, A-5, G-5
Analytical Method/SOP Reference[2]	Guidance in DoD Perchlorate Handbook
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per batch not to exceed 20 field samples	no target compounds > 1/2 the reporting limit	If contaminated, find and eliminate the source and reprep and reanalyze the associated samples	LQAO	contamination/bias	no target compounds > 1/2 the reporting limit
Reagent Blank	Prior to calibration and after each batch analyzed	no target compounds > 1/2 the reporting limit	If contaminated, reanalyze reagent blanks until no carryover is observed (<1/2 the reporting limit). Reanlayze all samples processed since the last clean reagent blank.	LQAO	contamination	no target compounds > 1/2 the reporting limit
LCS	1 per batch not to exceed 20 field samples	spike recovery limits must be within the range of 85-115%	reextract and reanalyzed associated samples	LQAO	accuracy/bias	spike recovery limits must be within the range of 85-115%
MS/MSD	if requested, 1 per 20 field samples in an SDG	spike recovery limits are 75-125%; RPD limts are 20%	Evaluate LCS; may report with qualifier and note outliers in the case narrative	LQAO	precision/accuracy	spike recovery limits are 75-125%; RPD limts are 20%

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-7
QC Samples Table

Matrix	Soil/Sediment
Analytical Group	Metals
Concentration Level	Low/Medium
Sampling SOP[1]	A-1, A-2, A-5, G-5
Analytical Method/SOP Reference[2]	EPA CLP ILM05.3
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
CRQL Check Standard (CRI)	1 at the beginning and end of each sample analysis sequence not to exceed 20 analytical samples, including the CRI	analyte recovery must fall within the limits of 70-130% (50-150 for antimony, lead, and thallium)	Stop analysis; correct problem; reanalyze CRI and associated samples	LQAO	accuracy	analyte recovery must fall within the limits of 70-130% (50-150 for antimony, lead, and thallium)
Calibration Blank	Following each initial and continuing calibration; every 2 hours or every 10 analytical samples, whichever is more frequent	absolute values of all analyte concentrations must be < the CRQL	Stop analysis; correct problem; recalibrate	LQAO	contamination/bias	All analytes must be < the CRQL
Preparation blank	1 per digestion batch	absolute values of all analyte concentrations must be ≤ the CRQL	re-prepare and reanalyze; except if concentration of analyte(s) in all associated samples is > 10x the concentation in the blank	LQAO	contamination/bias	absolute values of all analyte concentrations must be ≤ the CRQL
Interference Check Sample (ICS)	Follow the CRI at the beginning and end of the analytical sequence not to exceed 20 analytical samples, including the CRI, and the ICS; not required for Mercury or Cyanide analyses	must be within ± 2x the CRQL of the analyte's true value or ± 20% of the analyte's true value, whichever is greater	Check system. Correct problem. Recalibrate	LQAO	accuracy/bias	must be within ± 2x the CRQL of the analyte's true value or ± 20% of the analyte's true value, whichever is greater
Matrix Spike	1 per SDG	spike recovery limits are 75-125%	Flag data with an "N" and analyze a post digestion spike, unless recovery is > 4x the spike added	LQAO	accuracy/bias	spike recovery limits are 75-125%
LCS	1 per digestion batch not to exceed 20 field samples	purchased reference material;must meet the recovery limits established by the vendor	re-prepare and reanalyze digestion batch	LQAO	accuracy	purchased reference material;must meet the recovery limits established by the vendor
Duplicate Sample	1 per SDG	RPD of 20%, if concentration is > 5x CRQL; or ± the CRQL if the concentration is < 5x CRQL	flag data with a "*"	LQAO	precision/accuracy	RPD of 20%, if concentration is > 5x CRQL; or ± the CRQL if the concentration is < 5x CRQL
Serial Dilution	1 per SDG; not required fo Mercury and Cyanide analysis	should agree within 10% of the original sample	flag data with an "E"	LQAO	precision/accuracy	should agree within 10% of the undiluted sample

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-8
QC Samples Table

Matrix	Soil/Sediment
Analytical Group	Total Petroleum Hydrocarbons
Concentration Level	Normal
Sampling SOP[1]	A-1, A-2, A-5, G-5
Analytical Method/SOP Reference[2]	SW-846 8015M
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per 12-hour analytical batch of not more than 20 field samples for GRO; 1 per extraction batch of not more than 20 field samples for DRO	all petroleum hydrocarbons must be < the reporting limit	re-prepare and reanalyze batch; If any petroleum hydrocarbons detected at concentrations between the MDL and the reporting limit, find and correct the problem; flag associated data with a "B"	LQAO	contimination/bias	all petroleum hydrocarbons must be < the reporting limit
LCS	1 per 12-hour analytical batch of not more than 20 field samples for GRO; 1 per extraction batch of not more than 20 field samples for DRO	must meet the recovery limits of 50-150 for DRO; must meet recovery limits of 75-110 for GRO	re-prepare and reanalyze batch	LQAO	accuracy	must meet the recovery limits of 50-150 for DRO; must meet recovery limits of 75-110 for GRO
MS/MSD	if requested, 1 pair per SDG	should meet the spike recovery limits of 50-142 and RPD of 20 for GRO; should meet the spike recovery limits fo 50-150 fand RPD of 25 for DRO	may report with data qualifier	LQAO	accuracy/precision	should meet the spike recovery limits of 50-142 and RPD of 20 for GRO; should meet the spike recovery limits fo 50-150 fand RPD of 25 for DRO

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-9
QC Samples Table

Matrix	Soil/Sediment
Analytical Group	Wet Chemistry
Concentration Level	Medium
Sampling SOP[1]	A-1, A-2, A-5, G-5
Analytical Method/SOP Reference[2]	SW-846 9045C
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Electrode Check/LCS	1 per batch	0.05 pH units	recalibrate pH meter; reanalyze	LQAO	accuracy	0.1 pH units
Duplicate sample	1 per SDG	RPD or 20%	flag with the appropriate laboratory qualifier	LQAO	precision/accuracy	RPD or 20%

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-10
QC Samples Table

Matrix	Soil/Sediment
Analytical Group	Wet Chemistry
Concentration Level	Medium
Sampling SOP[1]	A-1, A-2, A-5, G-5
Analytical Method/SOP Reference[2]	SM2580B
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Calibration Check	1 at beginning of run	± 10 mV	Stop analysis; check instrument, reanalyze	LQAO	accuracy	± 50%
Duplicate sample	1 per SDG	RPD or 22%	flag with the appropriate laboratory qualifier	LQAO	precision/accuracy	RPD or 20%

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-11
QC Samples Table

Matrix	Soil/Sediment
Analytical Group	Wet Chemistry
Concentration Level	Medium
Sampling SOP[1]	A-1, A-2, A-5, G-5
Analytical Method/SOP Reference[2]	SW-846 9081
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Calibration Blank	following each initail and continuing calibration	< reporting limit	Stop analysis; correct problem; recalibrate	LQAO	contamination/bias	< reporting limit
Method Blank	1 per batch of 20 samples	< reporting limit	Stop analysis; correct problem; reanalyze	LQAO	contamination/bias	< reporting limit
Duplicate sample	1 per SDG	RPD or 20%	flag with the appropriate laboratory qualifier	LQAO	precision/accuracy	RPD or 20%

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-12
QC Samples Table

Matrix	Soil/Sediment
Analytical Group	Wet Chemistry
Concentration Level	Medium
Sampling SOP[1]	A-1, A-2, A-5, G-5
Analytical Method/SOP Reference[2]	Lloyd Kahn/SW-846 9060
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Calibration Blank	following each initail and continuing calibration	< reporting limit	Stop analysis; correct problem; recalibrate	LQAO	contamination/bias	< reporting limit
Method Blank	1 per batch of 20 samples	< reporting limit	Stop analysis; correct problem; reanalyze	LQAO	contamination/bias	< reporting limit
MS/MSD	if requested, 1 per SDG	spike recovery ± 25%; RPD of ≤ 20	flag with the appropriate laboratory qualifier	LQAO	accuracy	spike recovery ± 25%; RPD of ≤ 20
LCS	1 per batch of 20 samples	spike recovery ± 10%	reanalyze	LQAO	accuracy	spike recovery ± 10%
Duplicate sample	1 per SDG	RPD or 20%	flag with the appropriate laboratory qualifier	LQAO	precision/accuracy	RPD or 20%

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-13
QC Samples Table

Matrix	Waters/Groundwater
Analytical Group	Volatile Organic Compounds
Concentration Level	Low/Medium
Sampling SOP[1]	B-1, B-2, B-3, G-2
Analytical Method/SOP Reference[2]	EPA CLP SOM01.1
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per 12-hour period in which samples are analyzed	must meet acceptance criteria for deuterated monitoring compounds and internal standards; all target compound < CRQL, except DCM, acetone and 2-butanone < 2x CRQL	If contaminated, find and eliminate source of contamination. Reanalyze along with any associated samples	LQAO	contamination/bias	must meet acceptance criteria for deuterated monitoring compounds and internal standards; all target compound < CRQL, except DCM, acetone and 2-butanone < 2x CRQL
Instrument Blank	analyze after high concentration sample	must meet all internal standard and DMC criteria; all target compounds < CRQL	reanalyze	LQAO	contamination/bias	must meet all internal standard and DMC criteria; all target compounds < CRQL
Matrix spike/Matrix spike duplicate	if requested, per SDG or per 20 field samples within an SDG	must meet internal standard relative RT criteria; should meet advisory % recovery and RPD criteria in SOM01.1 SOW	No further action required; investigate if repeated failures occur	LQAO	precision/accuracy	must meet internal standard relative RT criteria; should meet advisory % recovery and RPD criteria in SOM01.1 SOW
Storage Blank	1 per SDG	same as method blank	reanalyze	LQAO	conatimination/bias	same as method blank

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-14
QC Samples Table

Matrix	Waters/Groundwater
Analytical Group	Volatile Organic Compounds
Concentration Level	Trace
Sampling SOP[1]	B-1, B-2, B-3, G-2
Analytical Method/SOP Reference[2]	EPA CLP SOM01.1
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per 12-hour period in which samples are analyzed	must meet acceptance criteria for DMC and internal standards; all target compounds must be < CRQL, except DCM, acetone and 2-butanone < 2x CRQL	If contaminated, find and eliminate source of contamination. Reanalyze along with any associated samples	LQAO	contamination/bias	must meet acceptance criteria for DMC and internal standards; all target compounds must be < CRQL, except DCM, acetone and 2-butanone < 2x CRQL
Instrument blank	analyze after high concentration sample	must meet acceptance criteria for DMC and internal standards; all target compounds must be < CRQL	reanalyze	LQAO	contamination/bias	must meet acceptance criteria for DMC and internal standards; all target compounds must be < CRQL
MS/MSD	if requested, per SDG or per 20 field samples in an SDG, whichever is more frequent; not required for SDGs contining only PE samples	must meet internal standard relative RT criteria; should meet advisory % recovery and RPD criteria in SOM01.1 SOW	No further action required; investigate if repeated failures occur	LQAO	precision/accuracy	must meet internal standard relative RT criteria; should meet advisory % recovery and RPD criteria in SOM01.1 SOW
Storage Blank	1 per SDG after all samples in that SDG have been analyzed.	same and method blank	reanalyze	LQAO	contamination	same and method blank

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-15
QC Samples Table

Matrix	Waters/Groundwater
Analytical Group	Semivolatile Organic Compounds
Concentration Level	Low
Sampling SOP[1]	B-1, B-2, G-2
Analytical Method/SOP Reference[2]	EPA CLP SOM01.1
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per extraction batch not to exceed 20 field samples	must meet acceptance criteria for DMC and internal standards; all target compounds < CRQL, except bis-(2-ethylhexyl)phthalate < 5x CRQL	If contaminated, find and eliminate the source. If internal or surrogate standard fail acceptance criteria; reanalyze. If surrogates continue to fail, re-extract and reanalyze along with all associated samples	LQAO	contamination/bias	must meet acceptance criteria for DMC and internal standards; all target compounds < CRQL, except bis-(2-ethylhexyl)phthalate < 5x CRQL
Matrix spike/Matrix spike duplicate	if requested, per 20 field samples; per concentration level	must meet internal standard reletive RT criteria; should meet advisory % recovery and RPD criteria in the SOM01.1 SOW	No further action required; investigate if repeated failures occur	LQAO	precision/accuracy	must meet internal standard reletive RT criteria; should meet advisory % recovery and RPD criteria in the SOM01.1 SOW

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer
DMC = Deuterated Monitoring Compounds

QAPP Worksheet #28-16
QC Samples Table

Matrix	Waters/Groundwater
Analytical Group	Semivolatile Organic Compounds
Concentration Level	Selected Ion Monitoring
Sampling SOP[1]	B-1, B-2, G-2
Analytical Method/SOP Reference[2]	EPA CLP SOM01.1
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per extraction batch not to exceed 20 field samples; analyze on same instruments as samples	DMC and internal standard acceptance criteria must be meet; all target compounds < CRQL except bis-(2-ethylhexyl)phthalate < 5x CRQL	If contaminated, find and eliminate the source. If internal or DMC standard fail acceptance criteria; reanalyze. If DMC continue to fail, re-extract and reanalyze along with all associated samples	LQAO	contamination/bias	DMC and internal standard acceptance criteria must be meet; all target compounds < CRQL except bis-(2-ethylhexyl)phthalate < 5x CRQL
MS/MSD	if requested, per SDG or per 20 field samples in an SDG, whichever is more frequent; not required for SDGs containing only PE samples	must meet relative RT criteria; should meet advisory % recovery and RPD criteria specified in the SOM01.1 SOW	No further action required; investigate if repeated failures occur	LQAO	precision/accuracy	must meet relative RT criteria; should meet advisory % recovery and RPD criteria specified in the SOM01.1 SOW

[1]Reference number from QAPP Worksheet #21.

[2]LQAO = Laboratory Quality Assurance Officer
DMC = Deuterated Monitoring Compounds

QAPP Worksheet #28-17
QC Samples Table

Matrix	Waters/Groundwater
Analytical Group	Explosives
Concentration Level	Medium
Sampling SOP[1]	B-1, B-2, G-2
Analytical Method/SOP Reference[2]	SW-846 8330
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per extraction batch not to exceed 20 field samples	no target compounds > the reporting limit; surrogate recovery must be within the limits of 39-132%	If contaminated, find and eliminate the source. If acceptance criteria not met, reanalyze. If acceptance criteria still not met re-extract and reanalyze along with all associated samples.	LQAO	contamination/bias	no target compounds > the reporting limit; surrogate recovery must be within the limits of 39-132%
LCS	1 per extraction batch not to exceed 20 field samples	surrogate recovery must be within the limits of 39-132%; spike recovery limits must be within the range of 50-150%	reextract and reanalyzed associated samples	LQAO	accuracy/bias	surrogate recovery must be within the limits of 39-132%; spike recovery limits must be within the range of 50-150%
MS/MSD	if requested, 1 per 20 field samples in an SDG	spike recovery limits are 50-150%; RPD limts are 30%	Evaluate LCS; may report with qualifier	LQAO	precision/accuracy	spike recovery limits are 50-150%; RPD limts are 30%

[1]Reference number from QAPP Worksheet #21.

[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-18
QC Samples Table

Matrix	Water/Groundwater
Analytical Group	Explosives
Concentration Level	Medium
Sampling SOP[1]	B-1, B-2, G-2
Analytical Method/SOP Reference	Guidance in DoD Perchlorate Handbook
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per batch not to exceed 20 field samples	no target compounds > 1/2 the reporting limit	If contaminated, find and eliminate the source and reprep and reanalyze the associated samples	LQAO	contamination/bias	no target compounds > 1/2 the reporting limit
Reagent Blank	Prior to calibration and after each batch analyzed	no target compounds > 1/2 the reporting limit	If contaminated, reanalyze reagent blanks until no carryover is observed (<1/2 the reporting limit). Reanlayze all samples processed since the last clean reagent blank.	LQAO	contamination	no target compounds > 1/2 the reporting limit
LCS	1 per batch not to exceed 20 field samples	spike recovery limits must be within the range of 85-115%	reextract and reanalyzed associated samples	LQAO	accuracy/bias	spike recovery limits must be within the range of 85-115%
MS/MSD	if requested, 1 per 20 field samples in an SDG	spike recovery limits are 75-125%; RPD limts are 20%	Evaluate LCS; may report with qualifier and note outliers in the case narrative	LQAO	precision/accuracy	spike recovery limits are 75-125%; RPD limts are 20%

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-19
QC Samples Table

Matrix	Waters/Groundwater
Analytical Group	Organochlorine Pesticides
Concentration Level	Low
Sampling SOP[1]	B-1, B-2, G-2
Analytical Method/SOP Reference[2]	EPA CLP SOM01.1
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per extraction batch not to exceed 20 field samples	target compounds must be < CRQL; surrogates must be within the RT window and within the recovery range of 30-150%	If contaminated, find and eliminate the source. If acceptance criteria not met, reanalyze. If acceptance criteria still not met re-extract and reanalyze along with all associated samples.	LQAO	contamination/bias	target compounds must be < CROL; surrogates must be within the RT window and within the recovery range of 30-150%
Sulfur Cleanup Blank	1 per batch of samples on which sulfur cleanup is performed	target compounds must be < CRQL; surrogates must be within the RT window and within the recovery range of 30-150%	If contaminated, find and eliminate the source. If acceptance criteria not met, reanalyze. If acceptance criteria still not met re-extract and reanalyze along with all associated samples.	LQAO	contamination/bias	target compounds must be < CRQL; surrogates must be within the RT window and within the recovery range of 30-150%
Instrument Blank	1 to initiate each 12-hour analytical sequence	target compounds must be < CRQL; surrogates must be within the RT windows	reanalyze	LQAO	contamination/bias	target compounds must be < CROL; surrogates must be within the RT windows
Laboratory Control Sample	1 per SDG	surrogate must be within the RT windows and within the recovery range of 30-150%; spike recoveries must be within the range specified in the SOM01.1 SOW	re-extract and reanalyze along with any associated samples	LQAO	accuracy	surrogate must be within the RT windows and within the recovery range of 30-150%; spike recoveries must be within the range specified in the SOM01.1 SOW
Matrix spike/Matrix spike duplicate	per 20 field samples in an SDG	surrogates must be within RT windows; should meet advisory % recovery and RPD critieria in the SOM01.1 SOW	No further action required; investigate if repeated failures occur	LQAO	precision/accuracy	surrogates must be within RT windows; should meet advisory % recovery and RPD critieria in the SOM01.1 SOW

[1] Reference number from QAPP Worksheet #21.
[2] LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-20
QC Samples Table

Matrix	Waters/Groundwater
Analytical Group	Polychlorinated Biphenyls
Concentration Level	Low
Sampling SOP[1]	B-1, B-2, G-2
Analytical Method/SOP Reference[2]	EPA CLP SOM01.1
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per extraction batch not to exceed 20 field samples	target compounds must be < CRQL; surrogates must be within the RT window and within the recovery range of 30-150%	If contaminated, find and eliminate the source. If acceptance criteria not met, reanalyze. If acceptance criteria still not met re-extract and reanalyze along with all associated samples.	LQAO	contamination/bias	target compounds must be < CRQL; surrogates must be within the RT window and within the recovery range of 30-150%
Sulfur Cleanup Blank	1 per batch of samples on which sulfur cleanup is performed	target compounds must be < CRQL; surrogates must be within the RT window and within the recovery range of 30-150%	If contaminated, find and eliminate the source. If acceptance criteria not met, reanalyze. If acceptance criteria still not met re-extract and reanalyze along with all associated samples.	LQAO	contamination/bias	target compounds must be < CRQL; surrogates must be within the RT window and within the recovery range of 30-150%
Instrument Blank	1 to initiate each 12-hour analytical sequence	target compounds must be < CRQL; surrogates must be within the RT window	reanalyze	LQAO	contamination/bias	target compounds must be < CRQL; surrogates must be within the RT windows
Laboratory Control Sample	1 per SDG	surrogate must be within the RT window and within the recovery range of 30-150%; spike recoveries must be within the range specified in the SOM01.1 SOW	re-extract and reanalyze along with any associated samples	LQAO	accuracy	surrogate must be within the RT window and within the recovery range of 30-150%; spike recoveries must be within the range specified in the SOM01.1 SOW
Matrix Spike/Matrix Spike Duplicate	per 20 field samples in an SDG	surrogates must be within RT windows; should meet advisory % recovery and RPD limits stated in the SOM01.1 SOW	If sufficent sample volume, reanalyze	LQAO	precision/accuracy	surrogates must be within RT windows; should meet advisory % recovery and RPD limits stated in the SOM01.1 SOW

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-21
QC Samples Table

Matrix	Waters/Groundwater
Analytical Group	Metals
Concentration Level	Low/Medium
Sampling SOP[1]	B-1, B-2, B-4, B-5, G-2, G-3
Analytical Method/SOP Reference[2]	EPA CLP ILM05.3
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
CRQL Check Standard (CRI)	1 at the beginning and end of each sample analysis sequence not to exceed 20 analytical samples, including the CRI	analyte recovery must fall within the imits of 70-130% (50-150 for antimony, lead, and thallium)	Stop analysis; correct problem; reanalyze CRI and associated samples	LQAO	accuracy	analyte recovery must fall within the limits of 70-130% (50-150 for antimony, lead, and thallium)
Calibration Blank	Follow each initial and continuing calibration; every 2 hours or every 10 analytical samples, whichever is more frequent	absolute values of all analyte concentrations must be < the CRQL	Stop analysis; correct problem; recalibrate	LQAO	contamination/bias	All analytes must be < the CRQL
Preparation blank	1 per digestion batch	absolute values of all analyte concentrations must be ≤ the CRQL	re-prepare and reanalyze; except if concentration of analyte(s) in all associated samples is > 10x the concentation in the blank	LQAO	contamination/bias	absolute values of all analyte concentrations must be ≤ the CRQL
Interference Check Sample (ICS)	Follow the CRI at the beginning and end of the analytical sequence not to exceed 20 analytical samples, including the CRI, and the ICS; not required for Mercury and Cyanide analyses	must be within ± 2x the CRQL of the analyte's true value or ± 20% of the analyte's true value, whichever is greater	Check system. Correct problem. Recalibrate	LQAO	accuracy/bias	must be within ± 2x the CRQL of the analyte's true value or ± 20% of the analyte's true value, whichever is greater
Matrix Spike	1 per SDG	spike recovery limits are 75-125%	Flag data with an "N" and analyze a post digestion spike, unless recovery is > 4x the spike added	LQAO	accuracy/bias	spike recovery limits are 75-125%
LCS	1 per digestion batch not to exceed 20 field samples	must meet the recovery limits of 20% of the true value	re-prepare and reanalyze digestion batch	LQAO	accuracy	must meet the recovery limits of 20% of the true value
Duplicate Sample	1 per SDG	RPD of 20%, if concentration is > 5x CRQL; or ± the CRQL if the concentration is < 5x CRQL	flag data with a "*"	LQAO	precision/accuracy	RPD of 20%, if concentration is > 5x CRQL; or ± the CRQL if the concentration is < 5x CRQL
Serial Dilution	1 per SDG; not required for Mercury and Cyanide analyses	should agree within 10% of the original sample	flag data with an "E"	LQAO	precision/accuracy	should agree within 10% of the undiluted sample

[1] Reference number from QAPP Worksheet #21.
[2] LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-22
QC Samples Table

Matrix	Waters/Groundwater
Analytical Group	Total Petroleum Hydrocarbons
Concentration Level	Medium
Sampling SOP[1]	B-1, B-2, G-2
Analytical Method/SOP Reference[2]	SW-846 8015M
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per 12-hour analytical batch of not more than 20 field samples for GRO; 1 per extraction batch of not more than 20 field samples for DRO	all petroleum hydrocarbons must be < the reporting limit	re-prepare and reanalyze batch; If any petroleum hydrocarbons detected at concentrations between the MDL and the reporting limit, find and correct the problem; flag associated data with a "B"	LQAO	contimination/bias	all petroleum hydrocarbons must be < the reporting limit
LCS	1 per 12-hour analytical batch of not more than 20 field samples for GRO; 1 per extraction batch of not more than 20 field samples for DRO	must meet the recovery limits of 50-139 for DRO; must meet recovery limits of 63-110 for GRO	re-prepare and reanalyze batch	LQAO	accuracy	must meet the recovery limits of 50-150 for DRO; must meet recovery limits of 75-110 for GRO
MS/MSD	if requested, 1 pair per SDG	should meet the spike recovery limits of 50-142 and RPD of 20 for GRO; should meet the spike recovery limits fo 50-150 fand RPD of 25 for DRO	may report with data qualifier	LQAO	accuracy/precision	should meet the spike recovery limits of 50-142 and RPD of 20 for GRO; should meet the spike recovery limits fo 50-150 fand RPD of 25 for DRO

[1] Reference number from QAPP Worksheet #21.
[2] LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-23
QC Samples Table

Matrix	Waters/Groundwater
Analytical Group	Wet Chemistry
Concentration Level	Medium
Sampling SOP[1]	B-1, B-2, G-2
Analytical Method/SOP Reference[2]	MCAWW 160.2
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Calibration Blank	following each initial and continuing calibration; every 10 samples	< reporting limit	Stop analysis; correct prolbem; recalibrate	LQAO	contamination/bias	< reporting limit
Method Blank	1 per batch of 20 field samples	< reporting limit	Stop analysis; correct prolbem; recalibrate	LQAO	contamination/bias	< reporting limit
MS/MSD	if requested, 1 per SDG	spike recovery limits of 20% RPD of 20%	flag with the appropriate laboratory qualifier	LQAO	precision/accuracy	spike recovery limits ± 20%; RPD of 20%
Method Blank	1 per batch of 20 field samples	< reporting limit	reanalyze	LQAO	contamination/bias	< reporting limit
LCS	1 per batch of 20 field samples	spike revcovery limits ± 10%	reanalyze	LQAO	accuracy	spike revcovery limits ± 10%
Duplicate	1 per SDG	RPD limits 20%	flag with the appropriate laboratory qualifier	LQAO	precision	RPD limits 20%

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-24
QC Samples Table

Matrix	Waters/Groundwater
Analytical Group	Wet Chemistry
Concentration Level	Medium
Sampling SOP[1]	B-1, B-2, G-2
Analytical Method/SOP Reference[2]	MCAWW 130.2
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Calibration Blank	following each initial and continuing calibration; every 10 samples	< reporting limit	Stop analysis; correct prolbem; recalibrate	LQAO	contamination/bias	< reporting limit
Method Blank	1 per batch of 20 field samples	< reporting limit	Stop analysis; correct prolbem; recalibrate	LQAO	contamination/bias	< reporting limit
LCS	1 per batch of 20 field samples or each SDG, whichever is more frequent	spike recovery limits 75-120% for method 130.1	reanalyze	LQAO	accuracy	spike recovery limits ± 10%
MS/MSD	if requested, 1 per SDG	spike recovery limits ± 20%	flag with the appropriate laboratory qualifier	LQAO	precision/accuracy	spike recovery limits ± 20%; RPD of 20%
Method Blank	1 per batch of 20 field samples	< reporting limit	reanalyze	LQAO	contamination/bias	< reporting limit
Duplicate	1 per SDG	RPD limits 20%	flag with the appropriate laboratory qualifier	LQAO	precision	RPD limits 20%

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #28-25
QC Samples Table

Matrix	Waters/Groundwater
Analytical Group	Wet Chemistry
Concentration Level	Medium
Sampling SOP[1]	B-1, B-2, G-2
Analytical Method/SOP Reference[2]	EPA 300.0
Field Team Leader	Stephen Brand/CH2M HILL
Field Sampling Organization	CH2M HILL
Analytical Organization[2]	TBD
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action[2]	Data Quality Indicator (DQI)	Measurement Performance Criteria
Calibration Blank	following each initial and continuing calibration; every 10 samples	< reporting limit	Stop analysis; correct prolbem; recalibrate	LQAO	contamination/bias	< reporting limit
Method Blank	1 per batch of 20 field samples	< reporting limit	Stop analysis; correct prolbem; recalibrate	LQAO	contamination/bias	< reporting limit
LCS	1 per batch of 20 field samples or each SDG, whichever is more frequent	spike recovery limits ± 10%	reanalyze	LQAO	accuracy	spike recovery limits ± 10%
MS/MSD	if requested, 1 per SDG	spike recovery limits of 20%; RPD of 20%	flag with the appropriate laboratory qualifier	LQAO	precision/accuracy	spike recovery limits ± 20%; RPD of 20%
Method Blank	1 per batch of 20 field samples	< reporting limit	reanalyze	LQAO	contamination/bias	< reporting limit
Duplicate	1 per SDG	RPD limits 20%	flag with the appropriate laboratory qualifier	LQAO	precision	RPD limits 20%

[1]Reference number from QAPP Worksheet #21.
[2]LQAO = Laboratory Quality Assurance Officer

QAPP Worksheet #29
Project Documents and Records Table

Sample Collection Documents and Records	Onsite Analysis Documents and Records	Offsite Analysis Documents and Records	Data Assessment Documents and Records	Other
Field Notebooks	PID/FID readings, recorded in field logbooks as they are collected.	Sample Receipt, Custody, and Tracking Records	Field Sampling Audit Checklists	
Chain-of-Custody Records	Water quality parameters collected during groundwater sampling will be recorded into field notebooks or logbooks	Standard Traceability Logs	Field Analysis Audit Checklists	
Air Bills	OVM/OVA readings will be recorded during drilling activities onto boring logs in bound notebooks.	Equipment Calibration Logs	Fixed Laboratory Audit Checklists	
Custody Seals	All field measurements will be recorded into field notebooks or logbooks	Sample Prep Logs	Data Validation Reports	
Telephone Logs	All sample shipping forms will be saved for the project files.	Run Logs	Corrective Action Forms	
Corrective Action Forms	All COCs will be copied and saved in the project files.	Equipment Maintenance, Testing, and Inspection Logs	Telephone Logs	
	All equipment calibration logs will be recorded daily in project notebooks or logbooks.	Corrective Action Forms	RI reports	
	Pertinent telephone conversations will be recorded in a field logbook.	Reported Field Sample Results	EE/CAs	
	Equipment maintenance records should be included with the unit that is shipped.	Reported Results for Standards, QC Checks, and QC Samples	FS reports	

Sample Collection Documents and Records	Onsite Analysis Documents and Records	Offsite Analysis Documents and Records	Data Assessment Documents and Records	Other
		Instrument Printouts (raw data) for Field Samples, Standards, QC Checks, and QC Samples		
		Data Package Completeness Checklists		
		Sample Disposal Records		
		Telephone Logs		
		Extraction/Clean-up Records		
		Raw Data (stored on disk or CD-R)		
Site Specific Work Plans				

QAPP Worksheet #30
Analytical Services Table

Matrix	Analytical Group	Concentration Level	Sample Locations/ID Numbers	Analytical SOP	Data Package Turnaround Time	Laboratory/Organization (Name and Address, Contact Person and Telephone Number)	Backup Laboratory/Organization (Name and Address, Contact Person and Telephone Number)
Soil/ Sediment	Volatiles	Low/Medium		TBD	28 Days	TBD	N/A
Soil/ Sediment	Semivolatiles	Low/Medium		TBD	28 Days	TBD	N/A
Soil/ Sediment	Organochlorine Pesticides	Low/Medium		TBD	28 Days	TBD	N/A
Soil/ Sediment	PCBs	Low/Medium		TBD	28 Days	TBD	N/A
Soil/ Sediment	Total Petroleum Hydrocarbon	Medium		TBD	28 Days	TBD	N/A
Soil/ Sediment	Explosives	Medium		TBD	28 Days	TBD	N/A
Soil/ Sediment	Perchlorate	Medium		TBD	28 Days	TBD	N/A
Soil/ Sediment	Metals	Medium		TBD	28 Days	TBD	N/A
Soil/ Sediment	Cyanide	Medium		TBD	28 Days	TBD	N/A
Soil/ Sediment	pH	Medium		TBD	28 Days	TBD	N/A
Soil/ Sediment	Redox Potential	Medium		TBD	28 Days	TBD	N/A

QAPP Worksheet #30
Analytical Services Table

Matrix	Analytical Group	Concentration Level	Sample Locations/ID Numbers	Analytical SOP	Data Package Turnaround Time	Laboratory/Organization (Name and Address, Contact Person and Telephone Number)	Backup Laboratory/Organization (Name and Address, Contact Person and Telephone Number)
Soil/ Sediment	Cation Exchange Capacity	Medium		TBD	28 Days	TBD	N/A
Soil/ Sediment	Total Organic Carbon	Medium		TBD	28 Days	TBD	N/A
Waters/ Groundwater	Volatiles	Low, Low/Medium		TBD	28 Days	TBD	N/A
Waters/ Groundwater	Semi-Volatiles	Low, Low/Medium		TBD	28 Days	TBD	N/A
Waters/ Groundwater	Organochlorine Pesticides	Low, Low/Medium		TBD	28 Days	TBD	N/A
Waters/ Groundwater	PCBs	Low, Low/Medium		TBD	28 Days	TBD	N/A
Waters/ Groundwater	Total Petroleum Hydrocarbon	Medium		TBD	28 Days	TBD	N/A
Waters/ Groundwater	Explosives	Medium		TBD	28 Days	TBD	N/A
Waters/ Groundwater	Perchlorate	Medium		TBD	28 Days	TBD	N/A
Waters/ Groundwater	Metals	Medium		TBD	28 Days	TBD	N/A
Waters/ Groundwater	Cyanide	Medium		TBD	28 Days	TBD	N/A
Waters/ Groundwater	Total Suspended Solids	Medium		TBD	28 Days	TBD	N/A

QAPP Worksheet #30
Analytical Services Table

Matrix	Analytical Group	Concentration Level	Sample Locations/ID Numbers	Analytical SOP	Data Package Turnaround Time	Laboratory/Organization (Name and Address, Contact Person and Telephone Number)	Backup Laboratory/Organization (Name and Address, Contact Person and Telephone Number)
Waters/ Groundwater	Hardness	Medium		TBD	28 Days	TBD	N/A
Waters/ Groundwater	Ion Chromatography	Medium		TBD	28 Days	TBD	N/A

QAPP Worksheet #31
Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for…			
				Performing Assessment (Title and Organizational Affiliation)	Responding to Assessment Findings (Title and Organizational Affiliation)	Identifying and Implementing Corrective Actions (CA) (Title and Organizational Affiliation)	Monitoring Effectiveness of CA (Title and Organizational Affiliation)
Field Sampling Technical Systems Audit	1 / At sampling startup	Internal	CH2M HILL	Project QA Officer – CH2M HILL	Field Team Lead – CH2M HILL	Field Team Lead – CH2M HILL	Project QA Officer – CH2M HILL
Offsite Laboratory Technical Systems Audit	1 / Prior to sampling startup	External	U.S. Navy	Project QA Officer – Pati Moreno/NFESC, Port Hueneme, CA	Lab's QA Officer – TBD	Lab's QA Officer – TBD	Project QA Officer – CH2M HILL

Worksheet #31-2
Corrective Action Form

Person initiating corrective action _____ Date _____

Description of problem and when identified: _____

_____

_____

Cause of problem, if known or suspected: _____

_____

_____

_____

Sequence of Corrective Action (CA): (including date implemented, action planned and personnel/data affected) _____

_____

_____

_____

_____

_____

_____

_____

CA implemented by: _____ Date: _____

CA initially approved by: _____ Date: _____

Follow-up date: _____

Final CA approved by: _____ Date: _____

Information copies to:

_____

_____

_____

_____

QAPP Worksheet #32
Assessment Findings and Response Actions

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, Org.)	Timeframe for Response
Field Performance Audit Checklist	Written Audit Report	Project Manager, CH2M HILL	Within one week of audit	Corrective action(s) for field performance will be recorded on the Field Performance Audit Checklist	Field Team Leader, CH2M HILL	Within one week of receipt of Corrective Action Form
Laboratory Performance and Systems Audits	Written Audit Report	Laboratory QA Manager	Within two months of the audit	Memorandum	NFESC Auditor	Within two months of receipt of response

Worksheet #32-2
Field Performance Audit Checklist

Project Responsibilities

Project No.: _____ Date: _____

Project Location: _____ Signature: _____

Team Members:

Yes __ No __ 1) Is the approved SAP being followed?
Comments _____

_____

Yes __ No __ 2) Was a briefing held for project participants?
Comments _____

_____

Yes __ No __ 3) Were additional instructions given to project participants?
Comments _____

_____

Sample Collection

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

_____

Yes __ No __ 2) Are samples collected as stated in the FSP?
Comments _____

_____

Yes __ No __ 3) Are samples collected in the type of containers specified in the FSP?
Comments _____

_____

Worksheet 32-2

FIELD PERFORMANCE AUDIT CHECKLIST
(Continued)

Yes __ No __ 4) Are samples preserved as specified in the FSP?
Comments _____

_____

Yes __ No __ 5) Are the number, frequency, and type of samples collected as specified in the FSP?
Comments _____

_____

Yes __ No __ 6) Are quality assurance checks performed as specified in the FSP?
Comments _____

_____

Yes __ No __ 7) Are photographs taken and documented as specified in the FSP?
Comments _____

_____

Document Control

Yes __ No __ 1) Have any accountable documents been lost?
Comments _____

_____

Yes __ No __ 2) Have any accountable documents been voided?
Comments _____

_____

Yes __ No __ 3) Have any accountable documents been disposed of?
Comments _____

Worksheet 32-2

FIELD PERFORMANCE AUDIT CHECKLIST
(Continued)

Yes __ No __ 4) Are the samples identified with sample tags?
Comments _____

_____

Yes __ No __ 5) Are blank and duplicate samples properly identified?
Comments _____

_____

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

_____

Yes __ No __ 7) Is chain-of-custody documented and maintained?
Comments _____

_____

QAPP Worksheet #33
QA Management Reports Table

Type of Report	Frequency (Daily, Weekly Monthly, Quarterly, Annually, Etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (Title and Organizational Affiliation)	Report Recipient(s) (Title and Organizational Affiliation)
Field Audit Report	One during major events	Submitted with project-specific Reports	Field Team Assessor CH2M HILL	Included in project-specific reports. See Worksheet #3 for distribution list.
Data Usability Assessment Report	One after all data are generated and validated	Submitted with project-specific Reports	Mark Stinnett/Project Chemist CH2M HILL	Included in project-specific reports. See Worksheet #3 for distribution list.
Project-specific Reports	One after QA reports and Risk Assessments are completed	TBD	John Swenfurth and Stephen Brand/ Project Managers CH2M HILL	See Worksheet #3 for distribution list.

QAPP Worksheet #34
Verification (Step I) Process Table

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Organization)
Chain-of-custody and shipping forms	Chain-of-custody forms and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the chain-of-custody will be initialed by the reviewer, a copy of the chain-of-custody retained in the site file, and the original and remaining copies taped inside the cooler for shipment. See chain-of-custody SOP for further details.	I	Stephen Brand CH2M HILL Chelsea Bennet CH2M HILL
Audit Reports	Upon report completion, a copy of all audit reports will be placed in the site file. If corrective actions are required, a copy of the documented corrective action taken will be attached to the appropriate audit report in the QA site file. Periodically, and at the completion of site work, site file audit reports and corrective action forms will be reviewed internally to ensure that all appropriate corrective actions have been taken and that corrective action reports are attached. If corrective actions have not been taken, the site manager will be notified to ensure action is taken. Audit reports will be included in the QA Assessment section of the final RI report.	I	Anita Dodson CH2M HILL
Field Notebooks	Field notes will be reviewed internally and placed in the site file.	I	John Swenfurth CH2M HILL
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal. All received data packages will be verified externally by the third party validator. Also, the data will be validated by an Environmental Information System (EIS) specialist and a Chemist according to the data validation procedures specified in Worksheet #6.	I E, I	Laboratory QA Officer Data validation contractor Chelsea Bennet (EIS) Mark Stinnett (Chemist)

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

Step IIa/IIb	Validation Input	Description	Responsible for Validation (Name, Organization)
IIb	Onsite Screening	All onsite analytical data will be reviewed against QAPP requirements for completeness and accuracy based on the field calibrations records.	Field Team Leader, CH2M HILL
IIa	SOPs	Ensure that all sampling and analytical SOPs were followed	Field Team Leader, CH2M HILL
Ia	Documentation of Method QC Results	Establish that all required QC samples were run and met required limits.	Selected third-party data validation contractor
IIb	Documentation of QAPP QC Sample Results	Establish that all required QAPP QC samples were run and met required limits	CH2M HILL QA officer and selected third-party data validation contractor
IIb	Project Quantification Limits	Ensure all sample results met the project quantification limit specified in the QAPP.	Project Chemist, CH2M HILL
IIa	Raw Data	10 percent review of raw data to confirm laboratory calculations.	Selected third-party data validation contractor

QAPP Worksheet #36
Validation (Steps IIa and IIb) Summary Table

Step IIa/IIb	Matrix	Analytical Group	Concentration Level	Validation Criteria[1]	Data Validator (Title and Organizational Affiliation)
IIa	Soil/Sediment, Waters/Groundwater	Volatiles	Low/Medium	CLP Organics Data Review and Preliminary Review (SOP HW-6, Revision 12, March 1993)	Selected third-party data validation contractor
IIa	Waters/Groundwater	Volatiles	Low	Organic Data Review for Low Concentration Water (HW-13, Revision 3.2, July 2001)	Selected third-party data validation contractor
IIa	Soil/Sediment, Waters/Groundwater	Semi-Volatiles	Low/Medium	CLP Organics Data Review and Preliminary Review (SOP HW-6, Revision 12, March 1993)	Selected third-party data validation contractor
IIa	Waters/Groundwater	Semi-Volatiles	Low	Organic Data Review for Low Concentration Water (HW-13, Revision 3.2, July 2001)	Selected third-party data validation contractor
IIa	Soil/Sediment, Waters/Groundwater	Organochlorine Pesticides	Low, Low/Medium	CLP Organics Data Review and Preliminary Review (SOP HW-6, Revision 12, March 1993)	Selected third-party data validation contractor
IIa	Soil/Sediment, Waters/Groundwater	PCBs	Low, Low/Medium	CLP Organics Data Review and Preliminary Review (SOP HW-6, Revision 12, March 1993)	Selected third-party data validation contractor
IIa	Soil/Sediment, Waters/Groundwater	Total Petroleum Hydrocarbon	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor
IIa	Soil/Sediment, Waters/Groundwater	Explosives	Medium	Nitroaromatics and Nitroamines by HPLC (HW-16, Revision 1.3, September 1994)	Selected third-party data validation contractor

QAPP Worksheet #36
Sampling and Analysis Validation Steps IIa and IIb) Summary Table

Step IIa/IIb	Matrix	Analytical Group	Concentration Level	Validation Criteria[1]	Data Validator (Title and Organizational Affiliation)
IIa	Soil/Sediment, Waters/Groundwater	Perchlorate	Medium	DoD Perchlorate Handbook, March 2006 along with the specific laboratory SOP	Selected third-party data validation contractor
IIa	Soil/Sediment, Waters/Groundwater	Metals	Medium	Evaluation of Metals Data for the CLP Program (SOP HW-2, Revision 13 for ILM05.3, September 2005)	Selected third-party data validation contractor
IIa	Soil/Sediment, Waters/Groundwater	Cyanide	Medium	Evaluation of Metals Data for the CLP Program (SOP HW-2, Revision 13 for ILM05.3, September 2005)	Selected third-party data validation contractor
IIa	Soil/Sediment	pH	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor
IIa	Soil/Sediment	Redox potential	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor
IIa	Soil/Sediment	Cation Exchange Capacity	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor
IIa	Soil/Sediment	Total Organic Carbon	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor
IIa	Waters/Groundwater	Total Suspended Solids	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor
IIa	Waters/Groundwater	Hardness	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor

QAPP Worksheet #36
Sampling and Analysis Validation Steps IIa and IIb) Summary Table

Step IIa/IIb	Matrix	Analytical Group	Concentration Level	Validation Criteria[1]	Data Validator (Title and Organizational Affiliation)
IIa	Waters/Groundwater	Ion Chromatography	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor
IIb	Soil/Sediment, Waters/Groundwater	Volatiles	Low/Medium	CLP Organics Data Review and Preliminary Review (SOP HW-6, Revision 12, March 1993)	Selected third-party data validation contractor
IIb	Waters/Groundwater	Volatiles	Low	Organic Data Review for Low Concentration Water (HW-13, Revision 3.2, July 2001)	Selected third-party data validation contractor
IIb	Soil/Sediment, Waters/Groundwater	Semi-Volatiles	Low/Medium	CLP Organics Data Review and Preliminary Review (SOP HW-6, Revision 12, March 1993)	Selected third-party data validation contractor
IIb	Waters/Groundwater	Semi-Volatiles	Low	Organic Data Review for Low Concentration Water (HW-13, Revision 3.2, July 2001)	Selected third-party data validation contractor
IIb	Soil/Sediment, Waters/Groundwater	Organochlorine Pesticides	Low, Low/Medium	CLP Organics Data Review and Preliminary Review (SOP HW-6, Revision 12, March 1993)	Selected third-party data validation contractor
IIb	Soil/Sediment, Waters/Groundwater	PCBs	Low, Low/Medium	CLP Organics Data Review and Preliminary Review (SOP HW-6, Revision 12, March 1993)	Selected third-party data validation contractor
IIb	Soil/Sediment, Waters/Groundwater	Total Petroleum Hydrocarbon	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor
IIb	Soil/Sediment, Waters/Groundwater	Explosives	Medium	Nitroaromatics and Nitroamines by HPLC (HW-16, Revision 1.3, September 1994)	Selected third-party data validation contractor

QAPP Worksheet #36
Sampling and Analysis Validation Steps IIa and IIb) Summary Table

Step IIa/IIb	Matrix	Analytical Group	Concentration Level	Validation Criteria[1]	Data Validator (Title and Organizational Affiliation)
IIb	Soil/Sediment, Waters/Groundwater	Perchlorate	Medium	DoD Perchlorate Handbook, March 2006 along with the specific laboratory SOP	Selected third-party data validation contractor
IIb	Soil/Sediment, Waters/Groundwater	Metals	Medium	Evaluation of Metals Data for the CLP Program (SOP HW-2, Revision 13 for ILM05.3, September 2005)	Selected third-party data validation contractor
IIb	Soil/Sediment, Waters/Groundwater	Cyanide	Medium	Evaluation of Metals Data for the CLP Program (SOP HW-2, Revision 13 for ILM05.3, September 2005)	Selected third-party data validation contractor
IIb	Soil/Sediment	pH	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor
IIb	Soil/Sediment	Redox potential	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor
IIb	Soil/Sediment	Cation Exchange Capacity	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor
IIb	Soil/Sediment	Total Organic Carbon	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor
IIb	Waters/Groundwater	Total Suspended Solids	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor
IIb	Waters/Groundwater	Hardness	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor

QAPP Worksheet #36
Sampling and Analysis Validation Steps IIa and IIb) Summary Table

Step IIa/IIb	Matrix	Analytical Group	Concentration Level	Validation Criteria[1]	Data Validator (Title and Organizational Affiliation)
IIb	Waters/Groundwater	Ion Chromatography	Medium	EPA National Functional Guidelines for Data Review (Organic and Inorganic) SOPs	Selected third-party data validation contractor

Note: [1] Regional data validation guidance takes precedence over EPA National Functional Guidelines whenever applicable.

QAPP Worksheet #37
Usability Assessment

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

It is the joint responsibility of the contractor Project Chemist and the data validators to ensure that the data meet the method detection limits, reporting limits, and laboratory QC limits listed in this MPP and the laboratory SOW. In this approach, the entire analytical process is reconstructed and recalculated from the raw data, non-conformances are documented, and the data are qualified for use in decision making

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

In-depth assessment occurs during the data validation process. The third-party validation contractor will follow the national EPA and Region II data validation guidance for the EPA CLP program to assess conformance with the quality control limits. Regional guidance takes precedence over National guidance. National guidance will be used for validation when Regional guidance isn't available. The findings of the data validation reports and the qualifiers applied to the data will be considered in context with field logs and corrective action reports to assess overall usability.

Identify the personnel responsible for performing the usability assessment:

Project Chemist, CH2M HILL

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

The data validation reports will identify precision and accuracy outliers with respect to the laboratory performance for each batch of samples, as well as comparability of field and lab duplicates. All the results will be assembled and statistically reported for an overall quality assessment provided in the final project event report. Discussion will cover completeness and representativeness. Attachments supporting this report will include data validation narratives, corrective action forms, and field audit reports.

ATTACHMENT 1

Field Standard Operating Procedures

Contents for Attachment 1 Standard Field Operating Procedures

A. Soil Sampling

A-1 Shallow Soil Sampling
A-2 Soil Sampling
A-3 Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils
A-4 Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
A-5 Homogenization of Soil and Sediment Samples
A-6 Soil Sampling for VOCs Using the Encore® Sampler
A-7 Soil Boring Sampling-Split Spoon
A-8 Direct-Push Soil Sample Collection
A-9 Standard Practice for Description and Identification of Soils
A-10 Soil Boring Drilling and Abandonment

B. Groundwater Sampling

B-1 Groundwater Sampling Procedure Low Stress (low Flow) Purging and Sampling
B-2 Direct-Push Groundwater Sample Collection
B-3 VOC Sampling - Water
B-4 Preserving Non-VOC Aqueous Samples

C. Field Instruments

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SOPs in this section:

A-1 Shallow Soil Sampling
A-2 Soil Sampling
A-3 Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils
A-4 Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
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A-7 Soil Boring Sampling-Split Spoon
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A. SOIL SAMPLING

STANDARD OPERATING PROCEDURE A-1

Shallow Soil Sampling

I. Purpose

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

II. Scope

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

III. Equipment and Materials

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

IV. Procedures and Guidelines

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

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

1. For samples on a grid:

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

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

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

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

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

2. For non-grid samples:

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

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

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

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

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

D. To collect samples:

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

2. If sampling:

a. Surface soil: Obtain soil sample by scooping soil using the augering scoop/trowel, starting from the surface and digging

down to a depth of about 6 inches, or the depth specified in the workplan.

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

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

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

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

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

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

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

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

V. Attachments

Shallow Soil Boring Log form.

VI. Key Checks and Items

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

CH2MHILL

PROJECT NUMBER	BORING NUMBER
	SHEET 1 OF 1

SHALLOW SOIL BORING LOG

PROJECT : LOCATION : DATE:

WEATHER: DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVELS : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole
0						
1						
2						
3						
4						
5						

Sampler Signature: _____ Date: _____

STANDARD OPERATING PROCEDURE A-2

Soil Sampling

I. Purpose and Scope

The purpose of this procedure is to provide guidelines for obtaining samples of surface and subsurface soils using hand and drilling-rig mounted equipment.

II. Equipment and Materials

- Stainless-steel trowel, shovel, scoopula, coring device, trier, hand auger, or other appropriate hand tool
- Stainless-steel, split-spoon samplers
- Thin-walled sampling tubes
- Drilling rig or soil-coring rig
- Stainless-steel pan or bowl
- Sample bottles

III. Procedures and Guidelines

Before sampling begins, equipment will be decontaminated using the procedures described in SOP *Decontamination of Drilling Rigs and Equipment*. The sampling point is located and recorded in the field logbook. Debris should be cleared from the sampling location.

A. Surface and Shallow Subsurface Sampling

A shovel, post-hole digger, or other tool can be used to remove soil to a point just above the interval to be sampled. A decontaminated sampling tool will be used to collect the sample when the desired sampling depth has been reached. Soil for semivolatile organic and inorganic analyses is placed in the bowl and mixed; soil for volatile organic analysis is not mixed or composited but is placed directly into the appropriate sample bottles. A stainless-steel or dedicated wooden tongue depressor is used to transfer the sample from the bowl to the container.

The soils removed from the borehole should be visually described in the field log book, including approximated depths.

When sampling is completed, photo-ionization device (PID) readings should be taken directly above the hole, and the hole is then backfilled.

More details are provided in the SOP *Shallow Soil Sampling*.

B. Split-Spoon Sampling

Using a drilling rig, a hole is advanced to the desired depth. For split-spoon sampling, the samples are then collected following the ASTM D 1586 standard (attached). The sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically this is 24 inches. The sampler is driven in 6-inch increments using a 140-pound weight (``hammer'') dropped from a height of 30 inches. The number of hammer blows for each 6-inch interval is counted and recorded. To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch ID sampler may be required. Blow counts obtained with a 3-inch ID spoon would not conform to ASTM D 1586 and would therefore not be used for geotechnical evaluations.

Once retrieved from the hole, the sampler is carefully split open. Care should be taken not to allow material in the sampler to fall out of the open end of the sampler. To collect the sample, the surface of the sample should be removed with a clean tool and disposed of. Samples collected for volatiles analysis should be placed directly into the sample containers from the desired depth in the split spoon. Material for samples for all other parameters should be removed to a decontaminated stainless steel tray. The sample for semivolatile organic and inorganic analyses should be homogenized in the field by breaking the sample into small pieces and removing gravel. The homogenized sample should be placed in the sample containers. If sample volume requirements are not met by a single sample collection, additional sample volume may be obtained by collecting a sample from below the sample and compositing the sample for non-volatile parameters only.

Split-spoon samples also will be collected using a tripod rig. When using a tripod rig the soil samples are collected using an assembly similar to that used by the drilling rig.

C. Thin-Walled Tube Sampling

Undisturbed samples may be collected for analysis for geotechnical parameters such as vertical hydraulic conductivity. These samples will be collected using thin-walled sampling tubes (sometimes called Shelby tubes) according to ASTM D 1587 (attached). Tubes will be 24- to 36 inches long and 3- to 4-inches in diameter, depending upon the quantity of sample required. Undisturbed samples will be obtained by smoothly pressing the sampling tube through the interval to be sampled using the weight of the drilling rig. Jerking the sample should be avoided. Once the sample is brought to the surface, the ends will be sealed with bees wax and then sealed with end caps and heavy tape. The sample designation, data and time of sampling, and the up direction will be noted on the sampling tube. The tube shall be kept upright as much as possible and will be protected from freezing, which could disrupt the undisturbed nature of the sample.

Samples for analysis normally are not collected from thin-walled tube samples.

IV. Attachments

ASTM D 1586 *Standard Penetration Test Method for Penetration Test and Split-Barrel Sampling of Soils*

ASTM D 1587 *Standard Practice for Thin-Walled Tube Sampling of Soils*

Soil Boring Log form

V. Key Checks and Preventative Maintenance

- Check that decontamination of equipment is thorough.
- Check that sample collection is swift to avoid loss of volatile organics during sampling.

Designation: D 1586 – 99

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Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.

1.2 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific precautionary statement, see 5.4.1.

1.3 The values stated in inch-pound units are to be regarded as the standard.

NOTE 1—Practice D 6066 can be used when testing loose sands below the water table for liquefaction studies or when a higher level of care is required when drilling these soils. This practice provides information on drilling methods, equipment variables, energy corrections, and blow-count normalization.

2. Referenced Documents

2.1 *ASTM Standards:*

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

D 4633 Test Method for Stress Wave Energy Measurement for Dynamic Penetrometer Testing Systems[2]

D 6066 Practice for Determining the Normalized Penetration Resistance Testing of Sands for Evaluation of Liquefaction Potential[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *anvil*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.1.2 *cathead*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.3 *drill rods*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.4 *drive-weight assembly*—a device consisting of the hammer, hammer fall guide, the anvil, and any hammer drop system.

3.1.5 *hammer*—that portion of the drive-weight assembly consisting of the 140 ± 2 lb (63.5 ± 1 kg) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.1.6 *hammer drop system*—that portion of the drive-weight assembly by which the operator accomplishes the lifting and dropping of the hammer to produce the blow.

3.1.7 *hammer fall guide*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.1.8 *N-value*—the blowcount representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.9 Δ*N*—the number of blows obtained from each of the 6-in. (150-mm) intervals of sampler penetration (see 7.3).

3.1.10 *number of rope turns*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.1.11 *sampling rods*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

3.1.12 *SPT*—abbreviation for standard penetration test, a term by which engineers commonly refer to this method.

4. Significance and Use

4.1 This test method provides a soil sample for identification purposes and for laboratory tests appropriate for soil obtained from a sampler that may produce large shear strain disturbance in the sample.

4.2 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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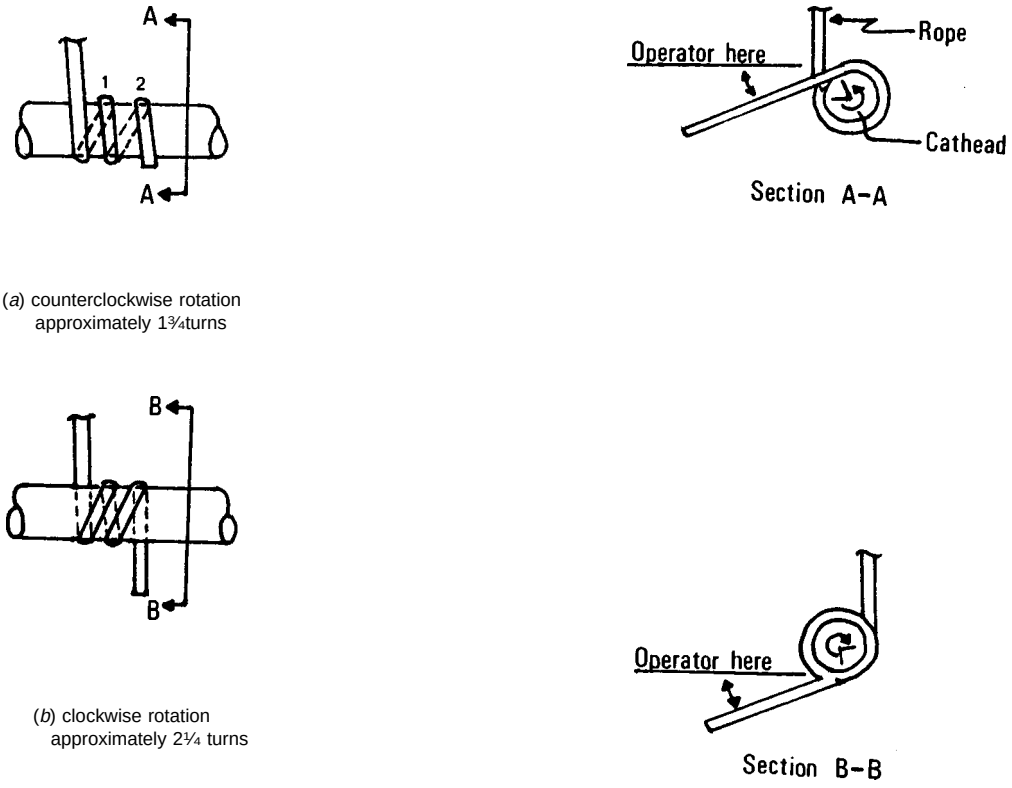
[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

***A Summary of Changes section appears at the end of this standard.**



(*a*) counterclockwise rotation approximately 1¾turns

(*b*) clockwise rotation approximately 2¼ turns

FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

widely published correlations which relate SPT blowcount, or *N*-value, and the engineering behavior of earthworks and foundations are available.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitably clean open hole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions.

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjuction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the boring. The inside diameter of the hollow-stem augers shall be less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used if the soil on the side of the boring does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod which has an outside diameter of 1⅝ in. (41.2 mm) and an inside diameter of 1⅛ in. (28.5 mm).

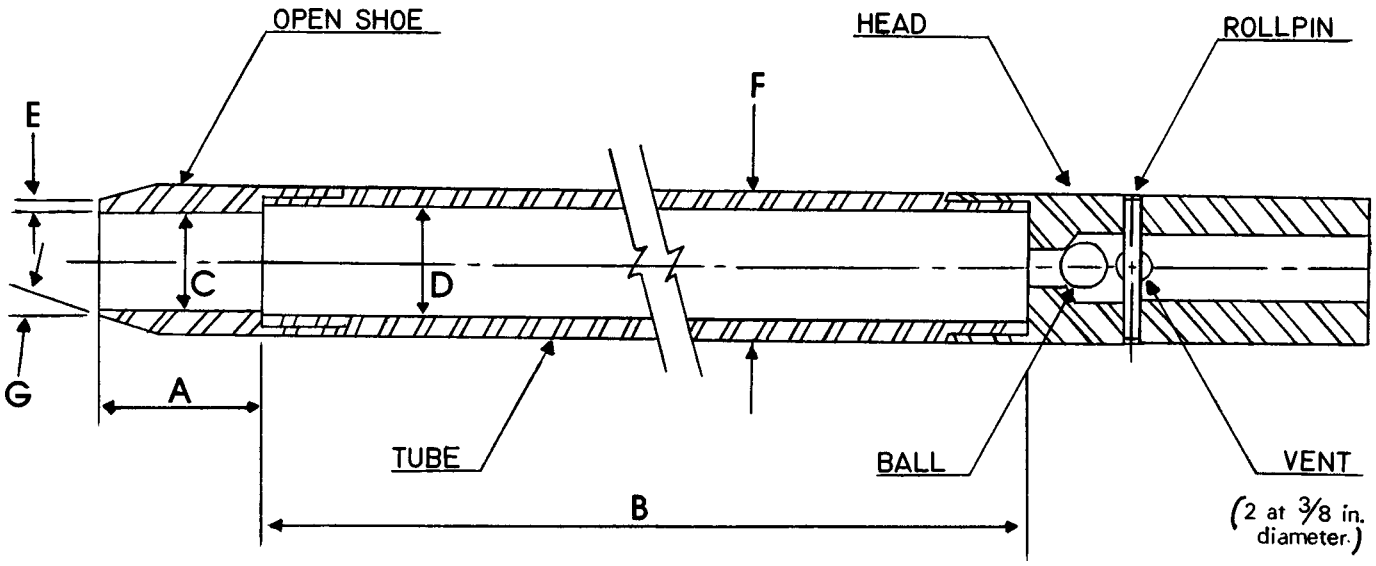
NOTE 2—Recent research and comparative testing indicates the type rod used, with stiffness ranging from "A" size rod to "N" size rod, will usually have a negligible effect on the *N*-values to depths of at least 100 ft (30 m).

5.3 *Split-Barrel Sampler*—The sampler shall be constructed with the dimensions indicated in Fig. 2. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The use of liners to produce a constant inside diameter of 1⅜ in. (35 mm) is permitted, but shall be noted on the penetration record if used. The use of a sample retainer basket is permitted, and should also be noted on the penetration record if used.

NOTE 3—Both theory and available test data suggest that *N*-values may increase between 10 to 30 % when liners are used.

5.4 *Drive-Weight Assembly*:

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lb (63.5 ± 1 kg) and shall be a solid rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting a free fall



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 = 16.0° 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.

FIG. 2 Split-Barrel Sampler

shall be used. Hammers used with the cathead and rope method shall have an unimpeded overlift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged.

NOTE 4—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic, or automatic hammer drop systems may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The boring shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 mm) or less in homogeneous strata with test and sampling locations at every change of strata.

6.2 Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures have proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable borings. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the boring below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a boring with bottom discharge bits is not permissible. It is not permissible to advance the boring for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the boring or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the boring has been advanced to the desired sampling elevation and excessive cuttings have been removed, prepare for the test with the following sequence of operations.

7.1.1 Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling

rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the boring, remove the sampler and sampling rods from the boring and remove the cuttings.

7.1.4 Mark the drill rods in three successive 6-in. (0.15-m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-in. (0.15-m) increment.

7.2 Drive the sampler with blows from the 140-lb (63.5-kg) hammer and count the number of blows applied in each 6-in. (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 6-in. (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 18 in. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.3 Record the number of blows required to effect each 6 in. (0.15 m) of penetration or fraction thereof. The first 6 in. is considered to be a seating drive. The sum of the number of blows required for the second and third 6 in. of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 18 in. (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 6-in. (0.15-m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 1 in. (25 mm), in addition to the number of blows. If the sampler advances below the bottom of the boring under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lb (63.5-kg) hammer shall be accomplished using either of the following two methods:

7.4.1 By using a trip, automatic, or semi-automatic hammer drop system which lifts the 140-lb (63.5-kg) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 25 mm) unimpeded.

7.4.2 By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM, or the approximate speed of rotation shall be reported on the boring log.

7.4.2.3 No more than 2¼ rope turns on the cathead may be used during the performance of the penetration test, as shown in Fig. 1.

NOTE 5—The operator should generally use either 1¾ or 2¼ rope turns, depending upon whether or not the rope comes off the top (1¾ turns) or the bottom (2¼ turns) of the cathead. It is generally known and accepted that 2¾or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be maintained in a relatively dry, clean, and unfrayed condition.

7.4.2.4 For each hammer blow, a 30-in. (0.76-m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

7.5 Bring the sampler to the surface and open. Record the percent recovery or the length of sample recovered. Describe the soil samples recovered as to composition, color, stratification, and condition, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 6-in. (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel.

8. Report

8.1 Drilling information shall be recorded in the field and shall include the following:

8.1.1 Name and location of job,

8.1.2 Names of crew,

8.1.3 Type and make of drilling machine,

8.1.4 Weather conditions,

8.1.5 Date and time of start and finish of boring,

8.1.6 Boring number and location (station and coordinates, if available and applicable),

8.1.7 Surface elevation, if available,

8.1.8 Method of advancing and cleaning the boring,

8.1.9 Method of keeping boring open,

8.1.10 Depth of water surface and drilling depth at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.1.11 Location of strata changes,

8.1.12 Size of casing, depth of cased portion of boring,

8.1.13 Equipment and method of driving sampler,

8.1.14 Type sampler and length and inside diameter of barrel (note use of liners),

8.1.15 Size, type, and section length of the sampling rods, and

8.1.16 Remarks.

8.2 Data obtained for each sample shall be recorded in the field and shall include the following:

8.2.1 Sample depth and, if utilized, the sample number,

8.2.2 Description of soil,

8.2.3 Strata changes within sample,

8.2.4 Sampler penetration and recovery lengths, and

8.2.5 Number of blows per 6-in. (0.15-m) or partial increment.

9. Precision and Bias

9.1 *Precision*—A valid estimate of test precision has not been determined because it is too costly to conduct the necessary inter-laboratory (field) tests. Subcommittee D18.02 welcomes proposals to allow development of a valid precision statement.

9.2 *Bias*—Because there is no reference material for this test method, there can be no bias statement.

9.3 Variations in *N*-values of 100 % or more have been

observed when using different standard penetration test apparatus and drillers for adjacent borings in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.4 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.5 The variability in *N*-values produced by different drill rigs and operators may be reduced by measuring that part of the hammer energy delivered into the drill rods from the sampler and adjusting *N* on the basis of comparative energies. A method for energy measurement and *N*-value adjustment is given in Test Method D 4633.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; split-barrel sampling; standard penetration test

SUMMARY OF CHANGES

(1) Added note to Section 1, Scope. The note refers to a related standard, Practice D 6066.

(2) Added Practice D 6066 to Section 2 on Referenced Documents.

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

Designation: D 1587 – 00

Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes[1]

This standard is issued under the fixed designation D 1587; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of engineering properties, such as strength, compressibility, permeability, and density. Thin-walled tubes used in piston, plug, or rotary-type samplers should comply with Section 6.3 of this practice which describes the thin-walled tubes.

NOTE 1—This practice does not apply to liners used within the samplers.

1.2 This Practice is limited to soils that can be penetrated by the thin-walled tube. This sampling method is not recommended for sampling soils containing gravel or larger size soil particles cemented or very hard soils. Other soil samplers may be used for sampling these soil types. Such samplers include driven split barrel samplers and soil coring devices (D 1586, D 3550, and D 6151). For information on appropriate use of other soil samplers refer to D 6169.

1.3 This practice is often used in conjunction with fluid rotary drilling (D 1452D 5783) or hollow-stem augers (D 6151). Subsurface geotechnical explorations should be reported in accordance with practice (D 5434). This practice discusses some aspects of sample preservation after the sampling event. For information on preservation and transportation process of soil samples, consult Practice D 4220. This practice does not address environmental sampling; consult D 6169 and D 6232for information on sampling for environmental investigations.

1.4 The values stated in inch-pound units are to be regarded as the standard. The SI values given in parentheses are provided for information purposes only. The tubing tolerances presented in Table 2 are from sources available in North America. Use of metric equivalent is acceptable as long as thickness and proportions are similar to those required in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Standard Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Penetration Resistance and Split Barrel Sampling of Soils[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

D 3740 Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock[3]

D 5783 Guide for Use of Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices[3]

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling[3]

D 6169 Guide for Selection of Soil and Rock Sampling

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved August 10, 2000. Published December 2000. Originally published as D 1587–58T. Last previous edition D 1587–83.

[2] *Annual Book of ASTM Standards,* Vol 04.08.

[3] *Annual Book of ASTM Standards,* Vol 04.09.

***A Summary of Changes section appears at the end of this standard.**

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TABLE 1 Suitable Thin-Walled Steel Sample Tubes[A]

Outside diameter (D_o):			
in.	2	3	5
mm	50.8	76.2	127
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.24	1.65	3.05
Tube length:			
in.	36	36	54
m	0.91	0.91	1.45
Inside clearance ratio, %	<1	<1	<1

[A] The three diameters recommended in Table 1 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

TABLE 2 Dimensional Tolerances for Thin-Walled Tubes

Nominal Tube Diameters from Table 1[A] Tolerances						
Size Outside Diameter	2 in.	50.8 mm	3 in.	76.2 mm	5 in.	127 mm
Outside diameter, D_o	+0.007 -0.000	+0.179 -0.000	+0.010 -0.000	+0.254 -0.000	+0.015 -0.000	0.381 -0.000
Inside diameter, D_i	+0.000 -0.007	+0.000 -0.179	+0.000 -0.010	+0.000 -0.254	+0.000 -0.015	+0.000 -0.381
Wall thickness	±0.007	±0.179	±0.010	±0.254	±0.015	±0.381
Ovality	0.015	0.381	0.020	0.508	0.030	0.762
Straightness	0.030/ft	2.50/m	0.030/ft	2.50/m	0.030/ft	2.50/m

[A] Intermediate or larger diameters should be proportional. Specify only two of the first three tolerances; that is, D_o and D_i, or D_o and Wall thickness, or D_i and Wall thickness.

Devices Used With Drill Rigs for Environmental Investigations[3]

D 6232 Guide for Selection of Sampling Equipment for Waste and Contaminated Media Data Collection Activities[4]

3. Terminology

3.1 *Definitions:*

3.1.1 For common definitions of terms in this standard, refer to Terminology D 653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *inside clearance ratio, %*—the ratio of the difference in the inside diameter of the tube, D_i, minus the inside diameter of the cutting edge, D_e, to the inside diameter of the tube, D_i expressed as a percentage (see Fig. 1).

3.2.2 *ovality*—the cross section of the tube that deviates from a perfect circle.

4. Summary of Practice

4.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil at the bottom of a boring, removing the soil-filled tube, and applying seals to the soil surfaces to prevent soil movement and moisture gain or loss.

5. Significance and Use

5.1 This practice, or Practice D 3550 with thin wall shoe, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of engineering properties or other tests that might be influenced by soil disturbance.

NOTE 2—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective sampling. Users of this practice. are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 5740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Drilling Equipment*—When sampling in a boring, any drilling equipment may be used that provides a reasonably clean hole; that minimizes disturbance of the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

6.2 *Sampler Insertion Equipment*, shall be adequate to provide a relatively rapid continuous penetration force. For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

6.3 *Thin-Walled Tubes*, should be manufactured to the dimensions as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. (50 to 130 mm) and be made of metal having adequate strength for the type of soil to be sampled. Tubes shall be clean and free of all surface irregularities including projecting weld seams. Other diameters may be used but the tube dimensions should be proportional to the tube designs presented here.

6.3.1 *Length of Tubes*—See Table 1 and 7.4.1.

6.3.2 *Tolerances*, shall be within the limits shown in Table 2.

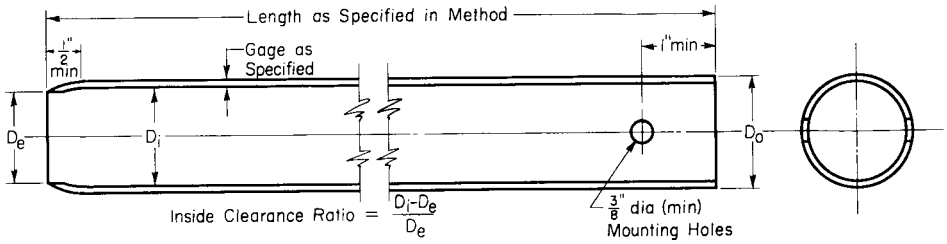
6.3.3 *Inside Clearance Ratio*, should be not greater than 1 % unless specified otherwise for the type of soil to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled, except for sensitive soils or where local experience indicates otherwise. See 3.2.1 and Fig. 1 for definition of inside clearance ratio.

6.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating, unless the soil is to be extruded less than 3 days. The type of coating to be used may vary depending upon the material to be sampled. Plating of the tubes or alternate base metals may be specified. Galvanized tubes are often used when long term storage is required. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, zinc oxide, and others.

NOTE 3—Most coating materials are not resistant to scratching by soils that contain sands. Consideration should be given for prompt testing of the sample because chemical reactions between the metal and the soil sample con occur with time.

6.4 *Sampler Head*, serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube,

[4] *Annual Book of ASTM Standards*, Vol 11.04.



NOTE 1—Minimum of two mounting holes on opposite sides for D_o smaller than 4 in. (101.6 mm).
NOTE 2—Minimum of four mounting holes equally spaced for D_o 4 in. (101.6 mm) and larger.
NOTE 3—Tube held with hardened screws or other suitable means.
NOTE 4—2-in (50.8 mm) outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for "undisturbed samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalent Conversions

in.	mm
⅜	9.53
½	12.7
1	25.4
2	50.8
3	76.2
4	101.6
5	127

FIG. 1 Thin-Walled Tube for Sampling

comprises the thin-walled tube sampler. The sampler head shall contain a venting area and suitable check valve with the venting area to the outside equal to or greater than the area through the check valve. In some special cases, a check valve may not be required but venting is required to avoid sample compression. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

7. Procedure

7.1 Remove loose material from the center of a casing or hollow stem auger as carefully as possible to avoid disturbance of the material to be sampled. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the drilling and sampling operation.

7.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted.

NOTE 4—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

7.3 Lower the sampling apparatus so that the sample tube's bottom rests on the bottom of the hole and record depth to the bottom of the sample tube to the nearest 0.1-ft (.03 m)

7.3.1 Keep the sampling apparatus plumb during lowering, thereby preventing the cutting edge of the tube from scraping the wall of the borehole.

7.4 Advance the sampler without rotation by a continuous relatively rapid downward motion and record length of advancement to the nearest 1 in. (25 mm).

7.4.1 Determine the length of advance by the resistance and condition of the soil formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays. In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3-in. (75 mm) for sludge and end cuttings.

NOTE 5—The mass of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 1.

7.5 When the soil formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

7.6 Withdraw the sampler from the soil formation as carefully as possible in order to minimize disturbance of the sample. The tube can be slowly rotated to shear the material at the end of the tube, and to relieve water and/or suction pressures and improve recovery. Where the soil formation is soft, a delay before withdraw of the sampler (typically 5 to 30 minutes) may improve sample recovery.

8. Sample Measurement, Sealing and Labeling

8.1 Upon removal of the tube, remove the drill cuttings in the upper end of the tube and measure the length of the soil sample recovered to the nearest 0.25 in. (5 mm) in the tube. Seal the upper end of the tube. Remove at least 1 in. (25 mm) of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube.

8.1.1 Tubes sealed over the ends, as opposed to those sealed

with expanding packers, should be provided with spacers or appropriate packing materials, or both prior to sealing the tube ends to provide proper confinement. Packing materials must be nonabsorbent and must maintain their properties to provide the same degree of sample support with time.

8.1.2 Depending on the requirements of the investigation, field extrusion and packaging of extruded soil samples can be performed. This allows for physical examination and classification of the sample. Samples are extruded in special hydraulic jacks equipped with properly sized platens to extrude the core in a continuous smooth speed. In some cases, further extrusion may cause sample disturbance reducing suitability for testing of engineering properties. In other cases, if damage is not significant, cores can be extruded and preserved for testing (D 4220). Bent or damaged tubes should be cut off before extruding.

8.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample (see Section 9). Assure that the markings or labels are adequate to survive transportation and storage.

NOTE 6—Top end of the tube should be labeled "top".

9. Field Log

9.1 Record the information that may be required for preparing field logs in general accordance to ASTM D 5434 "Guide for Field Logging of Subsurface Explorations of Soil and Rock". This guide is used for logging explorations by drilling and sampling. Some examples of the information required include;

9.1.1 Name and location of the project,

9.1.2 Boring number,

9.1.3 Log of the soil conditions,

9.1.4 Surface elevation or reference to a datum to the nearest foot (0.5 m) or better,

9.1.5 Location of the boring,

9.1.6 Method of making the borehole,

9.1.7 Name of the drilling foreman and company, and

9.1.8 Name of the drilling inspector(s).

9.1.9 Date and time of boring-start and finish,

9.1.10 Depth to groundwater level: date and time measured,

9.2 Recording the appropriate sampling information is required as follows:

9.2.1 Depth to top of sample to the nearest 0.1 ft. (.03 m) and number of sample,

9.2.2 Description of thin-walled tube sampler: size, type of metal, type of coating,

9.2.3 Method of sampler insertion: push or drive,

9.2.4 Method of drilling, size of hole, casing, and drilling fluid used,

9.2.5 Soil description in accordance with Practice D 2488,

9.2.6 Length of sampler advance (push), and

9.2.7 Recovery: length of sample obtained.

10. Keywords

10.1 geologic investigations; sampling; soil exploration; soil investigations; subsurface investigations; undisturbed

SUMMARY OF CHANGES

In accordance with committee D18 policy, this section identifies the location of changes to this standard since the last edition, 1994, which may impact the use of this standard.

(1) Editorial corrections to various sections based on comments received from Committee Balloting

(2) Added D 6232 to Section 2.

(3) Changed Note 7 to Section 8.1.2.

(4) Renumbered Note 8.

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CH2MHILL

PROJECT NUMBER	BORING NUMBER
	SHEET 1 OF 1

SOIL BORING LOG

PROJECT : LOCATION : DATE:

WEATHER: DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVELS : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole
2						
4						
6						
8						
10						

Sampler Signature: Date:

Designation: D 1586 – 99

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Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.

1.2 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific precautionary statement, see 5.4.1.

1.3 The values stated in inch-pound units are to be regarded as the standard.

NOTE 1—Practice D 6066 can be used when testing loose sands below the water table for liquefaction studies or when a higher level of care is required when drilling these soils. This practice provides information on drilling methods, equipment variables, energy corrections, and blow-count normalization.

2. Referenced Documents

2.1 *ASTM Standards:*

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

D 4633 Test Method for Stress Wave Energy Measurement for Dynamic Penetrometer Testing Systems[2]

D 6066 Practice for Determining the Normalized Penetration Resistance Testing of Sands for Evaluation of Liquefaction Potential[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *anvil*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.1.2 *cathead*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.3 *drill rods*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.4 *drive-weight assembly*—a device consisting of the hammer, hammer fall guide, the anvil, and any hammer drop system.

3.1.5 *hammer*—that portion of the drive-weight assembly consisting of the 140 ± 2 lb (63.5 ± 1 kg) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.1.6 *hammer drop system*—that portion of the drive-weight assembly by which the operator accomplishes the lifting and dropping of the hammer to produce the blow.

3.1.7 *hammer fall guide*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.1.8 *N-value*—the blowcount representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.9 Δ*N*—the number of blows obtained from each of the 6-in. (150-mm) intervals of sampler penetration (see 7.3).

3.1.10 *number of rope turns*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.1.11 *sampling rods*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

3.1.12 *SPT*—abbreviation for standard penetration test, a term by which engineers commonly refer to this method.

4. Significance and Use

4.1 This test method provides a soil sample for identification purposes and for laboratory tests appropriate for soil obtained from a sampler that may produce large shear strain disturbance in the sample.

4.2 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

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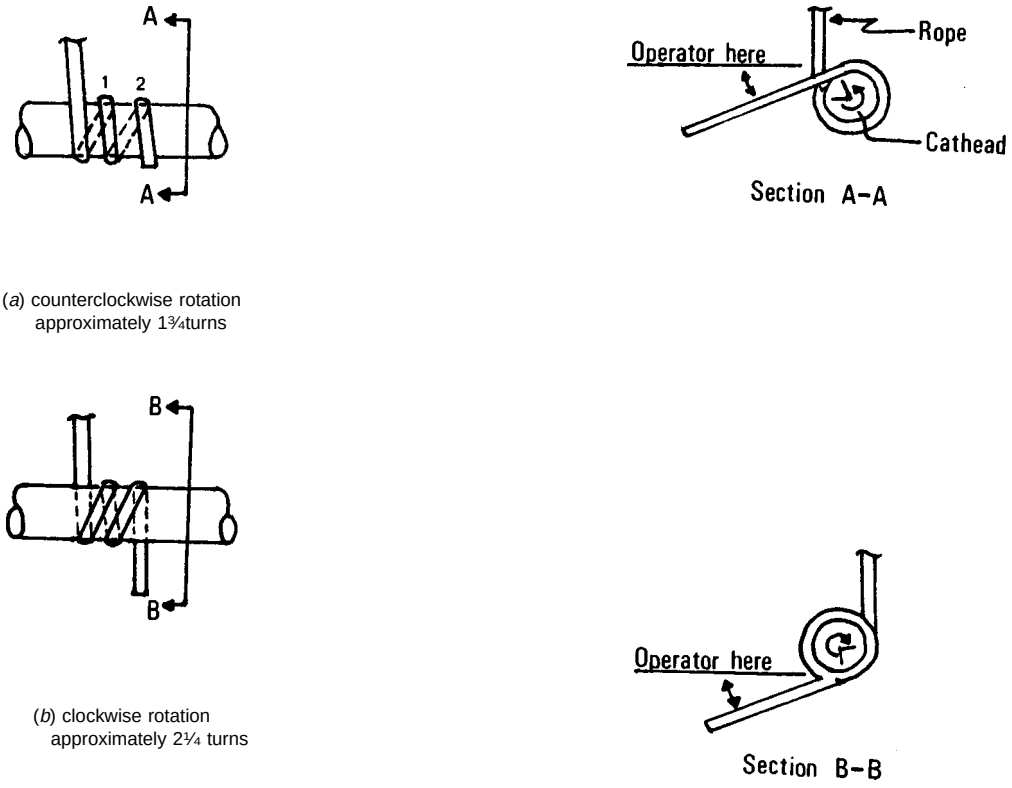
[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

***A Summary of Changes section appears at the end of this standard.**



(*a*) counterclockwise rotation approximately 1¾turns

(*b*) clockwise rotation approximately 2¼ turns

FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

widely published correlations which relate SPT blowcount, or *N*-value, and the engineering behavior of earthworks and foundations are available.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitably clean open hole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions.

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjuction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the boring. The inside diameter of the hollow-stem augers shall be less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used if the soil on the side of the boring does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod which has an outside diameter of 1⅝ in. (41.2 mm) and an inside diameter of 1⅛ in. (28.5 mm).

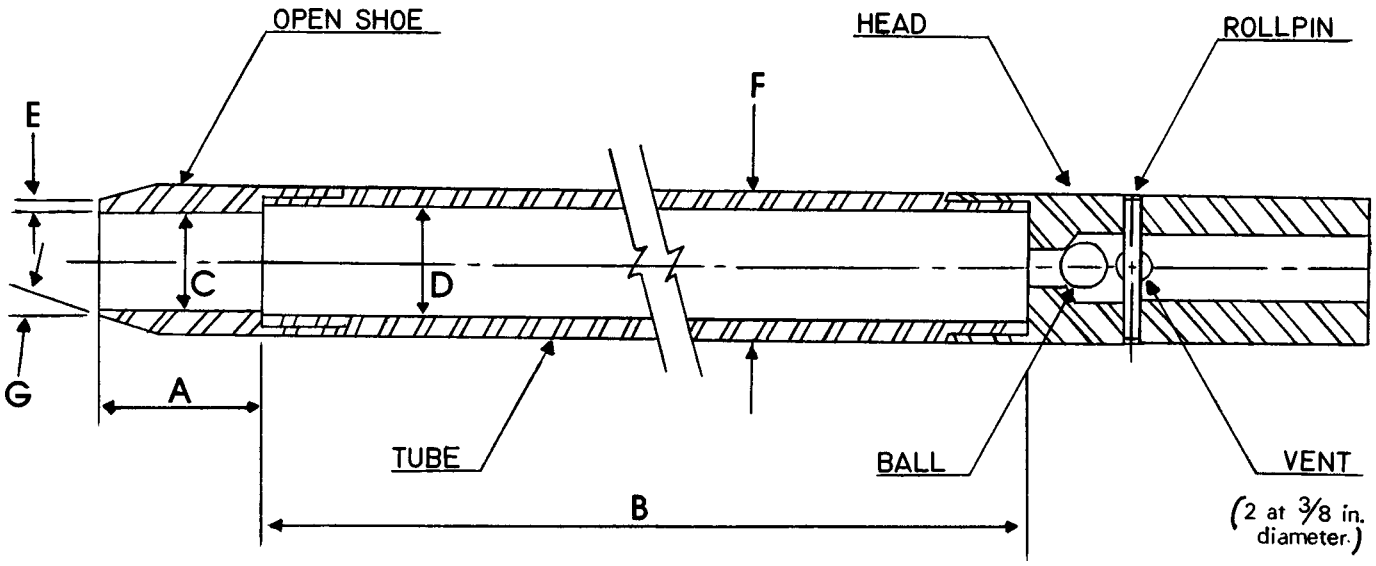
NOTE 2—Recent research and comparative testing indicates the type rod used, with stiffness ranging from "A" size rod to "N" size rod, will usually have a negligible effect on the *N*-values to depths of at least 100 ft (30 m).

5.3 *Split-Barrel Sampler*—The sampler shall be constructed with the dimensions indicated in Fig. 2. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The use of liners to produce a constant inside diameter of 1⅜ in. (35 mm) is permitted, but shall be noted on the penetration record if used. The use of a sample retainer basket is permitted, and should also be noted on the penetration record if used.

NOTE 3—Both theory and available test data suggest that *N*-values may increase between 10 to 30 % when liners are used.

5.4 *Drive-Weight Assembly*:

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lb (63.5 ± 1 kg) and shall be a solid rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting a free fall



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 = 16.0° 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.

FIG. 2 Split-Barrel Sampler

shall be used. Hammers used with the cathead and rope method shall have an unimpeded overlift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged.

NOTE 4—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic, or automatic hammer drop systems may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The boring shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 mm) or less in homogeneous strata with test and sampling locations at every change of strata.

6.2 Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures have proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable borings. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the boring below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a boring with bottom discharge bits is not permissible. It is not permissible to advance the boring for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the boring or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the boring has been advanced to the desired sampling elevation and excessive cuttings have been removed, prepare for the test with the following sequence of operations.

7.1.1 Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling

rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the boring, remove the sampler and sampling rods from the boring and remove the cuttings.

7.1.4 Mark the drill rods in three successive 6-in. (0.15-m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-in. (0.15-m) increment.

7.2 Drive the sampler with blows from the 140-lb (63.5-kg) hammer and count the number of blows applied in each 6-in. (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 6-in. (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 18 in. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.3 Record the number of blows required to effect each 6 in. (0.15 m) of penetration or fraction thereof. The first 6 in. is considered to be a seating drive. The sum of the number of blows required for the second and third 6 in. of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 18 in. (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 6-in. (0.15-m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 1 in. (25 mm), in addition to the number of blows. If the sampler advances below the bottom of the boring under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lb (63.5-kg) hammer shall be accomplished using either of the following two methods:

7.4.1 By using a trip, automatic, or semi-automatic hammer drop system which lifts the 140-lb (63.5-kg) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 25 mm) unimpeded.

7.4.2 By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM, or the approximate speed of rotation shall be reported on the boring log.

7.4.2.3 No more than 2¼ rope turns on the cathead may be used during the performance of the penetration test, as shown in Fig. 1.

NOTE 5—The operator should generally use either 1¾ or 2¼ rope turns, depending upon whether or not the rope comes off the top (1¾ turns) or the bottom (2¼ turns) of the cathead. It is generally known and accepted that 2¾or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be maintained in a relatively dry, clean, and unfrayed condition.

7.4.2.4 For each hammer blow, a 30-in. (0.76-m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

7.5 Bring the sampler to the surface and open. Record the percent recovery or the length of sample recovered. Describe the soil samples recovered as to composition, color, stratification, and condition, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 6-in. (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel.

8. Report

8.1 Drilling information shall be recorded in the field and shall include the following:

8.1.1 Name and location of job,

8.1.2 Names of crew,

8.1.3 Type and make of drilling machine,

8.1.4 Weather conditions,

8.1.5 Date and time of start and finish of boring,

8.1.6 Boring number and location (station and coordinates, if available and applicable),

8.1.7 Surface elevation, if available,

8.1.8 Method of advancing and cleaning the boring,

8.1.9 Method of keeping boring open,

8.1.10 Depth of water surface and drilling depth at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.1.11 Location of strata changes,

8.1.12 Size of casing, depth of cased portion of boring,

8.1.13 Equipment and method of driving sampler,

8.1.14 Type sampler and length and inside diameter of barrel (note use of liners),

8.1.15 Size, type, and section length of the sampling rods, and

8.1.16 Remarks.

8.2 Data obtained for each sample shall be recorded in the field and shall include the following:

8.2.1 Sample depth and, if utilized, the sample number,

8.2.2 Description of soil,

8.2.3 Strata changes within sample,

8.2.4 Sampler penetration and recovery lengths, and

8.2.5 Number of blows per 6-in. (0.15-m) or partial increment.

9. Precision and Bias

9.1 *Precision*—A valid estimate of test precision has not been determined because it is too costly to conduct the necessary inter-laboratory (field) tests. Subcommittee D18.02 welcomes proposals to allow development of a valid precision statement.

9.2 *Bias*—Because there is no reference material for this test method, there can be no bias statement.

9.3 Variations in *N*-values of 100 % or more have been

observed when using different standard penetration test apparatus and drillers for adjacent borings in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.4 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.5 The variability in *N*-values produced by different drill rigs and operators may be reduced by measuring that part of the hammer energy delivered into the drill rods from the sampler and adjusting *N* on the basis of comparative energies. A method for energy measurement and *N*-value adjustment is given in Test Method D 4633.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; split-barrel sampling; standard penetration test

SUMMARY OF CHANGES

(1) Added note to Section 1, Scope. The note refers to a related standard, Practice D 6066.

(2) Added Practice D 6066 to Section 2 on Referenced Documents.

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

Designation: D 1587 – 00

Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes[1]

This standard is issued under the fixed designation D 1587; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of engineering properties, such as strength, compressibility, permeability, and density. Thin-walled tubes used in piston, plug, or rotary-type samplers should comply with Section 6.3 of this practice which describes the thin-walled tubes.

NOTE 1—This practice does not apply to liners used within the samplers.

1.2 This Practice is limited to soils that can be penetrated by the thin-walled tube. This sampling method is not recommended for sampling soils containing gravel or larger size soil particles cemented or very hard soils. Other soil samplers may be used for sampling these soil types. Such samplers include driven split barrel samplers and soil coring devices (D 1586, D 3550, and D 6151). For information on appropriate use of other soil samplers refer to D 6169.

1.3 This practice is often used in conjunction with fluid rotary drilling (D 1452D 5783) or hollow-stem augers (D 6151). Subsurface geotechnical explorations should be reported in accordance with practice (D 5434). This practice discusses some aspects of sample preservation after the sampling event. For information on preservation and transportation process of soil samples, consult Practice D 4220. This practice does not address environmental sampling; consult D 6169 and D 6232for information on sampling for environmental investigations.

1.4 The values stated in inch-pound units are to be regarded as the standard. The SI values given in parentheses are provided for information purposes only. The tubing tolerances presented in Table 2 are from sources available in North America. Use of metric equivalent is acceptable as long as thickness and proportions are similar to those required in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Standard Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Penetration Resistance and Split Barrel Sampling of Soils[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

D 3740 Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock[3]

D 5783 Guide for Use of Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices[3]

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling[3]

D 6169 Guide for Selection of Soil and Rock Sampling

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved August 10, 2000. Published December 2000. Originally published as D 1587–58T. Last previous edition D 1587–83.

[2] *Annual Book of ASTM Standards,* Vol 04.08.

[3] *Annual Book of ASTM Standards,* Vol 04.09.

***A Summary of Changes section appears at the end of this standard.**

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TABLE 1 Suitable Thin-Walled Steel Sample Tubes[A]

Outside diameter (D_o):			
in.	2	3	5
mm	50.8	76.2	127
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.24	1.65	3.05
Tube length:			
in.	36	36	54
m	0.91	0.91	1.45
Inside clearance ratio, %	<1	<1	<1

[A] The three diameters recommended in Table 1 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

TABLE 2 Dimensional Tolerances for Thin-Walled Tubes

Nominal Tube Diameters from Table 1[A] Tolerances						
Size Outside Diameter	2 in.	50.8 mm	3 in.	76.2 mm	5 in.	127 mm
Outside diameter, D_o	+0.007 -0.000	+0.179 -0.000	+0.010 -0.000	+0.254 -0.000	+0.015 -0.000	0.381 -0.000
Inside diameter, D_i	+0.000 -0.007	+0.000 -0.179	+0.000 -0.010	+0.000 -0.254	+0.000 -0.015	+0.000 -0.381
Wall thickness	±0.007	±0.179	±0.010	±0.254	±0.015	±0.381
Ovality	0.015	0.381	0.020	0.508	0.030	0.762
Straightness	0.030/ft	2.50/m	0.030/ft	2.50/m	0.030/ft	2.50/m

[A] Intermediate or larger diameters should be proportional. Specify only two of the first three tolerances; that is, D_o and D_i, or D_o and Wall thickness, or D_i and Wall thickness.

Devices Used With Drill Rigs for Environmental Investigations[3]

D 6232 Guide for Selection of Sampling Equipment for Waste and Contaminated Media Data Collection Activities[4]

3. Terminology

3.1 *Definitions:*

3.1.1 For common definitions of terms in this standard, refer to Terminology D 653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *inside clearance ratio, %*—the ratio of the difference in the inside diameter of the tube, D_i, minus the inside diameter of the cutting edge, D_e, to the inside diameter of the tube, D_i expressed as a percentage (see Fig. 1).

3.2.2 *ovality*—the cross section of the tube that deviates from a perfect circle.

4. Summary of Practice

4.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil at the bottom of a boring, removing the soil-filled tube, and applying seals to the soil surfaces to prevent soil movement and moisture gain or loss.

5. Significance and Use

5.1 This practice, or Practice D 3550 with thin wall shoe, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of engineering properties or other tests that might be influenced by soil disturbance.

NOTE 2—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective sampling. Users of this practice. are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 5740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Drilling Equipment*—When sampling in a boring, any drilling equipment may be used that provides a reasonably clean hole; that minimizes disturbance of the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

6.2 *Sampler Insertion Equipment*, shall be adequate to provide a relatively rapid continuous penetration force. For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

6.3 *Thin-Walled Tubes*, should be manufactured to the dimensions as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. (50 to 130 mm) and be made of metal having adequate strength for the type of soil to be sampled. Tubes shall be clean and free of all surface irregularities including projecting weld seams. Other diameters may be used but the tube dimensions should be proportional to the tube designs presented here.

6.3.1 *Length of Tubes*—See Table 1 and 7.4.1.

6.3.2 *Tolerances*, shall be within the limits shown in Table 2.

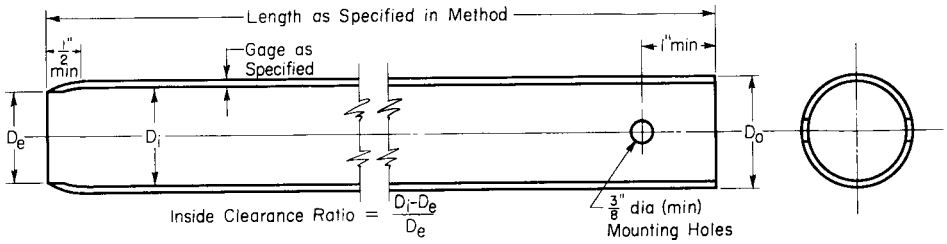
6.3.3 *Inside Clearance Ratio*, should be not greater than 1 % unless specified otherwise for the type of soil to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled, except for sensitive soils or where local experience indicates otherwise. See 3.2.1 and Fig. 1 for definition of inside clearance ratio.

6.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating, unless the soil is to be extruded less than 3 days. The type of coating to be used may vary depending upon the material to be sampled. Plating of the tubes or alternate base metals may be specified. Galvanized tubes are often used when long term storage is required. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, zinc oxide, and others.

NOTE 3—Most coating materials are not resistant to scratching by soils that contain sands. Consideration should be given for prompt testing of the sample because chemical reactions between the metal and the soil sample con occur with time.

6.4 *Sampler Head*, serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube,

[4] *Annual Book of ASTM Standards*, Vol 11.04.



NOTE 1—Minimum of two mounting holes on opposite sides for D_o smaller than 4 in. (101.6 mm).
NOTE 2—Minimum of four mounting holes equally spaced for D_o 4 in. (101.6 mm) and larger.
NOTE 3—Tube held with hardened screws or other suitable means.
NOTE 4—2-in (50.8 mm) outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for "undisturbed samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalent Conversions

in.	mm
⅜	9.53
½	12.7
1	25.4
2	50.8
3	76.2
4	101.6
5	127

FIG. 1 Thin-Walled Tube for Sampling

comprises the thin-walled tube sampler. The sampler head shall contain a venting area and suitable check valve with the venting area to the outside equal to or greater than the area through the check valve. In some special cases, a check valve may not be required but venting is required to avoid sample compression. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

7. Procedure

7.1 Remove loose material from the center of a casing or hollow stem auger as carefully as possible to avoid disturbance of the material to be sampled. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the drilling and sampling operation.

7.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted.

NOTE 4—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

7.3 Lower the sampling apparatus so that the sample tube's bottom rests on the bottom of the hole and record depth to the bottom of the sample tube to the nearest 0.1-ft (.03 m)

7.3.1 Keep the sampling apparatus plumb during lowering, thereby preventing the cutting edge of the tube from scraping the wall of the borehole.

7.4 Advance the sampler without rotation by a continuous relatively rapid downward motion and record length of advancement to the nearest 1 in. (25 mm).

7.4.1 Determine the length of advance by the resistance and condition of the soil formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays. In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3-in. (75 mm) for sludge and end cuttings.

NOTE 5—The mass of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 1.

7.5 When the soil formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

7.6 Withdraw the sampler from the soil formation as carefully as possible in order to minimize disturbance of the sample. The tube can be slowly rotated to shear the material at the end of the tube, and to relieve water and/or suction pressures and improve recovery. Where the soil formation is soft, a delay before withdraw of the sampler (typically 5 to 30 minutes) may improve sample recovery.

8. Sample Measurement, Sealing and Labeling

8.1 Upon removal of the tube, remove the drill cuttings in the upper end of the tube and measure the length of the soil sample recovered to the nearest 0.25 in. (5 mm) in the tube. Seal the upper end of the tube. Remove at least 1 in. (25 mm) of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube.

8.1.1 Tubes sealed over the ends, as opposed to those sealed

with expanding packers, should be provided with spacers or appropriate packing materials, or both prior to sealing the tube ends to provide proper confinement. Packing materials must be nonabsorbent and must maintain their properties to provide the same degree of sample support with time.

8.1.2 Depending on the requirements of the investigation, field extrusion and packaging of extruded soil samples can be performed. This allows for physical examination and classification of the sample. Samples are extruded in special hydraulic jacks equipped with properly sized platens to extrude the core in a continuous smooth speed. In some cases, further extrusion may cause sample disturbance reducing suitability for testing of engineering properties. In other cases, if damage is not significant, cores can be extruded and preserved for testing (D 4220). Bent or damaged tubes should be cut off before extruding.

8.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample (see Section 9). Assure that the markings or labels are adequate to survive transportation and storage.

NOTE 6—Top end of the tube should be labeled "top".

9. Field Log

9.1 Record the information that may be required for preparing field logs in general accordance to ASTM D 5434 "Guide for Field Logging of Subsurface Explorations of Soil and Rock". This guide is used for logging explorations by drilling and sampling. Some examples of the information required include;

9.1.1 Name and location of the project,

9.1.2 Boring number,

9.1.3 Log of the soil conditions,

9.1.4 Surface elevation or reference to a datum to the nearest foot (0.5 m) or better,

9.1.5 Location of the boring,

9.1.6 Method of making the borehole,

9.1.7 Name of the drilling foreman and company, and

9.1.8 Name of the drilling inspector(s).

9.1.9 Date and time of boring-start and finish,

9.1.10 Depth to groundwater level: date and time measured,

9.2 Recording the appropriate sampling information is required as follows:

9.2.1 Depth to top of sample to the nearest 0.1 ft. (.03 m) and number of sample,

9.2.2 Description of thin-walled tube sampler: size, type of metal, type of coating,

9.2.3 Method of sampler insertion: push or drive,

9.2.4 Method of drilling, size of hole, casing, and drilling fluid used,

9.2.5 Soil description in accordance with Practice D 2488,

9.2.6 Length of sampler advance (push), and

9.2.7 Recovery: length of sample obtained.

10. Keywords

10.1 geologic investigations; sampling; soil exploration; soil investigations; subsurface investigations; undisturbed

SUMMARY OF CHANGES

In accordance with committee D18 policy, this section identifies the location of changes to this standard since the last edition, 1994, which may impact the use of this standard.

(1) Editorial corrections to various sections based on comments received from Committee Balloting

(2) Added D 6232 to Section 2.

(3) Changed Note 7 to Section 8.1.2.

(4) Renumbered Note 8.

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STANDARD OPERATING PROCEDURE A-5

Homogenization of Soil and Sediment Samples

I. Purpose

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

II. Scope

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

III. Equipment and Materials

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

IV. Procedures and Guidelines

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

Samples for VOCs should be taken immediately upon opening the spoon and should not be homogenized.

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

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

V. Attachments

None.

VI. Key Checks and Items

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

STANDARD OPERATING PROCEDURE A-6

Soil Sampling for VOCs Using the EnCore® Sampler

I. Purpose and Scope

The purpose of this procedure is to provide guidelines for obtaining samples of surface and subsurface soils using the EnCore® Sampler.

II. Equipment and Materials

- The EnCore® Sampler 5g or 25g versions
- Reusable T-handle with a plunger
- 40 mL VOA vial
- 2 oz wide mouth jar

III. Procedures and Guidelines

The sampling point is located and recorded in the field logbook. Debris should be cleared from the sampling location. The EnCore® sampler is being used to collect, store and deliver soil in a sealed, headspace-free state.

A. Surface and Shallow Subsurface Sampling

A shovel, post-hole digger, or other tool can be used to remove soil to a point just above the interval to be sampled. Remove EnCore® sampler from package and attach handle. Quickly collect a 5 or 25 gram sample using the EnCore® sampler. Attach the cap. Fill out a label and attach to sampler.

Ship one EnCore® Sampler per sample location. If low-level analyses are needed, two additional EnCore® samplers will be required. T**he EnCore® sampler has to reach the lab for preservation within 48 hours.** Please refer to the SOP *Packaging and Shipping Procedures* for guidance on shipping.

The soils removed from the borehole should be visually described in the field log book, including approximated depths.

When sampling is completed, photo-ionization device (PID) readings should be taken directly above the hole, and the hole is then backfilled.

B. Split-Spoon Sampling

Using a drilling rig, a hole is advanced to the desired depth. For split-spoon

sampling, the samples are then collected following the ASTM D 1586 standard (see SOPs for *Soil Boring Drilling and Abandonment* or *Logging of Aoil Borings* for this ASTM). The sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically this is 24 inches. The sampler is driven in 6-inch increments using a 140-pound weight (``hammer'') dropped from a height of 30 inches. The number of hammer blows for each 6-inch interval is counted and recorded. To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch ID sampler may be required. Blow counts obtained with a 3-inch ID spoon would not conform to ASTM D 1586 and would therefore not be used for geotechnical evaluations.

Once retrieved from the hole, the sampler is carefully split open. Care should be taken not to allow material in the sampler to fall out of the open end of the sampler. To collect the sample, the surface of the sample should be removed with an empty EnCore® Sampler. Samples collected for volatiles analysis should be placed directly into the sample containers from the desired depth in the split spoon.

Split-spoon samples also will be collected using a tripod rig. When using a tripod rig the soil samples are collected using an assembly similar to that used by the drilling rig.

IV. Attachments

None

V. Key Checks and Preventative Maintenance

Check that sample collection is swift to avoid loss of volatile organics during sampling.

STANDARD OPERATING PROCEDURE A-7

Soil Boring Sampling–Split Spoon

I. Purpose

To provide a general procedure for sampling subsurface soil produced from a split spoon.

II. Scope

The scope of this procedure is to cover the sample team's responsibility beginning with the opening of the split spoon.

III. Equipment and Materials

- Latex or surgical gloves
- Stainless steel tray or pan
- Field notebook
- Stainless steel spoon or spatula
- Sampling jars
- Decontamination solutions and equipment

IV. Procedures and Guidelines

1. Field team personnel will wear latex or surgical inner gloves and nitrile or neoprene outer gloves to protect from potential dermal contact with hazardous substances.

2. After the split spoon is removed from the borehole and opened by the driller or driller's assistant, it will be turned over to field team personnel.

3. The sample description, depth, time, and date will be logged in the field notebook.

4. Samples for laboratory analysis will be separated and transferred from the split spoon half into the sample jars by a decontaminated stainless steel utensil. Samples for VOC analysis will be separated and transferred first, followed by semivolatile samples. For volatile samples, avoid mixing soil before or during transfer. Homogenize rest of samples according to SOP *Homogenization of Soil and Sediment Samples.*

5. Split spoon and media transfer tools will be decontaminated before being used again.

V. Attachments

None.

VI. Key Checks and Items

- Latex or surgical gloves.
- Decontaminate split spoon and transfer tools before next sample.
- Sample volatiles first, then semivolatiles.
- Avoid mixing.

STANDARD OPERATING PROCEDURE A-8

Direct-Push Soil Sample Collection

I. Purpose

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

II. Scope

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

III. Equipment and Materials

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

IV. Procedures and Guidelines

1. Decontaminate sampling tubes and other non-dedicated downhole equipment in accordance with SOP *Decontamination of Personnel and Equipment*.

2. Drive sampling tube to the desired sampling depth using the truck-mounted hydraulic percussion hammer. If soil above the desired depth is not to be sampled, first drive the lead rod, without a sampling tube, to the top of the desired depth.

3. Remove the rods and sampling tube from the borehole and remove the sample from the tube.

4. Fill all sample containers, beginning with the containers for VOC analysis, using a decontaminated or dedicated sampling implement.

5. Decontaminate all non-dedicated downhole equipment (rods, sampling tubes, etc.) in accordance with SOP *Decontamination of Personnel and Equipment*.

6. Backfill borehole at each sampling location with grout or bentonite and repair the surface with like material (bentonite, asphalt patch, concrete, etc.), as required.

V. Key Checks and Items

- Verify that the hydraulic percussion hammer is clean and in proper working order.
- Ensure that the direct-push operator thoroughly completes the decontamination process between sampling locations.
- Verify that the borehole made during sampling activities has been properly backfilled.

Designation: D 2488 – 00

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and rock as Used in Engineering Design and Construction[3]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[2]

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and
Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Feb. 10, 2000. Published May 2000. Originally published as D 2488 – 66 T. Last previous edition D 2488 – 93ε1.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

***A Summary of Changes section appears at the end of this standard.**

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limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-µm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-µm) sieve.

fine—passes a No. 40 (425-µm) sieve and is retained on a No. 200 (75-µm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols.*

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus*:

6.1.1 *Pocket Knife or Small Spatula*.

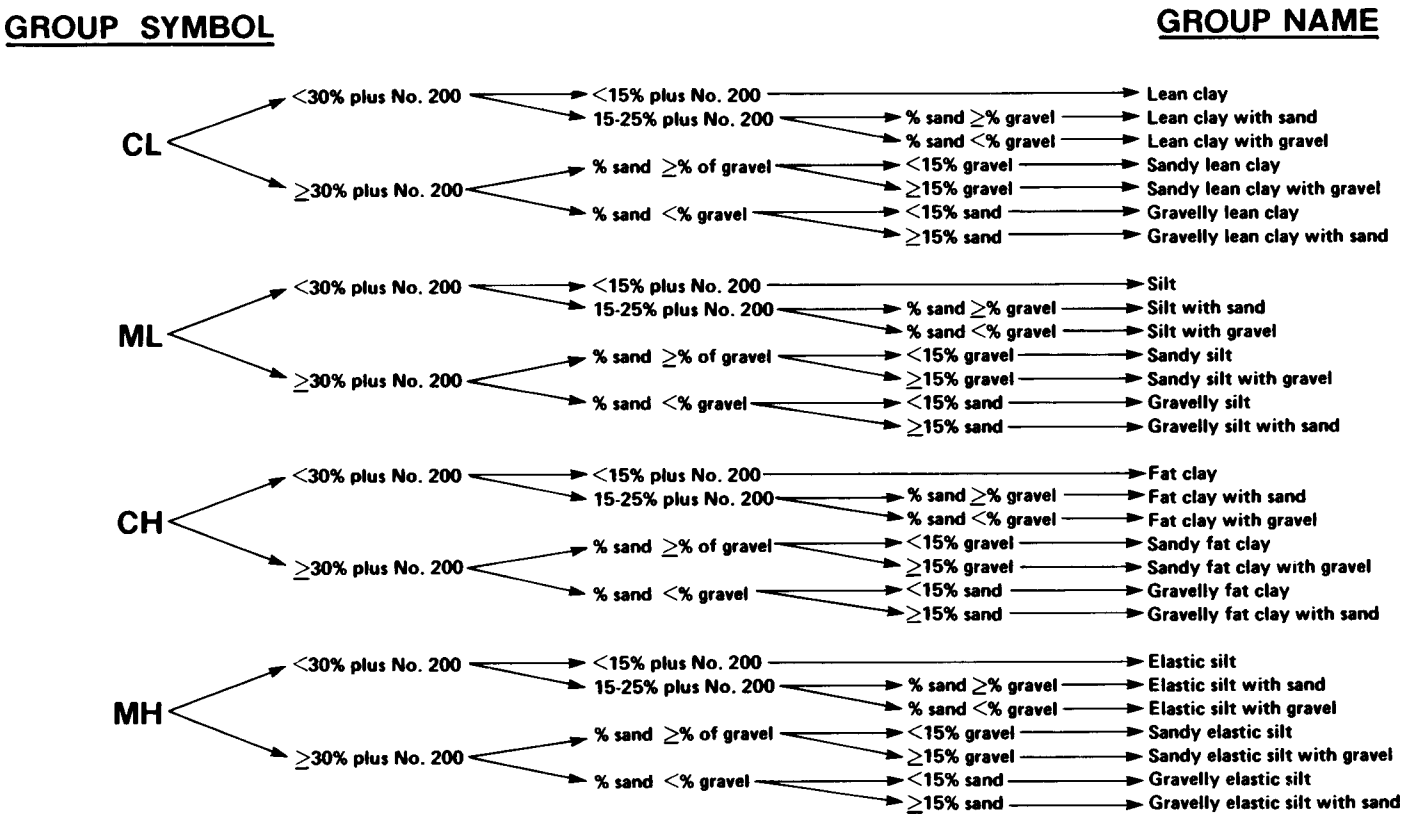
6.2 *Useful Auxiliary Apparatus*:

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens*.

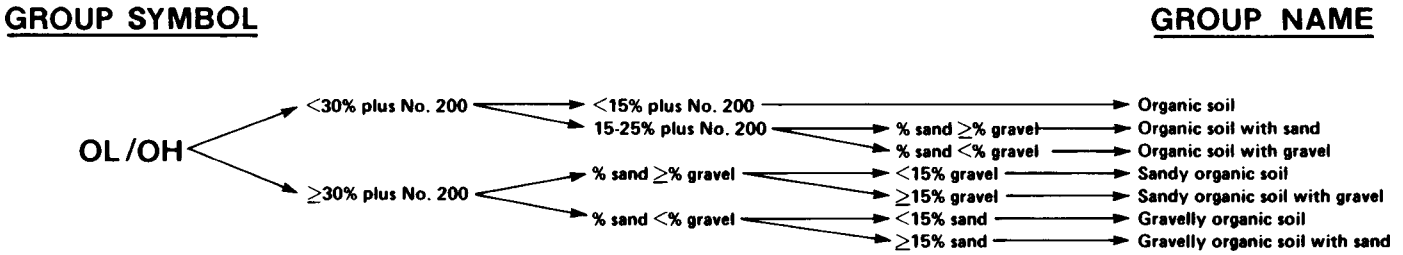
7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

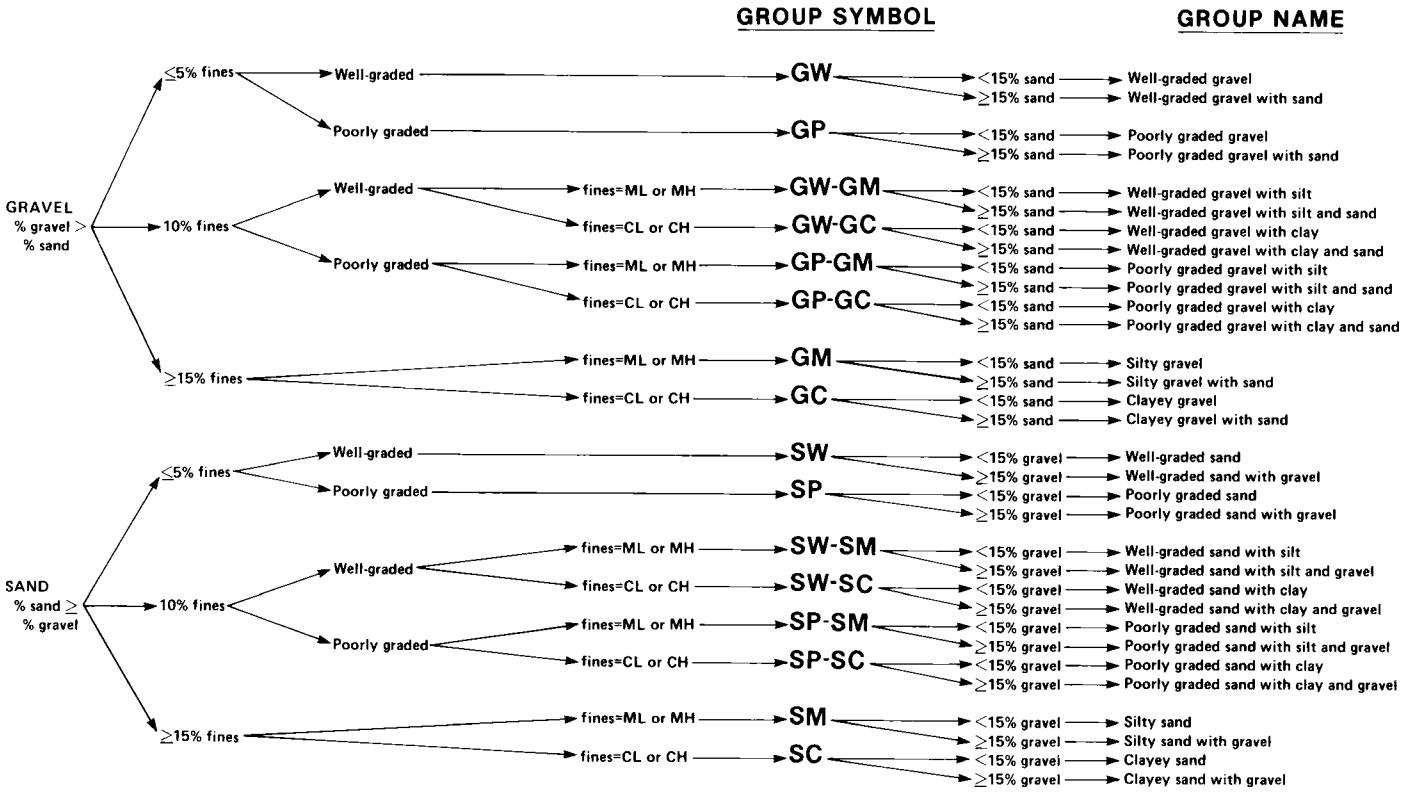
NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

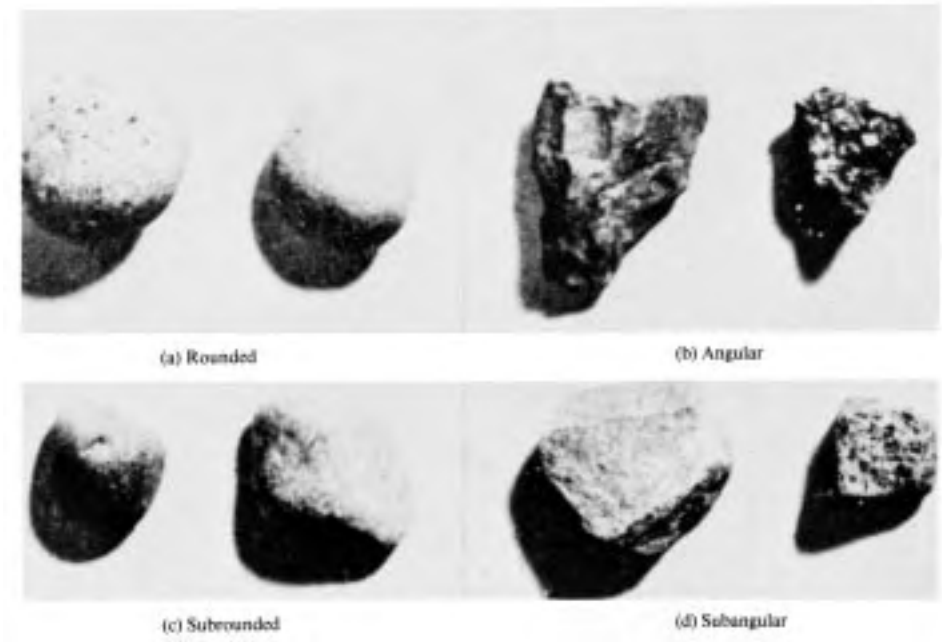


FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.	
Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

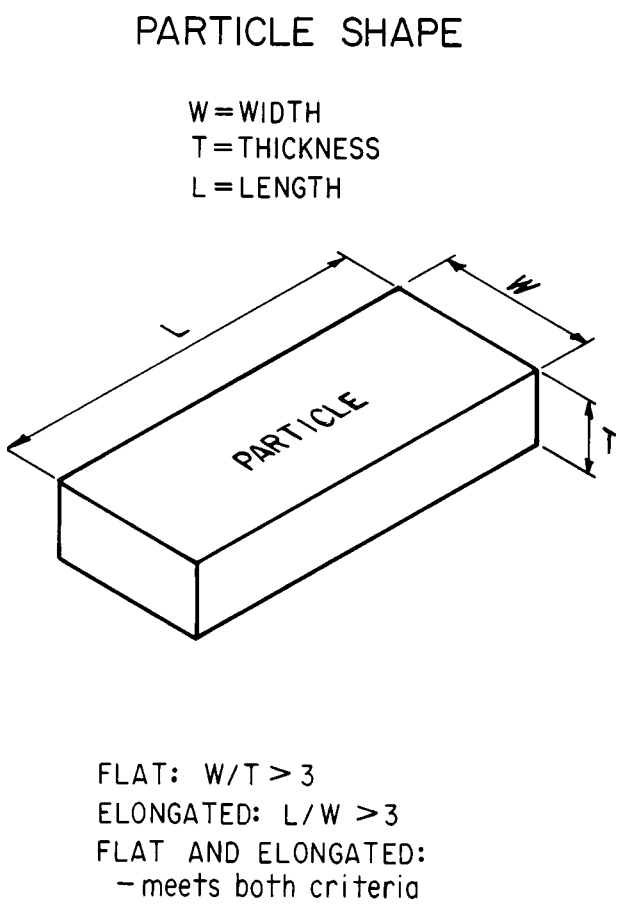


FIG. 4 Criteria for Particle Shape

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Dilatancy

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Toughness

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Dilatancy

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength*:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low,

medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy*:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness*:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

TABLE 8 Criteria for Describing Toughness

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.7 *Identification of Inorganic Fine-Grained Soils*:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

14.8 *Identification of Organic Fine-Grained Soils*:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils

(Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as “Sandy Lean Clay (CL)”; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; “Poorly Graded Sand with Silt (SP-SM)”; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; “Poorly Graded Gravel with Sand (GP).”

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; “Poorly Graded Gravel (GP)”; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard,

angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:	Suffix:

s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1993$^{\epsilon 1}$) that may impact the use of this standard.

(1) Added Practice D 3740 to Section 2.

(2) Added Note 5 under 5.7 and renumbered subsequent notes.

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STANDARD OPERATING PROCEDURE A-10

Soil Boring Drilling and Abandonment

I. Purpose and Scope

The purpose of this guideline is to describe methods to obtain samples of sub-surface soil using either hollow-stem auger, rotary or sonic drilling methods, or tripod-mounted rig and then backfill boreholes to the surface. The guideline covers both split-spoon sampling and thin-walled tube sampling and includes soil borings through surface casings installed to prevent potential contamination in shallow water-bearing units from migrating downward into deeper units.

II. Equipment and Materials

- Truck-mounted drilling rig, skid rig, or tripod rig
- Hollow-stem augers and associated equipment or either rotary-drilling or sonic-drilling equipment
- Steel or Schedule 80 PVC casing, at least 6.25-inch inside diameter (if surface casing is required)
- Split-spoon or thin-walled tube samplers
- Downhole compacting tool (e.g., a pipe with a flat plate attached to the bottom)
- Cement
- Bentonite

III. Procedures and Guidelines

A. Drilling

Continuous-fight hollow-stem augers (HSA) with an inside diameter of at least 3.25 inches typically are used. The use of water or other fluid to assist in hollow-stem drilling will be avoided. Rotary drilling will be with a similar minimum diameter.

The bit of the auger or drill is placed on the ground at the location to be drilled and then turned with the drilling or soil-coring rig. The drilling is advanced to a depth just above the top of the interval to be sampled. For sonic drilling, a continuous core is collected and the sample interval is selected from the length of core run.

While advancing the auger or drill to the full borehole depth, the soils removed from the boring will be screened using a portable volatile organics detector.

A tripod drilling rig is generally a tripod equipped to collect continuous samples using a hammer-driven sampler. The soil sample collection will be the same as that outlined for hollow-stem and rotary drilling. Borehole collapse due to soft sediments may occur when collecting samples using a tripod drilling rig.

Temporary surface casing may be installed where soil borings will penetrate a confining layer. The surface casing will be installed to prevent potential contamination in shallow water-bearing units from migrating downward into deeper units. Typically, surface casing has a 6.25-inch inside diameter (ID).

If the split-spoon sampling is to be advanced with a 3.25-inch ID and 7.25-inch outside diameter (O.D.) HSA, it will be necessary to pull the 3.25-inch augers and ream the hole with a minimum 10.25-inch ID HSA. Alternatively, if the split-spoon sampling is advanced with mud-rotary drilling, it would require a 10.25-inch rotary bit to make room for the 6.25-inch I.D. surface casing.

The surface casing will be seated at least 5 feet into an underlying clay or silt layer and will be sealed in place using a bentonite slurry or bentonite pellets. This seal will prevent movement of groundwater downward from the shallow water-bearing unit but will allow the casing to be removed easily when the split-spoon sampling is completed. The split-spoon sampling will then be advanced with 6-inch mud-rotary.

B. Sampling

Using a drilling rig, a hole is advanced to the desired depth. For split-spoon sampling, the samples are then collected following the ASTM D 1586 standard (attached). The sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically this is 24 inches. The sampler is driven in 6-inch increments using a 140-pound weight (``hammer'') dropped from a height of 30 inches. The number of hammer blows for each 6-inch interval is counted and recorded. To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch ID sampler may be required. Blow counts obtained with a 3-inch ID spoon would not conform to ASTM D 1586 and would therefore not be used for geotechnical evaluations. Samples will be collected from the soil borings at 2-foot to 5-foot intervals. For sonic drilling, a continuous core is collected and the sample interval is selected from the length of core run.

Once retrieved from the hole, the sampler is carefully split open. Care should be taken not to allow material in the sampler to fall out of the open end of the sampler. Samples may be collected for chemical analysis. These samples are collected in either decontaminated stainless-steel split-spoon

samplers or new plastic sleeves (or metal trough for sonic drilling). Sampling the soil for chemical analysis is described in SOP *Soil Boring Sampling – Split Spoon.*

Undisturbed samples may be collected for analysis for geotechnical parameters such as vertical hydraulic conductivity. These samples will be collected using thin-walled sampling tubes (sometimes called Shelby tubes). Tubes will be 24- to 36 inches long and 3- to 4-inches in diameter, depending upon the quantity of sample required. Undisturbed samples will be obtained by smoothly pressing the sampling tube through the interval to be sampled using the weight of the drilling rig. Jerking the sample should be avoided. Once the sample is brought to the surface, the ends will be sealed with bees wax and then sealed with end caps and heavy tape. The sample designation, data and time of sampling, and the up direction will be noted on the sampling tube. The tube shall be kept upright as much as possible and will be protected from freezing, which could disrupt the undisturbed nature of the sample. Samples for analysis normally are not collected from thin-walled tube samples. More details are provided in the ASTM D 1587 standard (attached).

C. Abandonment

The borehole will be grouted from total depth to the surface with bentonite-cement grout. The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface. When installing grout in soil borings, the grout will be installed through a tremie pipe that is placed inside the augers or to the bottom of the borehole. The grouting will be completed before the augers or any temporary casing or drilling mud is removed.

D. Decontamination and Waste Disposal

Before sampling begins, equipment will be decontaminated according to the procedures identified in SOPs *Decontamination of Personnel and Equipment* and *Decontamination of Drilling Rig and Equipment.* The location to be sampled is cleared of debris and trash, and the location is noted in the logbook.

The soil cuttings are to be drummed and managed as described in SOP *Disposal of Waste Fluids and Soils* and the investigation-derived waste management plan.

IV. Attachments

ASTM D 1586 *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*

ASTM D 1587 *Standard Practice for Thin-Walled Tube Sampling of Soils*

V. Key Checks and Preventative Maintenance

- Check that the drilling rig or soil-coring rig is in working order.
- Check that the borehole is grouted to the ground surface at the completion of drilling and sampling.

SOPs in this section:

B-1 Groundwater Sampling Procedure Low Stress (low Flow) Purging and Sampling
B-2 Direct-Push Groundwater Sample Collection
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B. GROUNDWATER SAMPLING

STANDARD OPERATING PROCEDURE B-1

Groundwater Sampling Procedure Low Stress (Low Flow) Purging And Sampling

I. Scope & Application

This Low Stress (or Low-Flow) Purging and Sampling Procedure is the EPA Region II standard method for collecting low stress (low flow) groundwater samples from monitoring wells. Low stress Purging and Sampling results in collection of groundwater samples from monitoring wells that are representative of groundwater conditions in the geological formation. This is accomplished by minimizing stress on the geological formation and minimizing disturbance of sediment that has collected in the well. The procedure applies to monitoring wells that have an inner casing with a diameter of 2.0 inches or greater, and maximum screened intervals of ten feet unless multiple intervals are sampled. The procedure is appropriate for collection of groundwater samples that will be analyzed for volatile and semi-volatile organic compounds (VOCs and SVOCs), pesticides, polychlorinated biphenyls (PCBs), metals, and microbiological and other contaminants in association with all EPA programs.

This procedure does not address the collection of light or dense non-aqueous phase liquids (LNAPL or DNAPL) samples, and should be used for aqueous samples only. For sampling NAPLs, the reader is referred to the following EPA publications: DNAPL Site Evaluation (Cohen & Mercer, 1993) and the RCRA Groundwater Monitoring: Draft Technical Guidance (EPA/530-R-93-001), and references therein.

II. Method Summary

The purpose of the low stress purging and sampling procedure is to collect groundwater samples from monitoring wells that are representative of groundwater conditions in the geological formation. This is accomplished by setting the intake velocity of the sampling pump to a flow rate that limits drawdown inside the well casing.

Sampling at the prescribed (low) flow rate has three primary benefits. First, it minimizes disturbance of sediment in the bottom of the well, thereby producing a sample with low turbidity (i.e., low concentration of suspended particles). Typically, this saves time and analytical costs by eliminating the need for collecting and analyzing an additional filtered sample from the same well. Second, this procedure minimizes aeration of the groundwater during sample collection, which improves the sample quality for VOC analysis. Third, in most cases the procedure significantly reduces the volume of groundwater purged from a well and the costs associated with its proper treatment and disposal.

III. Addressing Potential Problems

Problems that may be encountered using this technique include

a. difficulty in sampling wells with insufficient yield;

b. failure of one or more key indicator parameters to stabilize;

c. cascading of water and/or formation of air bubbles in the tubing;

d. cross-contamination between wells.

Insufficient Yield Wells with insufficient yield (i.e., low recharge rate of the well) may dewater during purging. Care should be taken to avoid loss of pressure in the tubing line due to dewatering of the well below the level of the pump's intake. Purging should be interrupted before the water level in the well drops below the top of the pump, as this may induce cascading of the sand pack. Pumping the well dry should therefore be avoided to the extent possible in all cases. Sampling should commence as soon as the volume in the well has recovered sufficiently to allow collection of samples. Alternatively, groundwater samples may be obtained with techniques designed for the unsaturated zone, such as lysimeters.

Failure to Stabilize Key Indicator Parameters

If one or more key indicator parameters fails to stabilize after 4 hours, one of four options should be considered:

a. continue purging in an attempt to achieve stabilization;

b. discontinue purging, do not collect samples, and document attempts to reach stabilization in the log book;

c. discontinue purging, collect samples, and document attempts to reach stabilization in the log book; or

d. Secure the well, purge and collect samples the next day (preferred).

The key indicator parameter for samples to be analyzed for VOCs is dissolved oxygen. The key indicator parameter or all other samples is turbidity.

Cascading

To prevent cascading and/or air bubble formation in the tubing, care should be taken to ensure that the flow rate is sufficient to maintain pump suction. Minimize the length and diameter of tubing (i.e., 1/4 or 3/8-inch ID) to ensure that the tubing remains filled with groundwater during sampling.

Cross-Contamination

To prevent cross-contamination between wells, it is strongly recommended that dedicated, in-place pumps be used. As an alternative, the potential for cross-contamination can be reduced by performing the more thorough "daily" decontamination procedures between sampling of each well in addition to the start of each sampling day (see Section VII, below).

Equipment Failure

Adequate equipment should be on-hand so that equipment failures do not adversely impact sampling activities.

IV. Planning Documentation And Equipment

- Approved site-specific Field Sampling Plan/Quality Assurance Project Plan (QAPP). This plan must specify the type of pump and other equipment to be used. The QAPP must also specify the depth to which the pump intake should be lowered in each well. Generally, the target depth will correspond to the mid-point of the most permeable zone in the screened interval. Borehole geologic and geophysical logs can be used to help select the most permeable zone. However, in some cases, other criteria may be used to select the target depth for the pump intake. In all cases, the target depth must be approved by the EPA hydrogeologist or EPA project scientist.
- Well construction data, location map, field data from last sampling event.
- Polyethylene sheeting.
- Flame Ionization Detector (FID) and Photo Ionization Detector (PID).
- Adjustable rate, positive displacement groundwater sampling pump (e.g., centrifugal or bladder pumps constructed of stainless steel or Teflon). A peristaltic pump may only be used for inorganic sample collection.
- Interface probe or equivalent device for determining the presence or absence of NAPL.
- Teflon or Teflon-lined polyethylene tubing to collect samples for organic analysis. Teflon or Teflon-lined polyethylene, PVC, Tygon or polyethylene tubing to collect samples for inorganic analysis. Sufficient tubing of the appropriate material must be available so that each well has dedicated tubing.
- Water level measuring device, minimum 0.01 foot accuracy, (electronic preferred for tracking water level drawdown during all pumping operations).
- Flow measurement supplies (e.g., graduated cylinder and stop watch or in-line flow meter).
- Power source (generator, nitrogen tank, etc.).
- Monitoring instruments for indicator parameters. Eh and dissolved oxygen must be monitored in-line using an instrument with a continuous readout display. Specific conductance, pH, and temperature may be monitored either in-line or using separate probes. A nephalometer is used to measure turbidity.
- Decontamination supplies (see Section VII, below).
- Logbook (see Section VIII, below).
- Sample bottles.

- Sample preservation supplies (as required by the analytical methods).
- Sample tags or labels, chain of custody.

V. Sampling Procedures

Pre-Sampling Activities

1. Start at the well known or believed to have the least contaminated groundwater and proceed systematically to the well with the most contaminated groundwater. Check the well, the lock, and the locking cap for damage or evidence of tampering. Record observations.

2. Lay out sheet of polyethylene for placement of monitoring and sampling equipment.

3. Measure VOCs at the rim of the unopened well with a PID and FID instrument and record the reading in the field log book.

4. Remove well cap.

5. Measure VOCs at the rim of the opened well with a PID and an FID instrument and record the reading in the field log book.

6. If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Note that the reference point should be surveyed for correction of groundwater elevations to the mean geodesic datum (MSL).

7. Measure and record the depth to water (to 0.01 ft) in all wells to be sampled prior to purging. Care should be taken to minimize disturbance in the water column and dislodging of any particulate matter attached to the sides or settled at the bottom of the well.

8. If desired, measure and record the depth of any NAPLs using an interface probe. Care should be taken to minimize disturbance of any sediment that has accumulated at the bottom of the well. Record the observations in the log book. If LNAPLs and/or DNAPLs are detected, install the pump at this time, as described in step 9, below. Allow the well to sit for several days between the measurement or sampling of any DNAPLs and the low-stress purging and sampling of the groundwater.

Sampling Procedures

9. Install Pump: Slowly lower the pump, safety cable, tubing and electrical lines into the well to the depth specified for that well in the EPA-approved QAPP or a depth otherwise approved by the EPA hydrogeologist or EPA project scientist. The pump intake must be kept at least two (2) feet above the bottom of the well to prevent disturbance and resuspension of any sediment or NAPL present in the bottom of the well. Record the depth to which the pump is lowered.

10. Measure Water Level: Before starting the pump, measure the water level again with the pump in the well. Leave the water level measuring device in the well.

11. Purge Well: Start pumping the well at 200 to 500 milliliters per minute (ml/min). The water level should be monitored approximately every five minutes. Ideally, a steady flow rate should be maintained that results in a stabilized water level (drawdown of 0.3 ft or less). Pumping rates should, if needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. As noted above, care should be taken to maintain pump suction and to avoid entrainment of air in the tubing. Record each adjustment made to the pumping rate and the water level measured immediately after each adjustment.

12. Monitor Indicator Parameters: During purging of the well, monitor and record the field indicator parameters (turbidity, temperature, specific conductance, pH, Eh, and DO) approximately every five minutes. The well is considered stabilized and ready for sample collection when the indicator parameters have stabilized for three consecutive readings as follows (Puls and Barcelona, 1996):

    +0.1 for pH
    +3% for specific conductance (conductivity)
    +10 mv for redox potential
    +10% for DO and turbidity

    Dissolved oxygen and turbidity usually require the longest time to achieve stabilization. The pump must not be removed from the well between purging and sampling.

13. Collect Samples: Collect samples at a flow rate between 100 and 250 ml/min and such that drawdown of the water level within the well does not exceed the maximum allowable drawdown of 0.3 ft. VOC samples must be collected first and directly into sample containers. All sample containers should be filled with minimal turbulence by allowing the groundwater to flow from the tubing gently down the inside of the container.

    Groundwater samples to be analyzed for volatile organic compounds (VOCs) require pH adjustment. The appropriate EPA Program Guidance should be consulted to determine whether pH adjustment is necessary. If pH adjustment is necessary for VOC sample preservation, the amount of acid to be added to each sample vial prior to sampling should be determined, drop by drop, on a separate and equal volume of water (e.g., 40 ml). Groundwater purged from the well prior to sampling can be used for this purpose.

    Where filtered metals samples are to be collected, a disposable in-line filter (0.45 micron filter, QED® FF8100 or equivalent) will be added to the end of the discharge tubing and the sample collected using the pressure provided by the pump.

14. Remove Pump and Tubing: After collection of the samples, the tubing, unless permanently installed, must be properly discarded or dedicated to the well for resampling by hanging the tubing inside the well.

15. Measure and record well depth.

16. Close and lock the well.

VI. Field Quality Control Samples

Quality control samples must be collected to determine if sample collection and handling procedures have adversely affected the quality of the groundwater samples. The appropriate EPA Program Guidance should be consulted in preparing the field QC sample requirements of the site-specific QAPP.

All field quality control samples must be prepared exactly as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples should be collected during the sampling event:

- Field duplicates
- Trip blanks for VOCs only
- Equipment blank (not necessary if equipment is dedicated to the well)

As noted above, groundwater samples should be collected systematically from wells with the lowest level of contamination through to wells with highest level of contamination. The equipment blank should be collected after sampling from the most contaminated well.

VII. Decontamination

Non-disposable sampling equipment, including the pump and support cable and electrical wires which contact the sample, must be decontaminated thoroughly each day before use ("daily decon") and after each well is sampled ("between-well decon"). Dedicated, in-place pumps and tubing must be thoroughly decontaminated using "daily decon" procedures (see #17, below) prior to their initial use. For centrifugal pumps, it is strongly recommended that non-disposable sampling equipment, including the pump and support cable and electrical wires in contact with the sample, be decontaminated thoroughly each day before use ("daily decon").

EPA's field experience indicates that the life of centrifugal pumps may be extended by removing entrained grit. This also permits inspection and replacement of the cooling water in centrifugal pumps. All non-dedicated sampling equipment (pumps, tubing, etc.) must be decontaminated after each well is sampled ("between-well decon," see #18 on the following page).

17. Daily Decon

    A. Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

    B. Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Alconox, for 5 minutes and flush other equipment with fresh detergent solution for 5 minutes. Use the detergent sparingly.

    C. Rinse: Operate pump in a deep basin of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

D. Disassemble pump.

E. Wash pump parts: Place the disassembled parts of the pump into a deep basin containing 8 to 10 gallons of non-phosphate detergent solution. Scrub all pump parts with a test tube brush.

F. Rinse pump parts with potable water.

G. Rinse the following pump parts with distilled/deionized water: inlet screen, the shaft, the suction interconnector, the motor lead assembly, and the stator housing.

H. Place impeller assembly in a large glass beaker and rinse with 1% nitric acid (HNO3).

I. Rinse impeller assembly with potable water.

J. Place impeller assembly in a large glass bleaker and rinse with isopropanol.

K. Rinse impeller assembly with distilled/deionized water.

18. Between-Well Decon

A. Pre-rinse: Operate pump in a deep basin containing 8 to 10 gallons of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

B. Wash: Operate pump in a deep basin containing 8 to 10 gallons of a non-phosphate detergent solution, such as Alconox, for 5 minutes and flush other equipment with fresh detergent solution for 5 minutes. Use the detergent sparingly.

C. Rinse: Operate pump in a deep basin of potable water for 5 minutes and flush other equipment with potable water for 5 minutes.

D. Final Rinse: Operate pump in a deep basin of distilled/deionized water to pump out 1 to 2 gallons of this final rinse water.

VIII. Field log book

A field log book must be kept each time groundwater monitoring activities are conducted in the field. The field log book should document the following:

- Well identification number and physical condition.
- Well depth, and measurement technique.
- Static water level depth, date, time, and measurement technique.
- Presence and thickness of immiscible liquid layers and detection method.
- Collection method for immiscible liquid layers.

- Pumping rate, drawdown, indicator parameters values, and clock time, at three to five minute intervals; calculate or measure total volume pumped.
- Well sampling sequence and time of sample collection.
- Types of sample bottles used and sample identification numbers.
- Preservatives used.
- Parameters requested for analysis.
- Field observations of sampling event.
- Name of sample collector(s).
- Weather conditions.
- QA/QC data for field instruments.

IX. References

Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation, C.K. Smoley Press, Boca Raton, Florida.

Puls, R.W. and M.J. Barcelona, 1996, Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures, EPA/540/S-95/504.

U.S. EPA, 1993, RCRA Ground-Water Monitoring: Draft Technical Guidance, EPA/530-R-93-001.

U.S. EPA Region II, 1989, CERCLA Quality Assurance Manual.

STANDARD OPERATING PROCEDURE B-2

Direct-Push Groundwater Sample Collection

I. Purpose

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

II. Scope

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

III. Equipment and Materials

- Truck-mounted hydraulic percussion hammer.
- Direct-push (e.g., Geoprobe®) sampling rods and slotted lead rod
- Polyethylene sampling tubing and stainless steel foot valve
- Pre-cleaned sample containers
- Clean latex or surgical gloves.

IV. Procedures and Guidelines

1. Decontaminate slotted lead rod and other downhole equipment in accordance with SOP *Decontamination of Personnel and Equipment*.
2. Drive slotted steel lead rod to the desired sampling depth using the truck-mounted hydraulic percussion hammer.
3. Insert the stainless steel foot valve into the end of the polyethylene sampling tubing and insert tubing through the rods.
4. Fill all sample containers, beginning with the containers for VOC analysis.
5. Remove polyethylene sampling tubing from the rods. Remove the foot valve and discard polyethylene tubing.
6. Backfill borehole at each sampling location with grout or bentonite and repair the surface with like material (bentonite, asphalt patch, concrete, etc.), as required.

V. Key Checks and Items

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

- Ensure that the direct-push operator thoroughly completes the decontamination process between sampling locations.
- Ensure that the slotted lead rod has been inserted to the desired sampling depth.
- Verify that the borehole made during sampling activities has been properly backfilled.

STANDARD OPERATING PROCEDURE B-3

VOC Sampling - Water

I. Purpose

To provide general guidelines for sampling aqueous volatile organic compounds.

II. Scope

Standard techniques for collecting representative samples are summarized. Site-specific details are discussed in the Field Sampling Plan.

III. Equipment and Materials

- Sample vials, clean latex or surgical gloves, pH meter
- Hydrochloric acid (HCl) for preservation
- pH meter or pH-indicating paper
- Surgical or latex gloves

IV. Procedures and Guidelines

1. Sample VOCs before sampling other analyte groups.
2. When sampling for VOCs, especially residential wells, evaluate the area around the sampling point for possible sources of air contamination by VOCs. Products that may give off VOCs and possibly contaminate a sample include perfumes and cosmetics, skin applied pharmaceuticals, automotive products (gasoline, starting fluid, windshield deicers, carburetor cleaners, etc.) and household paint products (paint strippers, thinners, turpentine, etc.).
3. To check the amount of hydrochloric acid (HCl) that needs to be added at each location, fill a test vial (40 ml) with the water to be sampled, add one drop of hydrochloric acid (HCl), gently mix, and check the pH. Repeat this cycle (if necessary) until you reach a pH of 2, counting the number of drops of HCl required. DISCARD THE TEST VIAL and add an equal number of drops of HCl to each of the sample vials. Proceed to sample.
4. Keep the caps off the sample vials for as short a time as possible.
5. Wear clean latex or surgical gloves.
6. Fill the sample vial immediately, allowing the water stream to strike the inner wall of the vial to minimize formation of air bubbles. DO NOT RINSE THE SAMPLE VIALS BEFORE FILLING.

7. Fill the sample vial with a minimum of turbulence, until the water forms a positive meniscus at the brim.

8. Replace the cap by gently setting it on the water meniscus. Tighten firmly, but DO NOT OVERTIGHTEN.

9. Invert the vial and tap it lightly. If you see air bubbles in the sample, do not add more sample. Use another vial to collect another sample. Repeat if necessary until you obtain a proper sample.

V. Attachments

None.

VI. Key Checks and Items

- Check for possible sources of contamination.
- Check pH.
- Fill slowly, with as little turbulence as possible.
- Check for air bubbles.

GROUNDWATER SAMPLING DATA SHEET

CH2M HILL, INC.

Project Number: _____

Client: _____ Well ID: _____

Location: _____ Sample ID: _____

Event: _____ MS/MSD YES / NO

Date: _____ Sample Team: _____

Weather: _____

_____

Total Depth: _____ FT.(BTOC) Measuring Device: _____

Depth to water: (-) _____ FT.(BTOC) Date and Time: _____

Water Column: _____ FT. WELL DIAMETER

(x) _____ GAL/FT. [(2" DIA.= .163 GAL/FT.) (4" DIA. = .653 GAL/FT.)]

Well Volume: _____ GAL. (1" DIA.= .041 GAL/FT.) (1 1/4 " DIA.= .064 GAL/FT.)

Total Purge Volume: _____ GAL.

Purge Device: _____

Sample Time _____

Sample Appearance _____

FIELD PARAMETERS

Time	Purged Vol. (gals)	pH	Cond. µmhos/cm	Temp., °C	DO	ORP	Turbidity	Color / Odor / Comments

Signed by: _____ _____

Date and Time

PAGE 2 **Well ID:**

FIELD PARAMETERS								
Time	**Purged Vol. (gals)**	**pH**	**Cond. μmhos/cm**	**Temp., °C**	**DO**	**ORP**	**Turbidity**	**Color / Odor / Comments**

Notes:

STANDARD OPERATING PROCEDURE B-4

Preserving Non-VOC Aqueous Samples

I. Purpose

To provide general guidelines for preserving aqueous samples.

II. Scope

Standard aqueous sample preservation procedures for non-VOC samples are provided.

III. Equipment and Materials

- Disposable eye droppers
- Clean beakers for transfer of small portions of chemical preservative
- pH paper strips (range 0 to 14)
- Chemical preservatives, as appropriate
- Personal protection, as appropriate
- Clean out door or vented indoor area

IV. Procedures and Guidelines

1. Remove caps from sample containers to be chemically preserved in designated area. Add appropriate amount of chemical preservative to opened container. To determine the approximate amount of preservative required, preserve a sample of potable water and calculate the volume of preservative required.

2. After adding the appropriate preservatives to the sample containers, cap containers tightly. Invert sample container a few times to mix.

3. After preserving all the sample containers and mixing, open the container and check the pH of the sample by pouring out a small quantity of the sample to a clean receptacle and dipping a pH indicating strip into the sample. Add more preservative to the sample to adjust the pH, if necessary repeating steps 1 and 2. When three times the amount of preservative used to preserve a sample of potable water has been added, record the pH and notify the sample manager that the sample could not be preserved.

V. Attachments

None.

VI. Key Checks and Items

Be sure appropriate preservatives are used.

SOPs in this section:

C-1 Calibration and Measurement with Field Instruments
C-2 Bacharach Combustible Gas/Oxygen Meter and Personal Gas Monitor
C-3 Explosimeter
C-4 Operation of Dräger Gas Detector
C-5 Miniram Personal Monitor
C-6 Use of Data Loggers and Pressure Transducers
C-7 Volatile Monitoring with an OVA
C-8 Volatiles Monitoring by OVM

C. FIELD INSTRUMENTS

STANDARD OPERATING PROCEDURE C-1

Calibration and Measurement with Field Instruments

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for using field instruments to collect field measurements of pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature of liquid sample media (groundwater or surface water). The operator's manual should be consulted for detailed operating procedures for each specific instrument. This guideline will cover appropriate field equipment used on a routine basis for field conditions likely encountered on a field site.

II. Equipment and Materials

- Multi-parameter field instrument with flow-though cell
- Manufacturer's calibration manual
- Distilled water in squirt bottle
- Calibration Standard Solution(s) applicable to site conditions
- Beaker or cup
- Spare batteries for each instrument
- Spare instruments
- Weight and/or rope for depth measurements

III. Procedures and Guidelines

A. Documentation of Field Calibration and Measurements

Document acceptable calibration and calibration verification for each instrument unit and field test or analysis, linking this record with affected sample measurements.

- Designate the identity of specific instrumentation in the documentation with a unique description or code for each instrument unit used.
- Record manufacturer name, model number and identifying number such as a serial number for each instrument unit.
- Record the time and date of all initial calibrations and all calibration verifications.
- Record the instrument reading (value in appropriate measurement units) of all calibration verifications.
- Record the name of the analyst(s) performing the calibration or

verification.

- Document the specific standards used to calibrate or verify the instrument or field test with the following information:
- Type of standard or standard name (e.g., pH buffer) and value of standard, including correct units (e.g., pH = 7.0 SU)
- Document whether successful initial calibration occurred or failed.
- Document any corrective actions taken to modify instrument performance and date and time of any corrective actions.
- Note any incidence of discontinuation of use of the instrument due to calibration failure.

Record all field-testing measurement data, to include the following:

- Project name
- Date and time of measurement or test (including time zone, if applicable)
- Source and location of the measurement or test sample (e.g., monitoring well identification number, outfall number, station number or other description)
- Latitude and longitude of sampling source location (if known)
- Analyte or parameter measured
- Measurement or test sample value
- Reporting units for the measurement
- Initials or name of analyst performing the measurement

B. Instrument Calibration:

Prior to each day's use, clean the instrument probe and flow-through cell using deionized water and calibrate using the procedure described by the manufacturer of the instrument The following describes typical calibration checks for specific field parameters:

1. pH

Use at least two standards for initial calibration. One of the standards must be pH 7.0, the other at a value such that it will bracket the anticipated pH of the samples. Always the pH 7 first and rinse the probe between solutions. Follow the manufacturer's calibration instructions specific to your meter.

Most instruments allow for a two-point calibration and a few models can perform a three-point calibration. Use the appropriate number of standard buffer solutions for calibration. Groundwater is usually between pH 4 and 7 and surface water between pH 7 and 10 (including salt water). Acceptance criteria for initial or continuing calibrations will be Std X – 0.2 < Reading < Std X + 0.2

2. Conductivity

Check the meter in the field with at least one KCl std with a value close to the conductivity expected in the field. For fresh water groundwater and surface water applications, a standard of 1000 µS (or µmhos) is used while standards of 10,000, 30,000, and 50,000 µS are available for estuarine and marine surface water conditions. Acceptance criterion for this check is that the meter reads in the interval within Std X ± 3% of Std X.

3. Dissolved Oxygen

Calibrate the meter at 100% saturation. Before use, verify the meter calibration in water-saturated air to make sure it is properly calibrated and operating correctly. Make a similar verification at the end of the day or sampling event. Follow the manufacturer's instructions for your specific instrument.

Allow an appropriate warm up period before initial field calibration. Wet the inside of the calibration chamber with water, pour out the excess water (leave a few drops), wipe any droplets off the membrane/sensor and insert the sensor into the chamber (this ensures 100% humidity). Allow adequate time for the DO sensor and the air inside the calibration chamber to equilibrate.

Once the probe/calibration chamber is stable at ambient temperature, check the air temperature and determine, from the DO versus temperature table (See FT 1500-1) what the DO should measure. A stable and accurate temperature is required for a valid calibration. The acceptance criterion for DO calibration verification is +/- 0.3 mg DO/L.

The dissolved oxygen probe requires careful attention to the following items:

- Check sensor for bubbles and membrane for wrinkles or tear (before mobilization)
- Always store probe in saturated atmosphere
- Salinity affects DO readings (make correction, if needed)
- Common interferences: reactive gases, chlorine gas and sulfide will cause bias in results

4. Turbidity

This SOP describes the use of true nephelometric measurement which measures the scattering effect that suspended solids have on the propagation of light through a body of water (surface or ground waters). The higher the effect (i.e., intensity of scattered light), the higher the turbidity value. The use of in-situ probes with turbidity sensors (infra-red light source) may be used for screening purposes (e.g., groundwater purge stabilization measurements) only. Do not

report their results for regulatory purposes.

Perform an initial calibration verification by reading at least one primary standard as a sample. The acceptance criterion for the initial calibration verification depends on the range of turbidity of the standard value:

- Standard Value = 0.1-10 NTU: the response must be within 10% of the standard;
- Standard Value = 11-40 NTU: the response must be within 8% of the standard;
- Standard Value = 41-100 NTU: the response must be within 6.5% of the standard; and
- Standard Value > 100 NTU: the response must be within 5% of the standard.

Take readings with a turbidimeter using the following procedure:

- Gently agitate the sample and wait until air bubbles disappear.
- Double-rinse the sample cell or cuvette with a small amount of the sample. Discard, and pour an aliquot into the sample cell or cuvette.
- Gently dry out its external surface with lint-free paper.
- Insert the cell in the instrument and read the turbidity directly from the meter display.
- Pour out the sample, double-rinse the cuvette with de-ionized water in preparation for the next sample.

5. Oxidation Reduction Potential (ORP)

Oxidation Reduction Potential (ORP) is a measurement of the potential for a reaction to occur where a positive value indicates that the water is in an oxidized state or oxygen is present and a negative value is indicative of an anaerobic type environment or reducing condition. Equilibrate the standard solution to the temperature of the sample. Calibrate as follows:

- Immerse the electrodes and gently stir the standard solution in a beaker (or flow cell). Turn the meter on, placing the function switch in the millivolt mode.
- Let the electrode equilibrate for several minutes and record the reading to the nearest millivolt. The reading must be within ±10 mV from the theoretical redox standard value at that temperature. If not, determine the problem and correct it before proceeding. Switch to temperature display and read the value.
- Record the mV reading and temperature in the field notebook.
- Rinse the electrode with distilled water and proceed with the

sample measurement.

C. Sample Measurement:

As water passes through the flow-through Cell, obtain reading; record in the field notebook. Watch for potential fouling of probe, high concentrations of odors, or other factors that may skew readings. Perform the calibrations prior to use and at the end of day if practicable on all field measurement equipment.

IV. Key Checks and Preventive Maintenance

- Calibrate meter
- Clean probe with deionized water when done
- Refer to operations manual for recommended maintenance
- Check batteries, and have a replacement set on hand
- Due to the importance of obtaining these parameters, the field team should have a spare unit readily available in case of an equipment malfunction.

STANDARD OPERATING PROCEDURE C-2

Bacharach Combustible Gas/Oxygen Meter and Personal Gas Monitor

I. Purpose

The purpose of this SOP is to provide general reference information for using the Bacharach Sentinel 4 and Bacharach Sniffer® 503-A meters in the field. Calibration and operation, along with field maintenance, will be included in this SOP.

II. Scope

This procedure provides information into the field operation and general maintenance of the Sentinel 4 Sniffer and 503-A. Review of the information contained herein will ensure that this type of field monitoring equipment will be properly utilized. Review of the owner's instruction manuals is a necessity for more detailed descriptions.

III. Definitions

Carbon Monoxide Sensor - Expresses the Carbon Monoxide concentration in parts per million (ppm).

Combustible Gas - Combustible gas is expressed as a percent of the lower explosive limit (LEL).

Hydrogen Sulfide Sensor - Expresses the Hydrogen Sulfide concentration in parts per million (ppm).

Oxygen Sensor - Expresses the Oxygen concentration as a percentage.

ppm - parts per million: parts of vapor or gas per million parts of air by volume.

Sentinel 4 - Combustible Gas/Oxygen/Hydrogen Sulfide/Carbon Monoxide meter.

Sniffer 503-A - portable Combustible Gas and Oxygen Alarm instrument.

IV. Responsibilities

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed. The Project Manager is responsible for selecting qualified individuals for the monitoring activities.

Health and Safety Coordinator - The Health and Safety Coordinator is responsible for developing a site-specific Health and Safety Plan (HASP) which specifies air monitoring requirements.

Field Team Leader - It is the responsibility of the Field Team Leader to implement these procedures in the field, and to ensure that the field team performing air monitoring activities have been briefed and trained to execute these procedures before the start of site operations.

Site Safety Coordinator (SSC) - The SSC is responsible for ensuring that the specified air monitoring equipment is on site, calibrated, and used correctly by the field personnel. The SSC will coordinate these activities with the Field Team Leader.

Field team - It is the responsibility of the field team to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader/Site Safety Coordinator. The field personnel are responsible for documenting all air monitoring results in the field logbook during each field investigation.

V. Procedures

The Sentinel 4 Personal Gas Monitor and Sniffer 503-A utilize the principle of detecting sensors. The following four paragraphs discuss theory of operation as it applies to each functional sensor.

The combustible gas sensor uses two elements that are wound with a platinum wire. One of the elements is impregnated with a catalyst to oxidize combustible gases. The other element is impregnated with material that will also oxidize combustible gases, but will respond to temperature and humidity conditions. When the meter is turned on, an electrical current is passed through the elements and wires. As a combustible gas enters the chamber, the elements will oxidize the combustible gas, thus increasing the heat and resistance of the element. This change in resistance causes a system imbalance, which produces a measurable signal proportional to the combustible gas concentration.

The percent oxygen is measured utilizing an electrochemical sensor. As atmospheric oxygen enters the meter it diffuses into the sensor which converts the amount of oxygen in the sensor to a voltage signal. This voltage is directly proportional to percent oxygen in the atmosphere.

The concentration of hydrogen sulfide is measured utilizing an electrochemical sensor. As atmospheric hydrogen sulfide enters the meter it diffuses into the sensor which converts the amount of hydrogen sulfide in the sensor to a voltage signal. This voltage is directly proportional to the atmospheric hydrogen sulfide concentration.

The concentration of carbon monoxide as measured utilizing an electrochemical sensor. As atmospheric carbon monoxide enters the meter it diffuses into the sensor which converts the amount of carbon monoxide in the sensor to a voltage

signal. This voltage is directly proportional to the atmospheric carbon monoxide concentration.

The Sentinel 4 Personal Gas Monitor and Sniffer 503-A are intrinsically safe for use in Class I, Division 1, Groups A, B, C and D hazard areas. One fact that needs to be expressed is that this type of monitoring equipment utilizes internal oxidation of combustibles, if the meter is placed in an oxygen deficient atmosphere, the combustible reading may be affected. Review of each of the instruction manuals will aid in determining the percentage of oxygen that affects the combustible gas readings.

The following subsections will discuss Sentinel 4 and Sniffer 503-A calibration, operation, and maintenance. These sections, however, do not take the place of the instruction manual.

A. Calibration

1. Sentinel 4

Due to the numerous steps involved in calibration, it is recommended that you follow the calibration procedures (on a daily basis) as outlined in the instruction manual from pages 5-12 to 501

NOTE: A calibration kit will be provided for each Sentinel 4. This kit contains a cylinder for the combustible gas sensor, one cylinder for the hydrogen sulfide sensor, and one cylinder for the carbon monoxide sensor. The oxygen sensor can be calibrated with (uncontaminated/fresh air environment) atmospheric air and does not need cylinder gas.

Note: When a single sensor doesn't zero, none of the sensors are zeroed.

2. Sniffer® 503-A

Oxygen Detector

1. Check battery charge by turning function switch to "BATTERY TEST," if battery is in recharge zone instrument will need to be charged.

2. To zero the oxygen detector, turn function switch to "BATTERY TEST" position and - press "TEST" switch and observe the 02 meter indication. If indicator is zero, no further adjustment is necessary. If not, follow procedures in Section 5.4.1 of the Operations Manual.

3. To calibrate the oxygen detector, turn function switch to "BATTERY TEST" position. Unlock the "OXYGEN CALIB" knob and adjust it for an 02 meter indication of 21 or at the CAL mark. Relock "OXYGEN CALIB" knob. If using zero calibration gas, follow procedures in Section 5.4.2 of the Operator's Manual.

4. Record on Calibration Sheet.

% LEL Detector

1. Check battery charge by turning function switch to "BATTERY TEST," if batter is in recharge zone, instrument will need to be charged. Allow 5 minutes for the instrument to warm up.
2. Turn function switch to the % LEL position. Note: To eliminate the annoyance of the audible alarm, cover the alarm with a hand or duct tape during calibration. The tape must be removed, prior to operation!!
3. Connect calibration gas (typically 30% of the LEL) and allow gas to flow for 1 minute. Note: If calibration gas has a concentration value, not a % LEL value, the % LEL can be calculated as follows:

   % calibration gas (i.e., methane) x 20% LEL (meter alarm setting) = % LEL calibration setting

   If meter indication is within ±5% of LEL calibration gas, no further adjustment is required. If not, follow procedures in Section 5.5.4 of Operator's Manual.

3. Sniffer® 503-A

1. Connect sample probe and tubing to the instrument's sample inlet (refer to Sections 8.4 and 8.5 for the Operator's Manual for available hoses and probes.
2. Check that battery is in Operational Range.
3. Turn instrument to % LEL range and allow to warm up for 1 minute.
4. Check in a fresh air environment that % LEL reads 0% and that 02 indicator reads 21% (calibration mark).
5. Sample air/gas from area to be tested, allow 30 seconds for readings to stabilize. When finished, allow at least 10 seconds (longer if extension line is used) to purge sample line.
6. B" instrument is operating erratically, refer to "TROUBLESHOOTING" Section (Table 5-2) in Operator's Manual.

B. Operation

1. Sentinel 4

Due to the Sentinel 4 having many functions in terms of operation, it is recommended that you follow the operational procedures as outlined in the instruction manual from pages 6-1 to 6-34.

NOTE: Since the Sentinel 4 is capable of measuring four different parameters, an understanding of the alarm, error, and fault messages must be obtained. This can be done ET reviewing the troubleshooting table found on pages 9-2 to 9-9.

C. Site Maintenance

After each use, the meters should be recharged and the outside of the instruments should be wiped clean with a soft cloth.

D. Scheduled Maintenance

Function	Frequency
Check alarm and settings	Monthly/before each use
Clean screens and gaskets around sensors	Monthly
Replace sensors	Biannually or when calibration is unsuccessful

VI. Quality Assurance Records

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the field logbook.

- Identification - Site name, date, location, CTO number, activity monitored, (surface water sampling, soil sampling, etc), serial number, time, resulting concentration, comments and identity of air monitoring personnel.
- Field observations - Appearance of sampled media (if definable).
- Additional remarks (e.g., Sentinel 4 or Sniffer 503-A had wide range fluctuations during air monitoring activities.)

NOTE: The "Toxic Gas Meter Calibration Form" will be completed daily, prior to performing any air monitoring.

VII. References

Bacharach Installation, Operation, Maintenance Manual Sentinel -1 Personal Gas Monitor, 1990.

Bacharach Installation, Operation, Maintenance Manual, Sniffer 503-A, Rev. 3 October-1990.

STANDARD OPERATING PROCEDURE C-3

Explosimeter

I. Purpose and Scope

This SOP provides a guideline for field measurements of the levels of combustible gas and oxygen in air. The following general discussion applies to most explosimeter but may differ between specific brands. The operator's manual should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Industrial Scientific (MX251) Combustible Gas and Oxygen Indicator, or equivalent meter, which can be field calibrated
- Flow-control regulator and hose
- Calibration gas (50 percent LEL pentane—0.75 percent pentane and 15 percent oxygen in nitrogen)
- Equipment calibration data sheet

III. Procedures and Guidelines

A. Calibration

The explosimeter must be calibrated before initial daily use. Record calibration information on equipment calibration data sheet. Calibration will be performed according to the following procedure:

1. Turn instrument on
   - Unscrew knurled nut on bottom
   - Rotate metal cover 180°
   - Tighten knurled nut
2. Check battery
   - Check for no ``LoBatt'' display—do not use if LoBatt displayed
3. Calibrate instrument
   - Observe that instrument reads 0 percent LEL and 21 percent Oxygen (OX) (record readings)
   - Connect sampling pump onto top of instrument

- Connect .75 percent Pentane/15 percent oxygen gas (with 1.5 LPM Regulator and direct tubing)
- Turn pump ON
- Turn gas ON
- Record LEL and O_2 after stabilized; LEL must read 50 percent +/-5 percent; O_2 must read 15 percent +/- 5 percent
- Disconnect sample pump and return to charger

B. Sample Measurement

The instrument is then ready for air sampling. Note and record the readings for percent LEL and percent O_2.

IV. Attachments

- Equipment calibration data sheet

V. Key Checks and Preventive Maintenance

Check that the batteries be adequately charged. Certain materials such as silicone, silicates, and organic lead compounds tend to poison the catalyst in the instrument, thereby giving erroneously low readings; calibration checks should be made frequently if such materials are suspected to be present.

If the CGI does not cal-check within ±5 percent of 50 percent LEL, an internal calibration must be performed, or the instrument replaced.

EXPLOSIMETER CALIBRATION SHEET

			Instrument Readings		
Date	**Time**	**Analyst Initials**	**Uncalibrated @LEL=0% O_2=21%**	**Calibrated @LEL=50%±5 O_2=15%±5**	**Comments**

STANDARD OPERATING PROCEDURE C-4

Operation of Dräger Gas Detector

I. Purpose

The purpose of this SOP is to provide general reference information for using the Dräger Gas Detector. Operation along with field maintenance will be included in this SOP. This monitoring is intended for health and safety purposes only, not for analytical characterization of air quality.

II. Scope

This procedure provides information as it applies to field operation and general maintenance of the Dräger Gas Detector. Application of the information contained herein will ensure that this type of field air monitoring equipment will be operated properly. The various calorimetric detector tubes required for each specific site operation will be addressed in the respective Health and Safety Plan (HASP).

III. Definitions

Dräger Bellows Pump - A hand-operated bellows pump that draws in 100 cubic centimeters (cc's) of air through a detector tube with each pump stroke.

Detector Tube (Dräger Tube) - A glass tube impregnated with an indicating chemical resulting in a color change.

IV. Responsibilities

Project Manager -The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed. The Project Manager is responsible for selecting qualified individuals for the monitoring activities.

Health and Safety Officer - The Health and Safety Officer is responsible for developing a site-specific Health and Safety Plan (HASP) which specifies air monitoring requirements.

Field Team Leader - It is the responsibility of the Field Team Leader to implement these procedures in the field, and to ensure that the field team performing air monitoring activities have been briefed and trained to execute these procedures before the start of site operations.

Site Safety Coordinator (SSC) - The SSC is responsible for ensuring that the specified air monitoring equipment is on site, calibrated, and used correctly by the

field personnel. The SSC will coordinate these activities with the Field Team Leader.

Field team - It is the responsibility of the field team to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader/Health and Safety Officer. The field team is responsible for documenting all air monitoring results in the field logbook during each field investigation.

V. Procedures

The Dräger Gas Detector uses the principle of exposing a measured concentration of a reagent to a measured volume of air, to produce a proportional reaction of the contaminant in question. There are various types and styles of detector tubes with each being specific to air contaminants, reaction principal, reaction color and number of pump strokes. Care must be taken to follow the instructions provided with each box of tubes. Always note the expiration date on the box and refrigerate the tubes whenever possible to maintain tube life.

The following subsections will discuss the operation and maintenance of the Dräger Gas Detector. These sections, however, should not be used as a substitute for the manufacturer's operating procedures.

A. Operation

- Check the pump for leaks before each series of measurements (according to the Leak Test procedures outlined in Section B).
- Break off both tips of the Dräger Tube in the break-off eyelet.
- Tightly insert the Dräger Tube in the pump head with the arrow on the tube pointing towards the pump.
- Fully compress the bellows.
- Straighten the fingers. The suction process takes place automatically and is completed when the limit chain is taut (Model 31) or the white dot is completely visible (Accuro).
- Repeat the suction process as often as specified in the Tube Operating Instructions.

Evaluate the indication as described in the Tube Operating Instructions, paying special attention to interfering chemicals, etc. These instructions are supplied with the package of tubes.

B. Maintenance

- Leak testing: Check the pump for leaks prior to use. To do this, completely compress the bellows and seal the pump with an unopened Dräger Tube. The pump is sufficiently air-tight if the bellows has not completely expanded after 30 seconds, (i.e., the limit chain is not taut

[Model 31] or the white dot is not visible [Accuro]). It will then deliver the volume required.

- Eliminating leaks: For Model 31, any leak can usually be eliminated by cleaning the valve. To do this, remove the front plate and unscrew the valve using the special spanner. Raise the valve disc to prevent it from being damaged by the spanner. Clean the valve by blowing it through with air or by rinsing it with water. Dry the valve after cleaning. If the rubber of the valve disc is sticky, brittle, hard or cracked, it must be replaced. Remove the pin from the valve seat stem and push in the pin of the new valve disc until the disc lies flat against the valve seat. It is best to moisten the pin a little at first. When fitting the cover plate, ensure that the limit chain is not twisted and that the fixing hook lies in the longitudinal direction of the pump, so that it fits satisfactorily in the slot of the cover plate.

- Cleaning the metal screen: After prolonged use of the Bellows Pump, the wire mesh sieve under the rubber bung in the pump head may become blocked. Therefore, the sieve must be cleaned from time to time, about every four weeks, when the pump is used frequently. For Model 31, loosen the two-hole nut with the special spanner and remove the rubber bung. Take out the sieve and clean it with a brush under running water. When re-inserting the two-hole nut, tighten it only until the rubber bung is just under stress and the Dräger Tube can be inserted easily, but tightly.

- Flushing the pump with air: To prevent corrosion of the interior portions of the pump, flush out the pump with air by making a few strokes without a Dräger Tube after each time it has been used.

C. Limitations and Considerations

The chemical reactions involved in the use of the tubes are affected by temperature. Cold weather decreases the reactions and thus the response times. Therefore, it is recommended that the tubes (prior to use) be kept warm if the measurement is done in cold temperatures; or for hot temperatures (which can increase the reaction and can cause a problem by discoloring the indicator when a contaminant is not present), the tubes should be stored at a moderate temperature.

The chemical utilized in the tubes will deteriorate over time, and therefore the tubes are assigned a shelf life. This will vary from one to three years and should be checked prior to use.

An advantage that detector tubes have over some other instrument is that it is possible to select a tube that is specific to a chemical. However, some tubes will respond to interfering compounds. Fortunately, the manufacturers provide information in the tube package on interfering gases and vapors.

Due to these many considerations, it is very important to read the instructions that are provided with and are specific to a set of tubes. The information includes the number of pump strokes needed, time for each pump stroke, interfering gases and vapors, effects of humidity and temperature, shelf life, proper color change and whether the tube is reusable.

VI. Quality Assurance Records

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the field logbook.

- Identification - Site name, date, location, CTO number, activity monitored, (surface water sampling, soil sampling, etc.), serial number, time, resulting concentration, comments and identity of air monitoring personnel.
- Field observations - Appearance of sampled media (if definable).
- Additional remarks - (e.g., the Dräger tube changed to a color representing an interference during air monitoring activities).

VII. References

National Dräger, Inc. 1992. Dräger Detector Tube Handbook. Lubeck, 8th Edition, Pittsburgh, Pennsylvania.

STANDARD OPERATING PROCEDURE C-5

Miniram Personal Monitor

I. Purpose

The purpose of this SOP is to provide general reference information using the Miniram (Mini Real-time Aerosol Monitor) Model PDM-3 to monitor airborne particulates.

II. Scope

This procedure provides information regarding the field operation and general maintenance of the Miniram Model PDM-3. The information contained herein presents the operation procedures for this field monitoring equipment. Review of the owner's instruction manual is a necessity for more detailed descriptions pertaining to the operation and maintenance of the monitor.

III. Definitions

Miniram - Mini Real-time Aerosol Monitor (Miniram) Model PDM-3 used to monitor airborne particulates for preferential response to the particle size range of 0.1 to 10 micrometers.

Sun Shield -.An accessory to the Miniram that protects the sensing elements from excessive ambient light fluctuations.

Z-Bag kit - A calibration kit that consists of a one-way flow rubber bulb for manual air pumping, a filter cartridge, a zippered plastic container, and connecting hardware.

mg/m3 - milligrams per cubic meter of particulate (size range of 0.1 to 10 micrometers) in air, by volume

IV. Responsibilities

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed The Project Manager is responsible for selecting qualified individuals for the monitoring activities.

Health and Safety Officer - The Health and Safety Officer is responsible for developing a site-specific Health and Safety Plan (HASP) which specifies air monitoring requirements.

Field Team Leader - It is the responsibility of the Field Team Leader to implement these procedures in the field, and to ensure that the field team performing air monitoring activities, have been briefed and trained to execute these procedures before the start of site operations.

Site Safety Coordinator (SSC) - The SSC is responsible for ensuring that the specified air monitoring equipment is on site, calibrated, and used correctly by the field team. The SSC will coordinate these activities with the Field Team Leader.

Field team - It is the responsibility of the field team to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader/SSC. The field team is responsible for documenting the air monitoring results in the field logbook during field investigation.

V. Procedures

The following sections provide information on the operating principles, calibration, operation, and maintenance of the Miniram.

A. Principle of Operation

The Miniram Model PDA13 (Miniram) is an airborne particulate monitor whose operating principle is based on the detection of scattered electromagnetic radiation in the near infrared. The Miniram uses a pulsed light emitting source which generates a narrow-band emission centered at 880 nanometers (=). It is a light scattering aerosol monitor of the nephelometric type (i.e., the instrument continuously senses the combined scattering from the population of particles present within its sensing volume [approximately 1 cm3] whose dimensions are large compared with the average separation between the individual airborne particles.)

In the "Open Sensing Chamber Sampling Method", air surrounding the Miniram passes freely through the open aerosol sensing chamber as a result of air transport caused by convection, circulation, ventilation and personnel movement (i.e., a pump is not used). The scattering sensing parameters have been designed for preferential response to the particle size range of 0.1 to 10 micrometers, ensuring high correlation with standard gravimetric measurements of both the respirable and inhalable size fractions. The rate at which air passes through the sensor does not influence the indicated concentration because the detection is performed directly on every parcel of air traversing the fixed sensing volume. Therefore, flow velocity through a real-time sensor such as the Miniram influences only the response time.

The Miniram measures the concentration of any airborne particles, both solid and liquid, and the display indicates this level in the units of milligrams per cubic meter (mg/m3), based on its factory calibration. The Miniram should be operated in a vertical position and away from reflecting surfaces.

The Miniram comes with a sun shield accessory that protects the sensing elements from excessive ambient light fluctuations. The sun shield is used for outdoor use and under fluctuating bright light illumination. However, it is advisable to use the sun shield at all times.

B. Calibration

Calibration is achieved in the field using a Z-Bag TM Calibrator which will provide a clean-air environment inside a plastic bag into which the Miniram is placed for zeroing. The Z-Bag kit consists of a one-way flow rubber bulb for manual air pumping, a filter cartridge, a zippered plastic container, and connecting hardware.

Prior to calibration, ensure that the Miniram is clean before placing into Z-Bag. Do not expose Z-Bag to sub-zero freezing temperatures as the plastic zippered bag may crack.

The calibration procedure is as follows:

1. Place Z-Bag on flat surface with red flow fitting facing up. Flatten bag. Remove small plastic cap from flow fitting on bag.
2. Connect rubber bulb/filter assembly to red flow fitting of plastic bag, until flush with bottom of fitting.
3. Miniram should be in its OFF condition (check display). If display is blanked, or if Miniram is in another mode, press OFF.
4. Open Z-Bag and place Miniram inside at the center. Press ZERO* and immediately zip closed the bag and begin pumping the rubber bulb/filter assembly.
5. Inflate Z-Bag up to a height of about five inches, then maintain the bag pressure until the Miniram displays OFF again.
6. Record background reading displayed while zeroing, on calibration form.
7. Unzip Z-Bag and remove Miniram. Place rubber bulb/filter assembly inside Z-Bag, and plug small plastic cap into flow fitting to close it. Zip close while flattening Z-Bag to ensure cleanliness of the bag interior.
8. Miniram is ready for use.

The "zero value" is the background level and is automatically subtracted from all aerosol concentrations readings during the measurement mode. Therefore, the displayed readings depend only on the actual dust concentration present within the sensing chamber. It will increase somewhat as the chamber inner walls and windows become contaminated with dust. A **zero** value greater than 3 mg/m2 indicates excessive chamber contamination. For cleaning instructions, refer to manufacturer's operating manual.

C. Use and Applications

To use the Miniram, remove it from the case and observe the display. If the display is blank the Miniram is in the minimum power mode. An "OFF" display means that it has been in the off mode for less than 48 hours.

Depending on the mode of interest, refer to the subsections below for a brief explanation of the use and applications.

1. Measure (MEAS) Mode

With a blank display mode, press OFF and wait until the display reads "OFF" (approximately 5 seconds), before pressing MEAS to initiate measurement cycle. - If the Miniram shows OFF, press MEAS directly to initiate measurement cycle.

The first readout displayed is "GO" (or "CGO" if TIME is also pressed), followed by the last concentration reading or ".00". Approximately 36 seconds after pressing MEAS the first new 10 second averaged concentration reading is displayed. All subsequent readings are concentration values in milligrams per cubic meter, updated every 10 seconds. The Miniram will run in this mode for 500 minutes after which it will stop and display the OFF reading (retaining in storage the concentration average and elapsed time information).

Once the measurement cycle has started, the only way it will be stopped is by pressing OFF. The Miniram normally operates in the .00 to 9.99 mg/m3 range but whenever a 10-second concentration exceeds 9.99 mg/m3 it will automatically switch to a .0 to 99.9 mg/m3 range and remain their until the concentration drops to the lower range.

If both MEAS and TIME are pressed at the same moment (TIME then MEAS) the Miniram will display "CGO" (for Continuous Go) which will cause the instrument to measure continuously in 500 minute intervals. It will run continuously until OFF is engaged or the batteries are exhausted at which time "OFF" will be displayed. Concentration averages and timing information for the last seven 500 minute intervals will remain in storage.

2. Time-Weighted Average (TWA) Mode

During the measurement mode, if TWA is pressed the display will indicate the average concentration in mg/m^3 up to that instant, from the start of the last run. The value of TWA is updated every 10 seconds. After releasing the TWA key the Miniram display returns to the 10-second concentration display.

3. Shift-Average (SA) Mode

During the measurement mode, if SA is pressed the display will provide the aerosol concentration up to that moment, averaged over an 8-hour shift period. This concentration corresponds to the exposure from the start of the measurement cycle and is updated every 10 seconds. After releasing the SA key the Miniram display returns to the 10-second concentration display.

4. Play Back (PBK) Mode

With the Miniram in the off mode, the stored information can be played back by pressing PBK for more than 1 second. The information will be played back in the following order:

- ID number
- Shift or run number
- Sampling time in minutes
- Off-time between the last and next run (in tens of minutes)
- Average in mg/m^3

This sequence is repeated seven times; an average reading of 9.99 mg/m^3 indicates that a significant overload condition occurred during that run. It will take approximately 70 seconds to run through this program.

5. ID Number Selection

In order to change the Miniram identification number, press the OFF key then the ID# key and the presently stored number (between 1 and 999) will be displayed. The raise the number press the up arrow key, and to lower the number press the down arrow key. Pressing the OFF key after this selection will lock-in that number.

D. Maintenance

After each use, the Miniram should be wiped clean with a soft cloth and connected to charger. The Miniram requires a minimum 8 hour charge for daily operation. When not in use it should be stored in the accompanying case to avoid particulate build up in the sensing chamber.

When the zero value exceeds 3 mg/m^3, the sensing chamber may need to be cleaned following the instructions provided in the manufacturer's operating manual.

VI. Quality Assurance Records

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the Field Logbook.

- Identification - Site name, date, location, CTO number, activity monitored (monitoring --well installation, etc.), serial number, time, resulting concentration, comments and identity of air monitoring personnel.
- Field observations - Appearance of sampled media (if definable).
- Additional remarks (e.g., the Miniram experienced a wide range of fluctuations).

VII. References

Monitoring Instruments for the Environment (MIE), INC., Miniram Personal Monitor

Model PDM-3 Operations Manual. March 1990.

STANDARD OPERATING PROCEDURE C-6

Use of Data Loggers and Pressure Transducers

I. Purpose and Scope

The purpose of this procedure is to provide a guideline for the use of continuously recording data loggers and pressure transducers to monitor changes in water levels and barometric pressure. Procedures for using a particular type of data logger are not included and should be obtained from the equipment manuals. The SOP *Water-Level Measurements* provides guidance for collecting discrete measurements of water levels.

II. Equipment and Materials

- Continuously recording data logger (e.g., Campbell® or In Situ® Hermit)
- Pressure transducers (e.g., Druck®) of adequate pressure ranges and cable lengths
- Electronic water-level meter (e.g., Solinst®) with a minimum 100-foot tape; the tape should have graduations in increments of 0.01 feet or less
- Duct tape

III. Procedures and Guidelines

The procedures for using the particular type of data logger should be obtained from the operating manuals for the equipment. In general, all data loggers have a means of specifying such data as the pressure range of the transducer, the type of monitoring to be performed (e.g., slug test), the frequency of measurements, the length of the test, and the number of transducers to be monitored.

Transducers should be selected with the appropriate pressure range for the expected range of water-level or barometric changes. A change of 1 pound per square inch (psi) of pressure is equivalent to a change of 2.3 feet of water level. Therefore, if the change in water level is expected to be small (i.e., less than 10 feet), a transducer with a range from 0 to 5 psi would be best.

For downhole applications, measure the initial water level with the water-level meter. Attach the transducer cable to the proper port on the data logger. Lower the transducer into the piezometer or well until it reaches the surface of the water. The data logger should begin reading a positive pressure. Lower the transducer to a depth below the water-level surface that is comfortably below the surface. Tape the transducer cable to the casing so that the transducer does not move in the piezometer or well. Confirm that the transducer is at the proper depth in the water

by reading the data logger. Set the data logger for the appropriate frequency of data collection.

Transducers for measuring barometric pressure are attached to a secure fixture (e.g., casing or light post) and are plugged into the proper logger port. Transducers for measuring the changes in water level in surface-water bodies are attached to a weight and lowered to the bottom. The depth of water above the transducer can be read from the data logger. Care should be taken to prevent the cable from interfering with boat traffic.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- Prior to each use, verify that the batteries charged and that there is sufficient space in the data-logger memory for the data to be collected.
- Ensure that all settings are appropriate for the transducer pressure range and the type of test.
- Protect the logger from inclement weather and vandalism.

STANDARD OPERATING PROCEDURE C-7

Volatiles Monitoring with an OVA

I. Purpose and Scope

The purpose of this procedure is to provide guidelines for the calibration and use of an OVA Organic Vapor Analyzer.

II. Equipment and Materials

- Operations manual
- An OVA hand readout unit and side pack assembly
- 100 ppm methane as calibration gas
- T-type feeder tube with 1.5 liter/min. regulator

III. Procedures and Guidelines

ONLY PROPERLY TRAINED PERSONNEL SHOULD USE THIS INSTRUMENT. FOR SPECIFIC INSTRUCTIONS, SEE OPERATIONS MANUAL.

A. OVA, Organic Vapor Analyzer

The OVA Organic Vapor Analyzer is designed to detect organic materials in air. It uses a flame-ionization detector (FID) as its detection principle. This detector allows the monitor to respond to a wide variety of organic compounds.

1. Operational Checks

   - See OVA Operators Manual included with instrument.

2. Calibration

   - See OVA Operators Manual included with instrument.
   - Calibration will be done daily prior to use and additionally if erratic instrument readings are observed and at the end of the day if practicable.

IV. Key Checks and Preventative Maintenance

- Check battery.
- Zero and calibrate.

- Verify sensor probe is working.
- Recharge unit after use.

A complete preventative maintenance program is beyond the scope of this document. For specific instructions, refer to the operations manual.

- A complete spare instrument should be available whenever field operations require volatiles monitoring.
- Spare parts should be on hand so minor repairs may be made in the field.
- Batteries should be charged daily.
- Occasionally allow the batteries to totally discharge before recharging to prevent battery memory from occurring.

STANDARD OPERATING PROCEDURE C-8

Volatiles Monitoring by OVM

I. Purpose and Scope

The purpose of this procedure is to provide guidelines for the calibration and use of an OVM Organic Vapor Monitor. This is a broad guideline for field use of an OVM; for specific instruction, refer to the operators manual.

II. Equipment and Materials

- Operations manual
- An OVM hand readout unit and side pack assembly
- 100 ppm isobutylene as calibration gas
- T-type feeder tube with 1.5 liter/min. regulator

III. Procedures and Guidelines

ONLY PROPERLY TRAINED PERSONNEL SHOULD USE THIS INSTRUMENT. FOR SPECIFIC INSTRUCTIONS, SEE OPERATIONS MANUAL.

A. OVM, Organic Vapor Monitor

The OVM Organic Vapor Monitor is designed to detect organic materials in air. It uses a photo-ionization detector (PID) as its detection principle. This detector allows the monitor to respond to a wide variety of organic compounds.

1. Operational Checks
   - See basic operating instructions in operations manual.
2. Calibration
   - See basic operating instructions in operations manual.
   - Calibration will be done daily prior to use and additionally if erratic instrument readings are observed and at the end of the day if practicable.

IV. Key Checks and Preventive Maintenance

- Check battery.

- Zero and calibrate.
- Verify sensor probe is working.
- Recharge unit after use.

A complete preventive maintenance program is beyond the scope of this document. For specific instructions, refer to the operations manual. Some key issues are discussed below:

- A complete spare instrument should be available whenever field operations require volatiles monitoring.
- Spare parts should be on hand so minor repairs may be made in the field.
- Batteries should be charged daily.
- Occasionally allow the batteries to totally discharge before recharging to prevent battery memory from occurring.

SOPs in this section:

D-1 General Guidance for Monitoring Well Installation
D-2 Installation of Shallow Monitoring Wells
D-3 Installation of Surface-Cased Monitoring Wells
D-4 Installation of Bedrock Monitoring Wells
D-5 Monitoring Well and borehole Abandonment

D. MONITORING WELL INSTALLATION

STANDARD OPERATING PROCEDURE D-1

General Guidance for Monitoring Well Installation

I. Purpose

To provide site personnel with a review of the well installation procedures that will be performed. These procedures are to be considered general guidelines only and are in no way intended to supplement or replace the contractual specifications in the driller's subcontract.

II. Scope

Monitoring well installations are planned for shallow and/or deep unconsolidated aquifers and/or for bedrock aquifers. The SOPs *Installation of Shallow Monitoring Wells, Installation of Surface-Cased Monitoring Wells, Installation of Bedrock Monitoring Wells,* and *Installation of Monitoring Wells Using Sonic Drilling* provide more specifics.

III. Equipment and Materials

1. Drilling rig (hollow stem auger, sonic, air hammer, air rotary, or mud rotary)
2. Well-construction materials (i.e., surface casing, screens, riser, casing, caps, bottom plugs, centering guides, sand, bentonite, grout, and surface-finish materials)
3. Development equipment

IV. Procedures and Guidelines

1. Wells will be installed in accordance with standard EPA procedures. Note that USEPA Region III requires any well penetrating a confining layer to be double-cased.
2. The threaded connections will be water-tight.
3. Well screens generally will be constructed of 10-slot or 20-slot Schedule 40 PVC and will be 5 to 10 feet in length depending on saturated thickness of unconsolidated sediments. The exact slot size and length will be determined by the field team supervisor. Stainless steel may be required under certain contaminant conditions.

4. Wells will be surrounded by four concrete-filled, 3-inch diameter guard posts.

5. A record of the finished well construction will be compiled.

6. All soils and liquids generated during well installations will be drummed for proper disposal.

A. Monitoring Well Installation

- Monitoring wells in unconsolidated materials will be installed in at least 6-inch-diameter boreholes to accommodate well completion materials in designated locations.
- All monitoring wells penetrating a confining layer will be surface-cased from the ground surface to approximately 5 feet into the confining layer. Exceptions to this may be allowed under certain circumstances (e.g., evidence of significant natural gaps in the confining layer).
- Monitoring wells in unconsolidated materials will be constructed of 2-inch-diameter, factory manufactured, flush-jointed, Schedule 40 PVC screen with threaded bottom plug and riser.
- Screens will be filter packed with a properly sized and graded, thoroughly washed, sound, durable, well-rounded basalt or siliceous sand. When using hollow-stem augers, the filter pack will be installed by slowly pouring the sand into the annular space while simultaneously raising the augers and using a weighted tape to sound for the sand surface. For rotary-drilled wells, the height of the sand pack also will be sounded with a weighted tape.
- The primary filter sand pack (typically Morie #2) will extend from 1 to 2 feet below the base to 2 feet above the top of the screen; filter pack will be allowed to settle and hydrate before final measurement is taken. For wells deeper than 30 feet, the filter pack will be placed using a tremie pipe and flowing water.
- A secondary filter sand pack (typically Morie #00) 1-foot thick will be placed above the primary sand pack.
- Annular well seals will consist of 2 feet of pelletized or granular bentonite clay placed above the filter pack. If necessary the pellets will be hydrated using potable water. For wells installed using hollow-stem augers, the bentonite will be poured into the annular space while slowly raising the augers and sounding for the top of the bentonite with a weighted tape. A high-solids bentonite slurry introduced with a side-discharging tremie pipe will be used for the bentonite seals in wells greater than 30 feet deep. For rotary-drilled wells, the height of the well seal also will be sounded with a weighted tape. High-solids slurries will have solids content of at least 20 percent.

- The top of the annular seal will be measured after the bentonite seal has been allowed to hydrate and before the grout is applied. The seal will be allowed to hydrate for at least 30 minutes before work in the well continues.
- The annular space above the bentonite seal will be filled to grade with a bentonite-cement slurry grout mixture.
- The grout mixture consists of 94 pounds (lbs) of cement (1 bag) per 6 gallons of water and 2 to 3 lbs of powdered bentonite per bag of cement to reduce shrinkage.
- The grout mix will be carefully applied to avoid disturbing the bentonite seal; the method of grout placement must force grout from the bottom of the space to be grouted to the surface.
- After allowing the grout to settle and set up overnight, additional grout will be added to maintain grade.
- A protective steel casing equipped with keyed alike locking caps will be grouted in place for each new well; the casing will extend at least 2 feet above grade and 3 feet below grade, and will be painted a bright color.

B. Well Development

- New monitoring wells will be developed after the well has been completely installed and the grout has hardened (at least 24 hours)
- The well will be developed by surging and pumping.
- Equipment placed in the well will be decontaminated before use.
- If information is available, begin developing in the least-contaminated well first.
- Development will include surging the well by abruptly stopping flow and allowing water in the well column to fall back into the well.
- Pipes and pumps must not be fitted with foot valves or other devices that might inhibit the return flow of water to the well.
- Surging should continue throughout the development process.
- The air-lift method may be used to pump materials out of the well. The air compressor will be fitted with filters to remove all oil and the air lift hose used will be made of inert materials.
- Well development will continue until a NTU value of less than 5 is attained.
- Development water will be considered hazardous and placed in sealed 55-gallon U.S. DOT approved steel drums. CH2M HILL will label and date the drums, and transport the drums to a designated site for storage.

V. Attachments

Well Development Log Form.

VI. Key Check and Items

- Ensure that all equipment is properly decontaminated as needed.
- Only new, sealed materials (e.g., screens, risers, and sand) will be used in constructing the well.
- Care shall be taken when making downhole measurements to ensure that proper heights of sand, seal, and grout are achieved.

PROJECT NUMBER	WELL NUMBER SHEET 1 OF 1

WELL DEVELOPMENT LOG

PROJECT : LOCATION :

DEVELOPMENT CONTRACTOR :

DEVELOPMENT METHOD AND EQUIPMENT USED :

START WATER LEVELS : START : END : LOGGER :

MAXIMUM DRAWDOWN DURING PUMPING:

RANGE AND AVERAGE DISCHARGE RATE:

TOTAL QUANTITY OF WATER DISCHARGED:

DISPOSITION OF DISCHARGE WATER:

Time	Water Volume Discharged (gal)	Water Level (ft BTOC)	Turbidity (NTU)	Temperature (°C)	pH	Conductivity (µmhos/cm)	Remarks (color, odor, sheen, sediment, etc.)

Time	Water Volume Discharged (gal)	Water Level (ft BTOC)	Turbidity (NTU)	Temperature (°C)	pH	Conductivity (µmhos/cm)	Remarks (color, odor, sheen, sediment, etc.)

STANDARD OPERATING PROCEDURE D-2

Installation of Shallow Monitoring Wells

I. Purpose and Scope

The purpose of this guideline is to describe methods for drilling and installation of shallow monitoring wells and piezometers in unconsolidated or poorly consolidated materials using hollow stem augers or mud rotary. Installing monitoring wells in unconsolidated materials using sonic drilling is discussed in SOP *Installation of Monitoring Wells Using Sonic Drilling*. Methods for drilling and installing bedrock monitoring wells and deep, surface-cased wells in unconsolidated materials are presented in SOPs *Installation of Bedrock Monitoring Wells* and *Installation of Surface-Cased Monitoring Wells,* respectively.

II. Equipment and Materials

A. Drilling

- Drilling rig (hollow stem auger or mud rotary) and associated tools and equipment

B. Well Riser/Screen and Associated Materials

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded riser; alternatively, stainless-steel riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted screen; alternatively, stainless-steel screen
- PVC bottom cap, threaded to match the well screen; alternatively, stainless steel
- PVC or stainless-steel centering guides (if used)
- Above-grade well completion: PVC well cap, threaded or push-on type, vented
- Flush-mount well completion: PVC well cap, locking, leak-proof seal
- Stainless steel to be used as appropriate

C. Sand

- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse) filter pack, and secondary (fine) filter pack. Grain size determined based on sediments observed during drilling.

D. Bentonite

- Pure, additive-free bentonite pellets or chips
- Pure, additive-free powdered bentonite
- Coated bentonite pellets; coating must biodegrade within 7 days
- Cement-Bentonite Grout: proportion of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 6 pounds of bentonite added per bag of cement to reduce shrinkage

E. Protective Casing

- Above-grade well completion: 6-inch minimum ID steel pipe with locking cover, diameter at least 2 inches greater than the well casing, painted with epoxy paint for rust protection; heavy duty lock; protective posts if appropriate
- Flush-mount well completion: Morrison 9-inch or 12-inch 519 manhole cover, or equivalent; rubber seal to prevent leakage; locking cover inside of road box

F. Well Development

- Surge block
- Well-development pump and associated equipment
- Calibrated meters to ensure pH, temperature, specific conductance, ORP, and dissolved oxygen of development water
- Containers (e.g., DOT-approved 55-gallon drums) for water produced from well.

III. Procedures and Guidelines

A. Drilling Method

Typically, continuous-flight hollow-stem augers with a minimum 4-inch inside diameter (ID) will be used to drill shallow monitoring well boreholes. Alternatively, mud rotary may be used.

The bit of the auger is placed at the ground surface and then turned with the drilling rig. To collect split spoon samples, the auger is advanced to the top of the sampling depth, and the split-spoon sample is collected from below the auger head. The split spoon is advanced through repeated blows from a 140- or 300-pound hammer dropped from a height of 30 inches. Thin-walled tube samplers are advanced by pressing down on the rods with the weight of the drilling rig. Split-spoon samples will be collected at selected intervals for chemical analysis and/or lithologic classification. Soil sampling

procedures are detailed in SOPs *Soil Boring Sampling – Split Spoons* and *Soil Sampling*.

The use of water to assist in hollow-stem auger drilling for monitoring well installation will be avoided, unless required for such conditions as running sands.

Hollow-stem augers, drilling bits, rods, split-spoon samplers, and other downhole drilling tools will be properly decontaminated prior to the initiation of drilling activities and between each borehole location. Split-spoon samplers and other downhole soil sampling equipment will also be properly decontaminated before and after each use. SOP *Decontamination of Drill Rigs and Equipment* details proper decontamination procedures.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in the SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan (IDWMP).

Mud rotary or other rotary drilling may be used instead of hollow-stem augers. The use of added mud should be kept to a minimum.

B. Monitoring-Well Installation

Shallow monitoring wells will be constructed inside the hollow-stem augers, once the borehole has been advanced to the desired depth, or in the mudded borehole once the drilling rods have been withdrawn. If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole will be backfilled with bentonite pellets or chips or a bentonite-cement slurry to a depth approximately 1 foot below the intended well depth. Approximately 1 foot of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be joined watertight and lowered inside the augers to the bottom of the borehole. Centering guides, if used, will be placed at the bottom of the screen and above the interval in which the bentonite seal is placed.

Selection of the filter pack and well screen intervals for the shallow monitoring wells shall be made in the field.

A primary sand pack (nominally Morie #2) consisting of clean silica sand will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. The augers will be raised gradually during sand pack installation to avoid caving of the borehole wall; at no time will the augers be raised higher than the top of the sand pack during installation. During placement of the sand, the position of the top of the sand will be continuously sounded. The primary sand pack will be extended from the bottom of the borehole to a minimum height of 2 feet above the top of the

well screen. A secondary, finer-grained (e.g., Morie #00), sand pack will be installed for a minimum of 1 foot above the coarse sand pack. Heights of the coarse and fine sand packs and bentonite seal may be modified in the field to account for a shallow water table and a small saturated thickness of the surficial aquifer.

A bentonite seal at least 2 feet thick will be placed above the sand pack. The seal will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. If all or a portion of the bentonite seal is above the water table, clean water will be added to hydrate the bentonite. A hydration period of at least 30 minutes will be required following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface through a tremie pipe. The tremie pipe must be plugged at the bottom and have small openings along the sides of the bottom 1-foot length of pipe. This will allow the grout to diffuse laterally into the borehole and not disturb the bentonite pellet seal.

C. Well Completion

For monitoring wells that will be completed above-grade, a locking steel protective casing set in a concrete pad will be installed. The steel protective casing will extend at least 3 feet into the ground and 2 feet above ground but should not penetrate the bentonite seal. The concrete pad will be square, approximately 3 feet on a side, and poured into wooden forms. The concrete will be sloped away from the protective casing.

Guard posts may be installed in high-traffic areas for additional protection. Four steel guard posts will be installed around the protective casing. Guard posts will be concrete-filled, at least 3 inches in diameter, and will extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, Morrison 9-inch or 12-inch 519 manhole cover or equivalent, with a rubber-sealed cover and drain will be installed. The top of the manhole cover will be positioned approximately 1 inch above grade. A square concrete pad, approximately 2 to 3 feet per side, will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic.

Concrete pads installed at all wells will be a minimum of 6 inches below grade. The concrete pad will be 12 inches thick at the center and taper to 6-inch thick at the edge. The surface of the pad should slope away from the

protective casing to prevent water from pooling around the casing. Protective casing, guard posts, and flush mounts will be installed into this concrete.

Each well will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the permanent well number.

D. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer at the site may not allow low turbidity results to be achieved.

The surging apparatus will include a surge block. Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone. Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is below 5 NTUs, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of 30 minutes and until the water removed from the well is as clear of turbidity as practicable.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP *Decontamination of Personnel and Equipment*. Water generated during well development will be contained and managed as detailed in the SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan.

IV. Attachments

Schematic diagram of shallow monitoring-well construction

CH2MHILL	PROJECT NUMBER	WELL NUMBER SHEET 1 OF 1

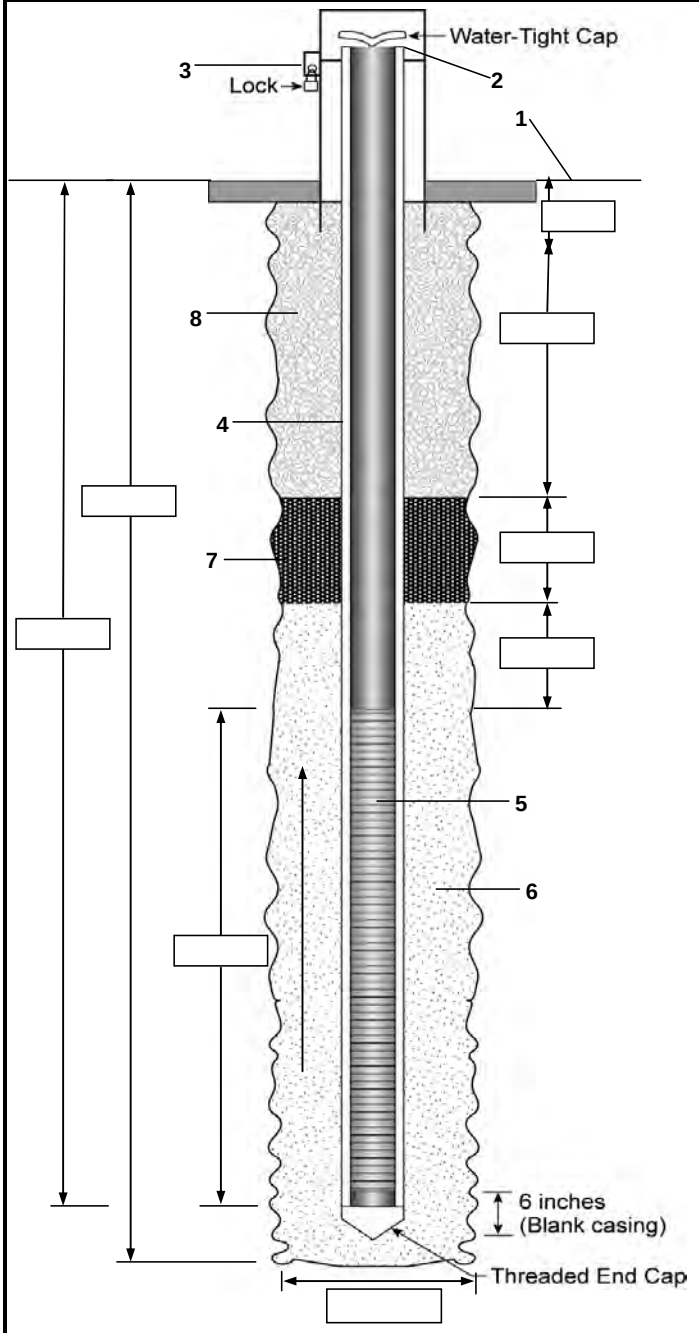
WELL COMPLETION DIAGRAM

PROJECT : LOCATION : DATE:

DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVEL : START : END : LOGGER :



1- Ground elevation at well _____

2- Top of casing elevation _____

3- Wellhead protection cover type _____

a) concrete pad dimensions _____

4- Dia./type of well casing _____

5- Screen slot size _____

6- Type screen filter _____
a) Quantity used _____

7- Type of seal _____
a) Quantity used _____

8- Grout
a) Grout mix used _____
b) Method of placement _____
c) Vol. of well casing grout _____

Development method _____

Volume purged during development _____

Comments

STANDARD OPERATING PROCEDURE D-3

Installation of Surface-Cased Monitoring Wells

I. Purpose and Scope

The purpose of this procedure is to outline equipment and methods that will be used to install surface casings to isolate shallow intervals from deeper drilling. The guideline only addresses installation in unconsolidated materials. Installation of monitoring wells in bedrock is discussed in SOP *Installation of Bedrock Monitoring Wells* and installation of shallow, single-cased monitoring wells is discussed in SOP *Installation of Shallow Monitoring Wells.*

II. Equipment and Materials

A. Drilling

- Drilling rig (hollow stem auger or mud rotary)

B. Surface Casing

- 8-inch to 12-inch ID steel or Schedule 80 polyvinyl chloride (PVC) surface casing, depending upon application
- Temporary bottom plug
- Bentonite for grout: pure, additive-free powdered bentonite
- Cement-Bentonite Grout. Proportion 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 10 pounds of bentonite added per bag of cement to reduce shrinkage.

C. Well Installation

- PVC, Schedule 40, minimum 2-inch ID, flush-threaded well riser; alternatively, stainless-steel riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted well screen; alternatively, stainless-steel screen
- PVC or stainless steel bottom cap, threaded to match the well screen.
- Centering guides (if used); same material as the casing, except stainless steel may be used in lieu of PVC.
- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse – e.g., Morie #2) filter pack, and secondary

(fine – e.g., Morie #00) filter pack. Grain size determined based on sediments observed during drilling.

- Bentonite seal: Pure, additive-free bentonite pellets or chips.
- Bentonite for grout: Pure, additive-free powdered bentonite.
- Cement-Bentonite Grout: Proportion 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 10 pounds of bentonite added per bag of cement to reduce shrinkage.
- Above-grade well completion: PVC or stainless-steel well cap, threaded or push-on type, vented.
- Flush-mount well completion: PVC or stainless-steel well cap, locking, leak-proof seal.
- Above-grade protective casing: Permanent isolation casing with heavy duty locking cover, painted with epoxy paint for rust protection, industrial lock.
- Flush-mount protective casing: Morrison 9-inch or 12-inch 519 manhole cover; rubber seal for cover; heavy duty locking cap on permanent isolation casing.

D. Well Development

- Surge block
- Pump and associated development equipment
- Calibrated meters to ensure pH, temperature, specific conductance, Eh, and dissolved oxygen of development water
- Containerization for water produced from well

III. Procedures and Guidelines

A. Drilling Methods

Boreholes for the surface casing can be drilled with hollow-stem auger or mud or other rotary. Boreholes will be drilled to various diameters, depending upon applications. In the case of temporary surface casing, where grout will not be used to install the casing, the borehole for the casing will be drilled with a method by which the borehole will be as close to the diameter of the surface casing as possible to minimize the size of the annular space. This may be by a rotary method or by using a hollow-stem auger with as small an inside diameter as possible. For permanent surface casing, typically hollow-stem auger will be used.

1. Hollow-Stem Auger Drilling

Hollow-stem auger (HSA) drilling techniques can be used to drill boreholes for installation of surface casing. The borehole will be drilled into a clay layer of significant thickness. Minimum 8-1/4-inch ID HSA will be used to drill the borehole a minimum of 5 feet into a clay layer of significant thickness.

The use of water or other fluid to assist in hollow-stem auger drilling is to be avoided.

The bit of the auger is placed at the ground surface and then turned with the drilling rig. To collect split-spoon or other samples, the auger is advanced to the top of the sampling depth, and the sample is collected from below the auger head. The split spoon is advanced through repeated blows from a 140-pound or 300-pound hammer dropped from a height of 30 inches. Thin-walled tube samplers are advanced by pressing down on the rods with the weight of the drilling rig. Split-spoon samples will be collected at selected intervals for chemical analysis and/or lithologic classification. Soil sampling procedures are detailed in SOPs *Soil Boring Sampling – Split Spoons* and *Soil Sampling*.

Material brought to the surface on the outside of the augers should be containerized at a convenient space away from the working area. Material may be stored on plastic sheeting and containerized at the completion of activities at the drilling location. Such material will be disposed of according to SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan (IDWMP).

Drilling equipment will be decontaminated before drilling in accordance with the procedures detailed in SOP *Decontamination of Drilling Rigs and Equipment*.

2. Rotary Drilling

Mud rotary or other rotary drilling techniques can be used to install surface casing.

To collect split spoon samples, the drill bit is advanced to the depth to be sampled, the bit is removed from the borehole, and the split-spoon sample is collected from the borehole.

Drill cuttings and fluids generated during rotary drilling activities will be contained until completion of activities at the drilling location. Such material will be disposed of according to SOP *Disposal of Waste Fluids and Solids* and the IDWMP.

Drilling equipment will be decontaminated before drilling in accordance with the procedures detailed in SOP *Decontamination of Drilling Rigs and Equipment*.

B. Surface-Casing Installation

Surface casing will be constructed of minimum 6-inch ID steel with a minimum wall thickness of 0.20 inches or Schedule 80 PVC. Casing lengths for permanent surface casings will be welded or connected by threaded connections sealed with Teflon tape, while casing lengths for temporary surface casings will be either threaded connections of casing installed as part of the rotary-drilling method. The steel casing and threaded couplings must be free of paint, varnish, or coatings of any kind, both inside and outside. Threaded connections must be free of oils or grease. Welding of the casing is permissible provided that the welds meet the Standards of the American Welding Society.

Surface casing will be decontaminated prior to installation in accordance with the procedures detailed in SOP *Decontamination of Drilling Rigs and Equipment*.

Surface casing will be installed at least 5 feet into a significant clay layer, if adequate thickness is available.

Permanent surface casing will be placed in the bottom of the borehole and the surface casing will be pressed into the clay. The surface casing will be grouted in place by installing the grout through a tremie pipe from the bottom of the annulus to the ground surface.

Alternatively, the surface casing may be installed and grouted in place by a grout displacement method. The bottom of the surface casing is fitted with a tight, drillable plug. The borehole is then filled with the estimated volume of cement-bentonite grout to fill the annular space, and the casing is lowered to the bottom of the borehole (displacement method). If the weight of the casing is not sufficient to displace the grout and allow the casing to sink to the bottom of the borehole, the casing may be filled with clean water.

Well installation will proceed in the surface casing once the grout has been allowed to set up for approximately 16 to 24 hours. All water in the surface casing will be removed before drilling resumes in order to prevent carrying contamination downward into deeper intervals of the water-bearing unit. All water in the casing will be disposed of according to SOP *Disposal of Waste Fluids and Solids* and the IDWMP before drilling is resumed.

Temporary surface casing installed independently of the drilling process also will be placed in the bottom of the borehole and the surface casing will be pressed into the clay. However, it will not be grouted into place.

C. Monitoring-Well Installation

Typically, the well is completed within the surface casing using mud rotary.

If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole will be backfilled with bentonite pellets or chips or a bentonite-cement slurry to a depth approximately 1 foot below

the intended well depth. Approximately 1 foot of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be joined watertight, and lowered to the bottom of the borehole. Centering guides, if used, will be placed at intervals around the well casing, at the base of the screen, and 5 feet above the top of the well screen.

Selection of final filter pack and well screen depths for the wells shall be made in the field.

A primary sand pack consisting of clean nominally Morie No. 2 silica sand will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. During placement of the sand, the position of the top of the sand will be continuously sounded using a stainless steel weight attached to a fiberglass tape measure. The primary sand pack will be extended from the bottom of the borehole to a minimum height of 2 feet above the top of the well screen. A secondary (fine – e.g., Morie #00) sand pack will then be installed to a minimum of 1 foot above the primary sand pack.

A non-additive bentonite seal at least 2 feet thick will be placed above the sand pack. The seal will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. A hydration period of at least 30 minutes will be allowed following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the top of the bentonite seal to the ground surface. The cement-bentonite grout will be installed through a tremie pipe. The tremie pipe must be plugged at the bottom. Small openings along the bottom 1-foot length of pipe will allow the grout to diffuse laterally into the borehole and to avoid disturbance the bentonite seal.

D. Monitoring-Well Completion

For monitoring wells that will be completed above-grade, the surface casing itself will serve as the protective casing. The surface casing will be finished 2 to 3 feet above grade and fitted with a locking steel cap. A concrete pad with four guard posts will be installed.

The concrete pad will be square, approximately 3 feet per side, and poured into wooden forms. The concrete will be sloped away from the protective casing. The concrete pad will extend at least 6 inches below and 6 inches above the ground surface.

Four steel guard posts will be installed around the locking casing. Guard posts would be concrete-filled, at least 2 inches in diameter, and would

STANDARD OPERATING PROCEDURE D-4

Installation of Bedrock Monitoring Wells

I. Purpose and Scope

The purpose of this procedure is to outline equipment and methods that will be used for bedrock well installation and development. Installing monitoring wells in unconsolidated materials using sonic drilling is discussed in SOP *Installation of Monitoring Wells Using Sonic Drilling*. Methods for drilling and installing shallow and deep, surface-cased wells in unconsolidated materials are presented in SOPs *Installation of Shallow Monitoring Wells* and *Installation of Surface-Cased Monitoring Wells*, respectively.

II. Equipment and Materials

A. Drilling

- Drilling Rig (hollow-stem auger and air-rotary or air-hammer)

B. Surface casing

- 8-inch to 12-inch ID steel or Schedule 80 PVC, depending upon conditions
- Temporary bottom plug
- Bentonite for grout: pure, additive-free powdered bentonite
- Cement-Bentonite Grout. Proportion 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 10 pounds of bentonite added per bag of cement to reduce shrinkage.

C. Well Installation

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded well riser: alternatively, stainless-steel riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted well screen: alternatively, stainless-steel screen
- PVC or stainless steel bottom cap, threaded to match the well screen.
- Centering guides (if used). Same material as the casing, except stainless steel may be used in lieu of PVC.
- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous

material; primary (coarse – e.g., Morie #2) filter pack, and secondary (fine – e.g., Morie #00) filter pack. Grain size determined based on sediments observed during drilling.

- Bentonite seal: Pure, additive-free bentonite pellets or chips.
- Bentonite for grout: Pure, additive-free powdered bentonite.
- Cement-Bentonite Grout: Proportion 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 10 pounds of bentonite added per bag of cement to reduce shrinkage.
- Above-grade protective casing: Permanent isolation casing with heavy duty locking cover, painted with epoxy paint for rust protection, industrial lock.
- Flush-mount protective casing: Morrison 9-inch or 12-inch 519 manhole cover; rubber seal for cover; heavy duty locking cap on permanent isolation casing.

D. Development

- Surge block
- Pump and associated development equipment
- Calibrated meters to ensure pH, temperature, specific conductance, Eh, and dissolved oxygen of development water
- Containerization for water produced from well

III. Procedures and Guidelines

A. Drilling Methods

Boreholes for the bedrock monitoring wells will be drilled in several stages. Hollow-stem auger drilling and air-rotary or air-hammer drilling procedures are detailed below.

1. Hollow Stem Auger Drilling

Hollow stem auger drilling techniques may be used to drill boreholes for installation of surface isolation casing. Alternatively, mud-rotary drilling also may be used. 10-1/4-inch minimum ID HSA will be used to drill the borehole into competent bedrock.

The use of water or other fluid to assist in hollow stem drilling is to be avoided.

The bit of the auger is placed at the ground surface and then turned with the drilling rig. To collect split spoon samples, the auger is advanced to the top of the sampling depth, and the split-spoon

sample is collected from below the auger head. The split spoon is advanced through repeated blows from a 140- or 300-pound hammer dropped from a height of 30 inches. Thin-walled tube samplers are advanced by pressing down on the rods with the weight of the drilling rig. Split-spoon samples will be collected at selected intervals for chemical analysis and/or lithologic classification. Soil sampling procedures are detailed in SOPs *Soil Boring Sampling – Split Spoons* and *Soil Sampling*.

The borehole will be advanced as deep as possible until auger refusal is met. Ultimately it will be necessary to extend the borehole a minimum of 5 feet into competent bedrock for seating of the surface casing. This will be addressed in the next section.

Soil brought to the surface on the outside of the augers should be containerized at a convenient space away from the working area. Soil may be stored on plastic sheeting and containerized at the completion of activities at the well cluster.

Drilling equipment will be decontaminated before drilling in accordance with the procedures detailed in SOP *Decontamination of Drilling Rigs and Equipment*.

2. Bedrock Drilling

The borehole will be advanced into the bedrock for a minimum of 5 feet using air rotary or air hammer. The borehole will be of sufficient diameter (at least 8 inches) so that an 6-inch surface casing can be installed into the borehole. Once the borehole is drilled to at least 5 feet into the bedrock, the surface casing is installed per the procedure described in the Section B below.

Air-rotary or air-hammer drilling techniques will be used to install wells in each of the bedrock monitoring boreholes. When the borehole is advanced beyond the 6-inch surface casing, the borehole will have a diameter of 5-7/8 inches.

The bit, drill rods, and other borehole rotary drilling equipment will be decontaminated prior to the initiation of drilling and between each borehole location, in accordance with the decontamination procedures detailed in SOP *Decontamination of Drilling Rigs and Equipment*.

Prior to the continuing air-rotary or air-hammer drilling in boreholes where a surface casing has been installed, the bit, drill rods, and other downhole rotary drilling equipment will be thoroughly decontaminated before being inserted into the borehole.

Drill cuttings and decontamination fluids generated during rotary drilling activities will be contained according to the procedures

detailed in SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan (IDWMP).

B. Surface Casing Installation

Surface casing will be constructed of 6-inch ID steel or PVC with a minimum wall thickness of 0.20 inches. Casing lengths will be welded or connected by threaded connections sealed with Teflon tape. The steel casing and threaded couplings must be free of paint, varnish, or coatings of any kind, both inside and outside. Threaded connections must be free of oils or grease. Welding of the casing is permissible provided that the welds meet the Standards of the American Welding Society.

Surface casing will be decontaminated prior to installation in accordance with the procedures detailed in SOP *Decontamination of Drilling Rigs and Equipment*.

Permanent surface casing will be placed in the bottom of the borehole. The surface casing will be grouted in place by installing the grout through a tremie pipe from the bottom of the annulus to the ground surface.

Alternatively, the surface casing will be installed and grouted in place by a grout displacement method. The bottom of the surface casing is fitted with a tight, drillable plug. The borehole is then filled with the estimated volume of cement-bentonite grout to fill the annular space, and the casing is lowered to the bottom of the borehole (displacement method). If the weight of the casing is not sufficient to displace the grout and allow the casing to sink to the bottom of the borehole, the casing may be filled with clean water.

After the surface casing installation, the grout will be allowed to set up for at least 16-24 hours before drilling proceeds. Once the surface casing is installed, all water in the casing will be removed and disposed of according to SOP *Disposal of Waste Fluids and Solids* and the IDWMP before drilling is resumed. All water in the surface casing will be removed before drilling resumes in order to prevent carrying contamination downward into deeper intervals of the water-bearing unit.

C. Monitoring Well Installation

The borehole will be completed with either air-rotary or air-hammer methods to the proper depth. If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole will be backfilled with bentonite pellets or chips or a bentonite-cement slurry to a depth approximately 1 foot below the intended well depth. Approximately 1 foot of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be joined watertight, and lowered to the bottom of the borehole. Centering guides, if used, will be placed at intervals around the

well casing, at the base of the screen, and 5 feet above the top of the well screen.

Selection of final filter pack and well screen depths for the wells shall be made in the field.

A primary sand pack consisting of clean nominally Morie No. 2 silica sand will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. During placement of the sand, the position of the top of the sand will be continuously sounded using a stainless steel weight attached to a fiberglass tape measure. The primary sand pack will be extended from the bottom of the borehole to a minimum height of 2 feet above the top of the well screen. A secondary (fine – e.g., Morie #00) sand pack will then be installed to a minimum of 1 foot above the primary sand pack.

A non-additive bentonite seal at least 2 feet thick will be placed above the sand pack. The seal will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. A hydration period of at least 30 minutes will be allowed following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the top of the bentonite seal to the ground surface. The cement-bentonite grout will be installed through a tremie pipe. The tremie pipe must be plugged at the bottom. Small openings along the bottom 1-foot length of pipe will allow the grout to diffuse laterally into the borehole and to avoid disturbance the bentonite seal.

D. Monitoring-Well Completion

For monitoring wells that will be completed above-grade, the surface casing itself will serve as the protective casing. The surface casing will be finished 2 to 3 feet above grade and fitted with a locking steel cap. A concrete pad with four guard posts will be installed.

The concrete pad will be square, approximately 3 feet per side, and poured into wooden forms. The concrete will be sloped away from the protective casing. The concrete pad will extend at least 6 inches below and 6 inches above the ground surface.

Four steel guard posts will be installed around the locking casing. Guard posts would be concrete-filled, at least 2 inches in diameter, and would extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, a Morrison 519 manhole cover with a rubber-sealed cover and drain will be installed. The top of the manhole will be positioned approximately 1 inch above grade. A

extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, a Morrison 519 manhole cover with a rubber-sealed cover and drain will be installed. The top of the manhole will be positioned approximately 1 inch above grade. A square concrete pad, approximately 3 feet per side, will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic. The concrete pad will extend at least 12 inches below the ground surface.

Inside the manhole, a locking cap will be placed over the permanent casing.

Each well will be labeled on the exterior of the locking cap with a metal stamp indicating the permanent well number.

E. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer at the site may not allow low turbidity results to be achieved.

The surging apparatus will include a surge block. Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone. Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is below 5 NTUs, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of 30 minutes and until the water removed from the well is as clear of turbidity as practicable.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP *Decontamination of Personnel and Equipment*. Water generated during well development will be contained and managed as detailed in the SOP *Disposal of Waste Fluids and Solids* and the IDWMP.

IV. Attachments

Schematic diagram of double-cased monitoring-well construction.

PROJECT NUMBER	WELL NUMBER
	SHEET 1 OF 1

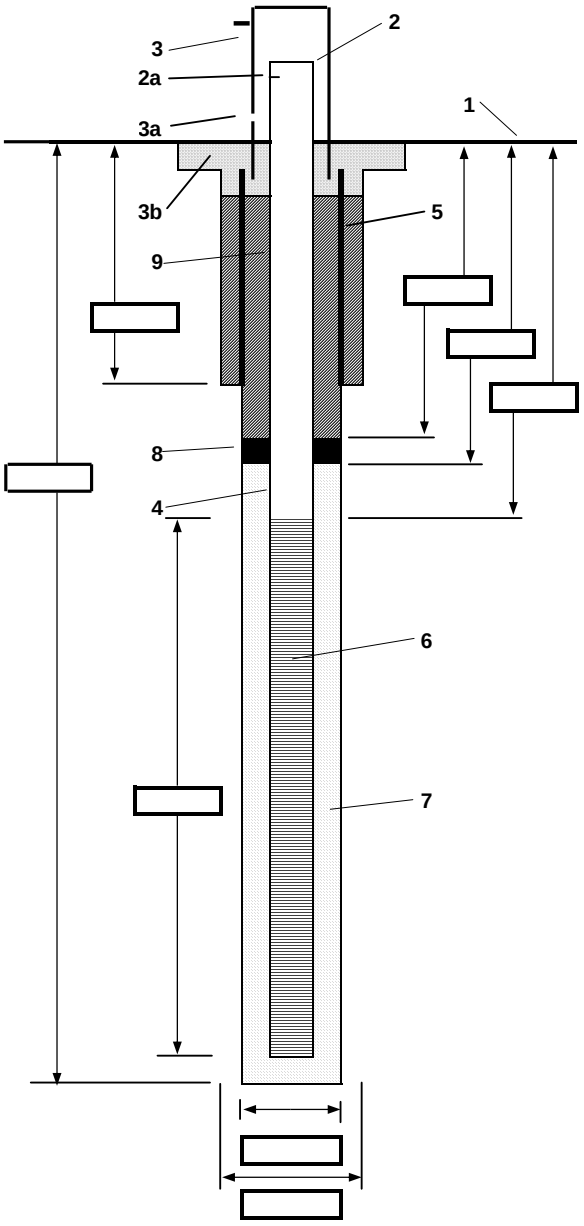
WELL COMPLETION DIAGRAM

PROJECT : LOCATION :

DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USE

WATER LEVELS : START : END : LOGGER :



1- Ground elevation at well

2- Top of casing elevation
a) vent hole?

3- Wellhead protection cover type
a) weep hole?
b) concrete pad dimensions

4- Dia./type of well casing

5- Dia./type of surface casing

6- Type/slot size of screen

7- Type screen filter
a) Quantity used

8- Type of seal
a) Quantity used

9- Grout
a) Grout mix used
b) Method of placement
c) Vol. of surface casing grout
d) Vol. of well casing grout

Development method

Development time

Estimated purge volume

Comments

square concrete pad, approximately 3 feet per side, will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic. The concrete pad will extend at least 12 inches below the ground surface.

Inside the manhole, a locking cap will be placed over the permanent casing.

Each well will be labeled on the exterior of the locking cap with a metal stamp indicating the permanent well number.

E. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer at the site may not allow low turbidity results to be achieved.

Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone. Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of 30 minutes and until the water removed from the well is as clear of turbidity as practicable.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP *Decontamination of Personnel and Equipment*. Water generated during well development will be contained and managed as detailed in the SOP *Disposal of Waste Fluids and Solids* and the IDWMP.

IV. Attachments

None.

STANDARD OPERATING PROCEDURE D-5

Monitoring Well and Borehole Abandonment

I. Purpose and Scope

The purpose of this procedure is to outline equipment and methods that will be used for abandoning monitoring wells. Temporary or permanent monitoring wells or boreholes may be abandoned, or sealed, in order to prevent the borehole or well from as acting as a conduit and/or to prevent cross contamination between hydrogeologic units. Abandoning surface casings installed for double-cased wells also is discussed.

The location, groundwater quality, age, condition of the well, borehole, or any surface casing; potential for groundwater contamination and cross contamination between water-bearing units; and well, borehole, or surface-casing construction should be considered to determine if a borehole or monitoring well should be abandoned. State-specific requirements for well abandonment should be reviewed and consulted along with this SOP; such requirements may be included in the well permit, if such documents are required. Adequate information to define the former well or borehole location should be collected and maintained in the project files to ensure that the facility can be relocated in the future, if necessary.

II. Equipment and Materials

- Drilling rig with appropriate equipment
- Pure, additive-free powdered bentonite for grout
- Cement-Bentonite Grout. Proportion 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 10 pounds of bentonite added per bag of cement to reduce shrinkage.
- Tremie Pipe
- Containerization for well riser, casing, and/or cuttings produced if riser and casing are drilled out and for water displaced from the well, borehole, or surface casing during abandonment.

III. Procedures and Guidelines

Boreholes and monitoring wells may be abandoned by sealing in place using grout or by removing or drilling out the well riser and sealing the remaining borehole. Surface casings may be abandoned by similar means.

A. Leaving the Well Riser and Sealing in Place

Monitoring wells known to be constructed with an impermeable annular space seal may be abandoned by leaving the well riser in place and sealing the well by filling with grout.

1. Prior to sealing, the monitoring well stick-up or flush mounted protective cover and ground surface seal should be removed and the well riser should be cut off at least 30 inches below the ground surface.

2. Boreholes and monitoring wells should be completely filled with cement grout, bentonite-cement grout, bentonite grout, or concrete. More than one pour may required to fill the well or borehole if the grout settles.

3. A gravity-fed tremie pipe should be used to abandon borehole or monitoring -wells deeper than 30 feet or in any borehole or monitoring well with standing water. For monitoring wells and boreholes greater than 100 feet in depth, sealant should be delivered with a grout or slurry pumped into a tremie pipe.

B. Well Riser Removal or Drilling Out and Sealing the Remaining Borehole

Monitoring wells that are not known to be constructed with an impermeable annular space seal should be abandoned by removing the well riser, if possible, or drilling out the well riser and then sealing the remaining borehole.

1. Prior to abandonment, the monitoring well stick-up or flush-mounted protective cover and ground surface seal should be removed.

2. The well riser may be removed by pulling on the riser or by overdrilling around the riser and then pulling the riser out of the ground. If it is not possible to remove the well riser, the well riser may be drilled over and removed from the borehole as borehole cuttings. Some well riser may remain in the borehole prior to sealing.

3. After the well riser is removed or drilled out, the remaining borehole should be sealed according to Section A above.

C. Surface Casing Removal and Sealing the Remaining Borehole

1. In the event that a surface casing is present around the well riser, information on the construction of the surface casing should be obtained, if possible. A decision must be made as to whether or not to remove the surface casing. If the integrity is uncertain, then the surface casing may be serving as a mode of cross connection. However, the assumption is that the surface casing does not fully penetrate the confining layer into which it is set, so it is often appropriate to leave it in place and abandon the well inside of it. The available information on the surface casing and its age and appearance should be considered in making this decision.

2. Any work to abandon the surface casing should be done after the well riser and screen have been removed and the borehole grouted up to the bottom of the surface casing. Otherwise, soil, groundwater, and possibly contamination may fall down the surface-casing borehole into the well borehole.

3. If the decision is made to leave the casing, it can be grouted up according to Section A above and the aboveground part of the surface casing and any concrete pad removed.

4. If the decision is made to remove the surface casing, typically the surface casing should be overdrilled with a large auger and then removed. The borehole then is sealed according to Section A above. Alternatively, if the integrity of the annular seal appears to be poor, the surface casing may be removed by inserting an extraction tool in to the surface casing, engaging it into the sides of the casing, and removing the casing accordingly. Again, the borehole then is sealed according to Section A above.

IV. Attachments

None.

V. Key Checks and Items

- Know the state or local regulations associated with abandoning the well or borehole.
- Know the construction details of the well, surface casing, or borehole so that sound decisions can be made.
- If well-construction materials are being removed from the borehole, remove as much as possible so that the borehole can be adequately grouted up.
- Use a tremie pipe to ensure proper placement of grout.
- Be sure the well or borehole is sealed completely to the surface.
- Control IDW.
- Maintain well- and borehole-location records in the project files.

SOPs in this section:

E-1 Decontamination of Personnel and Equipment
E-2 Decontamination of Drilling Rigs and Equipment

E. DECONTAMINATION

STANDARD OPERATING PROCEDURE E-1

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized ("DI") water (specifically, ASTM Type II water)
- Distilled water
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- Soap solution such as 2.5% (W/W) Liquinox, or Alconox, and water
- Concentrated solvent such as methanol, isopropyl, hexane or other approved solvent (DO NOT USE ACETONE). Pesticide-grade solvents will only be used as directed by project-specific Work Plans.
- Large plastic pails or tubs for soap solution, tap water, rinse water, scrub brushes, squirt bottles for soap and solvent solutions, and DI water, plastic bags and sheets
- DOT-approved 55-gallon drum for disposal of waste
- Phthalate-free gloves
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. Personnel Decontamination

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in soap solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with soap solution, remove, and discard into DOT-approved 55-gallon drum.
2. Wash outer gloves in soap solution, rinse, remove, and discard into DOT-approved 55-gallon drum.
3. Remove disposable coveralls ("Tyveks") and discard into DOT-approved 55-gallon drum.
4. Remove respirator (if worn).
5. Remove inner gloves and discard.
6. At the end of the work day, shower entire body, including hair, either at the work site or at home.
7. Sanitize respirator if worn.

B. Sampling Equipment Decontamination—Groundwater Sampling Pumps

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Spread plastic on the ground to keep hoses from touching the ground
3. Turn off pump after sampling. Remove pump from well and place pump in decontamination tube, making sure that tubing does not touch the ground
4. Turn pump back on and pump 1 gallon of soap solution through the sampling pump.
5. Rinse with 1 gallon of 10% solvent solution pumped through the pump. (DO NOT USE ACETONE).
6. Rinse with 1 gallon of tap water.
7. Rinse with 1 gallon of deionized water.
8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.

9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.

10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums.

C. Sampling Equipment Decontamination—Other Equipment

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.

2. Rinse and scrub equipment with potable water.

3. Wash all equipment surfaces that contacted the potentially contaminated soil/water with soap solution.

4. Rinse with potable water.

5. Rinse with distilled or potable water and solvent solution (DO NOT USE ACETONE).

6. Air dry.

7. Rinse with deionized water.

8. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.

9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.

10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums.

D. Health and Safety Monitoring Equipment Decontamination

1. Before use, wrap equipment in plastic to reduce need for subsequent cleaning.

2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with soap solution, then a towel wet with solvent solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT-approved 55-gallon drum.

E. Sample Container Exterior Decontamination

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with soap solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.

2. Dispose of all used paper towels in a DOT-approved 55-gallon drum.

F. Heavy Equipment and Tools

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the owner

2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

3. Collect and dispose decontamination solutions in a DOT-approved 55-gallon drum.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of soap, solvent, and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

STANDARD OPERATING PROCEDURE E-2

Decontamination of Drilling Rigs and Equipment

I. Purpose and Scope

The purpose of this guideline is to provide methods for the decontamination of drilling rigs, downhole drilling tools, and water-level measurement equipment. Personnel decontamination procedures are not addressed in this SOP; refer to the site safety plan and SOP *Decontamination of Personnel and Equipment*.

II. Equipment and Materials

- Portable steam cleaner and related equipment
- Potable water
- Phosphate-free detergent such as Liquinox®
- Buckets
- Brushes
- Distilled organic-free water
- Solvent such as methanol, isopropanol, or hexane
- ASTM–Type II grade water
- Aluminum foil

III. Procedures and Guidelines

A. Drilling Rigs and Monitoring Well Materials

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

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

B. Downhole Drilling Tools

Downhole tools will be steam cleaned and scrubbed with a stiff brush before the onset of drilling, prior to drilling through permanent isolation

casing, and between boreholes, and prior to leaving the site. This will include, but is not limited to, rods, split spoons or similar samplers, coring equipment, augers, and casing.

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

Before the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for chemical analysis, the sampler shall be decontaminated following the procedures outlined in the SOP titled "Decontamination of Equipment and Personnel."

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- The effectiveness of field cleaning procedures will be monitored by rinsing decontaminated equipment with organic-free water and submitting the rinse water in standard sample containers for analysis. Anytime a sampling event occurs, at least one such quality control sample shall be collected.

SOPs in this section:

F-1 Concrete Core Sampling
F-2 Concrete Chip Sampling
F-3 Concrete Wipes

F. CONCRETE SAMPLING

STANDARD OPERATING PROCEDURE F-1

Concrete Core Sampling

I. Purpose and Scope

The purpose of this guideline is to describe the method to obtain concrete core samples. The guideline covers sampling from horizontal surfaces or floor slabs using a floor mounted core drill.

II. Equipment and Materials

- Heavy-duty floor mounted diamond core drill and associated core drill bits.
- Power source for core drill (120 VAC, 25-60 HZ, 20 amps) and associated extension cord to reach core drill rig.
- Water source for core drill cooling (optional), and associated hose to connect water spigot to core drill rig.
- Large hammer.
- Large concrete/masonry chisel.
- Heavy plastic bags.
- Stainless steel mixing bowls.
- Stainless steel trowels.
- Protective eye ware (safety glasses).
- Latex gloves.
- Dust masks.
- Ear plugs.
- Sampling jars (supplied by laboratory).
- Ground fault circuit interrupter (GFCI) for use in-line with the core drill and/or extension cord

III. Procedures and Guidelines

A. Core Drilling

Core drilling will be performed using a heavy-duty floor mounted core drill. Depending on the availability, a diamond core drill bit anywhere from 2 inches in diameter to 4 inches in diameter will be used to collect the sample. If any soil samples will be collected below the concrete slab, a 4-inch core bit is recommended.

Choose a location to core that is level, away from any utilities that might run through the slab, and accessible to power. Extra extension cords can be used to facilitate this. If the site is not level, the core drill rig will not be stable and drilling will be difficult and unsafe. It is also recommended that a location be accessible to a water source (water spigot), however this is not necessary. Most core drills have a garden hose style screw fitting that will allow water to be discharged over the

core bit during drilling in order to lubricate and cool it. Drilling can be performed dry, however this will simply shorten the life of the core bit. Additionally, when coring through a slab that is not on grade, be sure to secure the area on the floor below where the sample core and cuttings might fall.

Once a suitable location is chosen, install the core bit per the manufacturer's instructions, then connect the rig to the power source and water source if available. At this time it is recommended that safety glasses, a dust mask, and earplugs are worn. Turn on the drill rig and lower the core bit to the concrete surface using the rack and pinion feed mechanism. Constant pressure must be applied to the feed mechanism during drilling in order to advance the core bit. If available, periodically discharge some water on the bit. This water will also serve to keep the dust down. At no time should the drill rig be left unattended while it is operating. Also, a wet-dry vacuum is recommended to vacuum any excess water which will need to be disposed of according to the applicable waste regulations if hazardous constituents are suspected to be present.

Typical core drill bits will allow a cut of 12 to 13 inches deep. If the slab that is being sampled is within this thickness, only one core run will be required to obtain a full profile. If the slab is greater than 12 or 13 inches, the first core run will need to be removed, and a second run will be needed in the same core hole in order to fully penetrate the slab. In order to determine the depth of the core bit, monitor its vertical displacement with a ruler during drilling operations.

If the slab is penetrated with a single core run, the core sample will be withdrawn within the core bit. Lightly tapping on the core bit with a hammer will free the core sample if it does not slide out on its own. If two core runs are required to penetrate the slab, the first core sample will remain in the hole while the core bit is withdrawn. In order to free the core sample, insert a chisel into the annulus cut by the core bit and advance it with a hammer. Note that the width of the chisel must be slightly greater than the width of the annulus. When the core sample breaks free, remove it from the hole. Re-insert the core bit in the hole and proceed with the second run. It is critical that for a given location, complete penetration of the slab is achieved in order to collect a true composite sample of the concrete/masonry profile.

It should be noted that several slab penetrations may be necessary in order to collect a sufficient amount of concrete/masonry to satisfy the analytical laboratory's sample quantity requirements. Sample preparation and rules of thumb for collection volume are discussed in the following section.

B. Sampling

Once the core run samples are collected from a given location, remove all excess soil from beneath slab that might be present on samples taken from slabs on grade. Next, the core samples must be pulverized into sand-sized grains or specific size sample fractions as agreed by the laboratory using a hammer. Place the sample into a plastic bag before pulverizing with the hammer. The plastic bag will help to contain the sample. Once a core sample is pulverized or cut into fractions, empty

the sample into a large mixing bowl and thoroughly mix it with a trowel in order to get a true homogeneous, composite sample. Remove any pieces of rebar that may have been included in the core sample. A good rule of thumb to follow when determining how many slab penetrations to perform at a given location is as follows: 3 to 4 inches of a 2-inch diameter core sample will fill a single 4-ounce jar when pulverized to a sand consistency. Using a trowel, fill the required number of sample containers with the pulverized material.

Depending on the analytical laboratory being used, a solid core sample may be accepted. The core is typically double bagged in zip-lock bags prior to shipment. Check with the analytical laboratory being used to find out how it prefers to receive the concrete samples.

All sampling equipment used for a given location must be decontaminated prior to use at the next sampling location. This includes the hammer, chisel, bowl, trowel, and core drill bit.

C. Abandonment

If the building in which the core samples are being taken is to be demolished, and is currently not occupied, the core holes will be left open. No further abandonment will be required. If the building is occupied, the core holes will be restored with concrete and/or other material to prevent future cracking of the surface.

D. Decontamination and Waste Disposal

Before sampling begins and between each sampling event, equipment will be decontaminated according to the procedures identified in SOPs *Decontamination of Personnel and Equipment* and *Decontamination of Drilling Rig and Equipment.*

Excess pulverized concrete and concrete cuttings will be left in place.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

Check that the core drilling rig is in working order prior to beginning operations. Check the condition of the core drilling bit after each run. If the bit shows excessive wear, have it replaced. If possible, try and choose sample locations where a water source can be accessed. Check the extension cord every day before operation and test the GFCI for proper operation.

STANDARD OPERATING PROCEDURE F-2

Concrete Chip Sampling

I. Purpose and Scope

The purpose of this guideline is to describe the method to obtain concrete chip samples. The guideline covers sampling from vertical surfaces or wall slabs using hand tools. Samples collected following this method will be analyzed for PCBs, metals, or other constituents as required by the Work Plan. The method would require modification prior to collecting samples for SVOC analysis.

II. Equipment and Materials

- Large hammer.
- Large concrete/masonry chisel.
- Heavy plastic bags.
- Stainless steel mixing bowls.
- Stainless steel trowels.
- Plastic tarp.
- Protective eye ware (safety glasses).
- Latex gloves.
- Heavy work gloves.
- Dust masks.
- Ear plugs.
- Sampling jars (supplied by laboratory).

III. Procedures and Guidelines

A. Concrete Chipping

Concrete chipping will be performed using a heavy hammer and masonry chisel to break off 3-inch or less size pieces from building walls or floors. Chip samples must be taken to a depth of 1 inch below the wall surface for risk assessment purposes.

Choose a location to chisel that is away from any utilities and fairly well lit. For wall samples, place a piece of plastic tarp below the area to be chiseled in order to catch the chips. Prior to chiseling, be sure that the proper personal protective equipment is being worn. Safety glasses, ear plugs, a dust mask, and heavy work gloves are recommended.

Using the hammer and chisel, break off enough concrete such that the laboratory sample volume requirements are met. Be sure to remove chips to a depth of 1 inch in any given spot before widening the sampling area.

Sample preparation and rules of thumb for collection volume are discussed in the following section.

B. Sampling

Once enough concrete chips are collected to constitute a sample, they must be prepared for the lab. The concrete chips must be pulverized into sand-sized grains using a hammer. Place the sample into a plastic bag before pulverizing with the hammer. The plastic bag will help to contain the sample. Once the concrete chips are pulverized, empty the sample into a large mixing bowl and thoroughly mix it with a trowel in order to get a true homogeneous composite sample. Using a trowel, fill the required number of sample containers with the pulverized material.

Depending on the analytical laboratory being used, un-pulverized concrete chip samples may be accepted. The concrete chips are typically double bagged in zip-lock bags prior to shipment. Check with the analytical laboratory being used to find out how it prefers to receive the concrete samples.

All sampling equipment used for a given location must be decontaminated prior to use at the next sampling location. This includes the hammer, chisel, bowl, and trowel.

C. Decontamination and Waste Disposal

Before sampling begins and between each sampling event, equipment will be decontaminated according to the procedures identified in SOPs *Decontamination of Personnel and Equipment*.

Excess pulverized chips will be left in place.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

Check that there is sufficient room to swing the hammer without striking adjacent objects or utilities. Also check the wear on the chisel. A dull chisel will not perform as well as a sharp one. Replace the chisel as needed.

STANDARD OPERATING PROCEDURE F-3

Concrete Wipes

Wipe samples will be collected from solid concrete surfaces with potential polychlorinated biphenyl (PCB) contamination in accordance with 40 CFR §761.123. The number and location of samples will be determined by the procedure specified in 40 CFR §761 Subpart P (Appendix J). The samples will be collected by applying hexane solvent to a gauze pad or glass wool. Prior to sampling, a disposable template will be developed that will designate a sampling area of 10 cm x 10 cm. The moistened gauze pad or glass wool will be held with a pair of stainless steel forceps and used to thoroughly swab the template area. The wipe sample will be stored in a precleaned (laboratory supplied) glass jar with a Teflon® lined cap. If reused, the template will be thoroughly cleaned between samples. It is preferable that the gauze (or glass wool) be prepared by the laboratory and stored in a glass container until use.

Wipe samples will be collected continuously until no residue can be observed within the template area. All wipe samples collected from the template area at each location will be stored in the same glass jar and treated as one sample. Each wipe will not be considered an individual sample. Each time the template area is relocated, a new precleaned glass sampling jar will be used to store that location's wipes.

A field blank will be collected daily on each day when concrete wipe samples are collected. Field blanks will be prepared by moistening a gauze pad or glass wool with the hexane solvent and storing it individually in a precleaned glass jar. Replicates must be collected in accordance with our QAPP.

SOPs in this section:

G-1 Flat Bottom Boat/Canoe Sampling Operations
G-2 Surface Water Sampling
G-3 Clean Sampling for Trace Metals in Surface Water
G-4 Streamflow Measurements
G-5 Sediment Sampling

G. SURFACE WATER & SEDIMENT SAMPLING

STANDARD OPERATING PROCEDURE G-1

Flat Bottom Boat/Canoe Sampling Operations

I. Purpose

Flat bottom boat sampling operations are a non-standard practice of RCRA/ CERCLA investigations. The objective of these operations is to access those sample locations inaccessible to larger, deeper draft, motorized water craft.

II. Scope

The provisions of this SOP apply to all program and project personnel engaged directly in technical boating operations, whether planning or executing those operations. These provisions apply whenever technical boating equipment or activities are used or included in project operations.

III. Responsibilities

Project Manager - The Project Manager is responsible for ensuring that project-specific plans for boating operations and federal and state boating safety regulations are in accordance with these procedures, where applicable, or that other approved procedures are developed.

Field Team Leader - The Field Team Leader is responsible for ensuring that these boating procedures are implemented in the field, and for ensuring that personnel performing these activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the sampling personnel to follow these procedures or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The sampling personnel are responsible for the proper sampling procedures, proper operation of the boat and adherence to waterborne health and safety procedures.

IV. Procedures

The following procedures outline the planning and execution of flat bottom boat sampling operations:

1. All operations involving technical boating will be directed by qualified and experienced boater as the team leader.
2. All persons participating in boating operations will be directed by the Team Leader.

3. All persons participating in boating operations will have been trained by the Team Leader or provide proof of experience in operating such water craft.
4. All personnel shall wear their Personnel Floatation Devices at all times while they are on the water.
5. The boating team will include at least one person qualified in First Aid/CPR for nonstandard conditions (for example: fire rescue, air/land/sea rescue).
6. All personnel shall wear bright colors (for example: hunter orange, yellow, etc.) to enhance their visibility to one another.
7. Team Leader has final authority on operations with regards to weather and water conditions and will ensure that the watercraft contains all U.S. Coast Guard-approved safety devices required for the size of the watercraft.

STANDARD OPERATING PROCEDURE G-2

Surface Water Sampling

I. Purpose and Scope

This procedure presents the techniques used in collecting representative surface water samples. Materials, equipment, and procedures may vary and will be dependent on the field conditions encountered during sampling. The following topics include acceptable equipment selection and equipment construction materials; and standard grab, depth-specific, and depth-composited surface water sampling techniques.

II. Materials and Equipment

Materials and equipment vary depending on type of sampling; the Work Plan should be consulted for project-specific details. Typical equipment required includes:

- Dip sampler for direct grabs
- Clean unpreserved containers
- Peristaltic pump and appropriate tubing
- Kemmerer or Van Dorn sampler
- Depth-integrating sampler
- Sample containers
- Polypropylene rope and weight
- Extendable pole
- Meters for specific conductance, temperature, pH, and dissolved oxygen

III. Procedures and Guidelines

Before surface water samples are taken, all sampler assemblies and sample containers are cleaned and decontaminated as described in SOP *Decontamination of Personnel and Equipment*. Surface water samples collected from tidal water bodies should be collected at low tide or ebbing tide to minimize the dilution of potential contaminants. Methods for surface water sample collection are described below.

A. Manual Sampling

Use manual sampling for collecting grab samples for immediate in-situ field analyses. Also use manual sampling in lieu of automatic equipment over

extended periods of time for composite sampling, especially when it is necessary to observe and/or note unusual conditions. Measurements of specific conductance, temperature, pH, dissolved oxygen and percent oxygen saturation are collected after all surface water samples are collected at each station or sample location.

1. Surface Grab Samples

Collect surface grab samples within the top 12 inches of the water column unless a specific depth strata has been specified in the Work Plan. Avoid skimming the surface of the water during collection unless specifically required by the sampling plan. Very shallow water bodies may require careful techniques of sample collection to avoid disturbing sediments

Where practical, use the actual sample container as the collection device (direct grab). Sample containers attached to poles are also considered direct grabs.

2. Direct Grab Technique

- Use an unpreserved sample container to collect the sample.
- Slowly remove the container cap and slowly submerge the container, opening first, into the water.
- Invert the bottle so the opening is upright and pointing towards the direction of water flow (if applicable). Allow water to run slowly into the container until filled.
- Return the filled container quickly to the surface.
- Pour out a small volume of sample away from and downstream of the sampling location. This procedure allows for addition of preservatives and sample expansion. Do not use this step for volatile organics or other analytes where headspace is not allowed in the sample container.
- Add preservatives, if required, securely cap container, label and complete field notes.
- If preservatives have been added, invert the container several times to ensure sufficient mixing of sample and preservatives.
- Check preservation of the sample and adjust pH with additional preservative, if necessary.

If the sample cannot be collected directly into the sample container to be submitted to the laboratory or if the laboratory provides prepreserved sample containers, use an unpreserved sample container or an intermediate vessel (e.g., beakers, buckets or dippers) to obtain the sample. These vessels must be constructed

appropriately including any poles or extension arms used to access the sample location.

Rinse the intermediate vessel with ample amounts of site water prior to collecting the first sample. Discard rinsate away from or downstream of the sampling location. After adequate rinsing, fill the intermediate vessel with sample water. Minimize agitation of the sample.

Leave adequate headspace in the sample container. This procedure allows for addition of preservatives (if required) and sample expansion. Do not use this step for volatile organics or other analytes where headspace is not allowed in the sample container.

Add preservatives if required, securely cap container, label and complete field notes. Invert the container several times to ensure sufficient mixing of sample and preservatives.

a. Pump and Tubing

Use appropriate pumps, equipment and tubing (see material restrictions listed in Table 1) when using a pump to collect surface water samples. Do not collect oil & grease or TRPH with a pump. Follow this procedure:

- Measure the water column to determine the maximum depth and the sampling depth (for surface samples collect at least 12 inches below the surface)
- Tubing will need to be tied to a stiff pole or be weighted down so the tubing placement will be secure. Do <u>not</u> use a lead or metallic weight if collecting metals samples. Any dense, non-contaminating, non-interfering material will work (brick, stainless steel weight, etc.). Tie the weight with a lanyard (braided or monofilament polypropylene, etc.) so that it is located below the inlet of the tubing.
- Lower tubing to a depth 6-12 inches below water surface, where possible.
- Pump several tubing volumes through the system to flush the tubing prior to collecting the first sample.
- Fill individual sample bottles via the discharge tubing, being careful not to remove the inlet tubing from the water.
- Do not touch the discharge tubing to the sample container.

Leave adequate headspace in the sample container. This procedure allows for addition of preservatives (if required)

and sample expansion. Do not use this step for volatile organics or other analytes where headspace is not allowed in the sample container.

3. Depth Grab Samples

Examples of equipment that may be used for depth grab sampling include Kemmerer, Niskin, Van Dorn and similar samplers; pumps with tubing and double check-valve bailers. Do not collect oil & grease or TRPH samples with a pump.

Many of these Kemmerer, Niskin and Van Dorn type samplers are constructed of plastic and rubber that preclude their use for all volatile and extractable organic sampling. Some newer devices are constructed of stainless steel or are all Teflon or Teflon-coated. These are acceptable for all analyte groups without restriction.

- Measure the water column to determine maximum depth and sampling depth prior to lowering the sampling device.
- Mark the line attached to the sampler with depth increments so that the sampling depth can be accurately recorded.
- Lower the sampler slowly to the appropriate sampling depth, taking care not to disturb the sediments.
- At the desired depth, send the messenger weight down to trip the closure mechanism.
- Retrieve the sampler slowly.
- Rinse the sampling device with ample amounts of site water prior to collecting the first sample. Discard rinsate away from and downstream of the sampling location.

B. Automatic Sampling

Automatic samplers will be used when several sites will be sampled at frequent intervals or when a continuous sample is required. Composite samplers can be used to collect time composite or flow proportional samples. Use appropriate equipment and tubing (see Table 1). Do not collect oil & grease or TRPH samples with automatic samplers unless required by the Work Plan.

1. Installing and Programming the Composite Sampler

Use all new or precleaned pump tubing each time the sampler is brought to the field and set up. If the automatic sampler is deployed in the field for extended periods, it is recommended to replace the tubing at a minimum of every six months. Other replacement schedules may be required, depending on the specific installation and project requirements. Inspect the tubing each time the

composite-sample container is picked up. If there is evidence of loss of elasticity or discoloration or other conditions that would impact the quality of the sample (such as algal growth), or the pumping flow rate, then replace the tubing. Set up the automatic sampler as follows:

- Cut the proper length of precleaned Teflon or Tygon tubing.
- Collect equipment blanks each time the tubing is changed or at a frequency of 5% of the tubing changes, whichever is less. Collect a minimum of one blank each year. Collect the blank by passing analyte-free water through the equipment that is exposed to the sample after a full decontamination cycle.
- Composite sample containers may be cleaned either in the field or in a fixed base operation. Demonstrate cleaning effectiveness by collecting equipment blanks on the composite sample containers according to the frequency specified in the Work Plan. Collect sample container equipment blanks by adding analyte-free water to the cleaned sample container, mix the water thoroughly within the container and then pour off an aliquot for analysis. This equipment blank may be combined with the tubing exchange cycle.
- Put the collection sieve and tubing in the appropriate sample location, using conduit if necessary to hold it in place. Ensure the supporting conduit does not contaminate the incoming sample water.
- Program the sampler per manufacturer's directions and as required in the permit or work plan conditions.
- Place a lock or seal on the sampler to prevent or detect tampering. This procedure, however, does not prevent tampering with the sampler tubing.
- At the end of each sampling period, stir the contents of the composite jug and siphon the contents (poured if no visible solids) into the respective containers. If the sampler was configured to collect discrete samples ensure that the contents of each container are adequately mixed while pouring the sample into the sample container.
- Immediately preserve the sample, if required, securely cap container, label and complete field notes.

In certain sampling situations, automatic composite samplers are permanently installed at surface water stations and remain in the field for months or even years. Under these conditions, there are specific sampling issues that need to be addressed.

IV. Attachments

None.

V. Key Checks and Items

- When using watercraft, take samples near the bow, away and upwind from any gasoline outboard engine. Orient watercraft so that bow is positioned in the upstream direction.
- When wading, collect samples upstream from the body.
- Avoid disturbing sediments in immediate area of sample collection.
- Collect water samples prior to taking sediment samples when obtaining both from the same area (site).
- Consider the representativeness of selected sampling locations, for example, when attempting to characterize a water body that may be stratified or heterogeneous.
- Unless dictated by the Work Plan, sampling at or near structures (e.g., dams, weirs or bridges) may not provide representative data because of unnatural flow patterns.
- Collect surface water samples from downstream towards upstream.

TABLE 1
Compatible Materials for Analyte groups

Analyte Group	Acceptable Materials
Extractable Organics	Teflon Stainless steel Glass Polypropylene Polyethylene All parts of the system including connectors and gaskets must be considered – Viton may be used if no other material is acceptable.
Volatile Organics	Teflon Stainless steel Glass Polypropylene Polyethylene All parts of the system including connectors and gaskets must be considered – Viton may be used if no other material is acceptable.
Metals	Teflon Stainless steel Polyethylene, including HDPE Polypropylene Tygon, Viton, Silicone, Neoprene PVC Glass (except silica and boron)
Ultratrace Metals	Teflon Polyethylene, including HDPE Polypropylene Polycarbonate Mercury must be in glass or Teflon
Inorganic Nonmetallics	Teflon Stainless steel Low carbon, Galvanized or Carbon steel Polyethylene, including HDPE Polypropylene Tygon, Viton, Silicone, Neoprene PVC Glass Brass

Surface Water Quality Sampling Field Data

SITE:

FIELD CREW:

DATE: **CLOUD COVER:**

TIME: **ANTECEDENT RAIN:**

DEPTH OF WATER (FT): **AMBIENT TEMPERATURE:**

FLOW VELOCITY AND DIRECTION:

FIELD MEASUREMENTS

Time	Conductivity (µmhos)	DO (mg/L)	Salinity (ppt)	Temperature (°C)	pH (su)	ORP	Turbidity (NTU)	

SAMPLE PARAMETERS (GRAB OR COMPOSITE) :

OBSERVATIONS

COLOR: CLEAR , AMBER , TAN , BROWN , GREY , MILKY WHITE , OTHER:

ODOR: NONE , LOW , MEDIUM , HIGH , VERY STRONG , H2S , FUEL LIKE , CHEMICAL ?, UNKNOWN

TURBIDITY: NONE , LOW , MEDIUM , HIGH , VERY TURBID. HEAVY SILTS

COMMENTS:

OTHER: PLEASE USE BACK OF SHEET.FOR SKETCHING MAPS , **SEE BACK OF SHT Y / N.**

Q.C. SAMPLE TYPE: DUPLICATE , EQUIPMENT BLANK , OTHER :

SIGNED/SAMPLER:

STANDARD OPERATING PROCEDURE G-3

Clean Sampling for Trace Metals in Surface Water

I. Purpose and Scope

This procedure presents the special techniques used in collecting surface water samples that will be analyzed for trace metals. Detection limits required are very low, and extra precautions must be taken both in the laboratory and in the field to avoid contaminating the samples. Materials, equipment, and procedures may vary depending upon the metals of concern and criteria levels; refer to the Field Sampling Plan and operator's manuals for specific details.

This method is not to be used for sampling for TAL analytes under normal conditions, but only in instances when selected metals with high toxicity (usually mercury or copper) have been detected in trace amounts at specific sites and an ecological or human health risk assessor has determined that the metals must be monitored at very low concentrations.

II. Materials and Equipment

Materials and equipment vary depending on type of sampling; the Field Sampling Plan should be consulted for project-specific details.

- Open tube sampler
- Dip sampler
- Weighted bottle sampler
- Peristaltic pump with in-line filter apparatus
- 0.45-micron filters
- Depth-integrating sampler
- Sample containers, furnished by the laboratory, cleaned and double-bagged
- Tubing, furnished by the laboratory, cleaned and double-bagged
- Non-talc gloves, multiple pairs for each sampling location
- Flat working area, such as a portable table
- Plastic drop-cloth or sheeting for a clean working surface
- Tyvek coveralls
- Storage coolers
- Meters for specific conductance, temperature, pH, and dissolved oxygen

III. General Clean Sampling Procedures

Clean sampling procedures minimize inadvertent contamination during the collection and handling of the sample in the field, as well as in the laboratory, by preventing contact of the sample with metal-containing materials and minimizing exposure to the air. The clean sampling procedures employed are based on EPA's *Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels* (July 1996). Clean sampling procedures are subject to field conditions and may be modified as necessary to ensure contamination-free sampling and worker safety.

Primary elements of clean sampling include the following:

- Metal-free sample apparatus, including sample containers, sampling devices, and all materials or equipment involved in the sample collection procedure. A clean working surface, such as a portable table covered with plastic sheeting, may be helpful.
- Advance planning and a dry-run practice session are highly recommended to prevent accidental decontamination while working. Review the EPA video, *Sampling Ambient and Effluent Water for Trace Metals* (17 minutes) for a demonstration of the techniques and equipment used. The video is available from the project chemist.
- Thorough decontamination and secure packaging of all apparatus before transportation to the site. Sample containers and tubing that will come into direct contact with the sample water are to be double-bagged.
- Field personnel trained in clean sampling techniques. One field worker is identified as the "clean-hands" worker, and another as the "dirty-hands" worker. All required contact with significant sources of contamination is made by the dirty-hands worker. In order to minimize sample contamination, the clean-hands worker contacts only the inner bags and sample containers and other items that are not expected to be significant sources of contamination.
- Special field clothing (Tyvek coveralls and non-talc latex gloves).
- QA/QC protocols to detect any source of contamination resulting from sample collection, handling, and analysis.

Clean sampling techniques address the potential for contamination by airborne sources. However, the EPA method does not address the potential for contamination from meteorological conditions like rain and wind, which have been shown to be airborne vectors for metal particulates and other contaminants. Field teams will make detailed notes regarding the weather and characterize any potential source of sample contamination that may result. Field and equipment blanks will be collected to assess possible contamination.

IV. Specific Procedures and Guidelines

All operations involving contact with the sample bottles, the inner plastic baggie, transfer of the sample, or any sample preparation are to be handled by the field worker designated as the "clean-hands" worker. The bottle caps are not to be set down on possibly contaminated surfaces while collecting the samples. The cap should not be held so that the inner side is exposed to the wind.

All operations involving opening of outer plastic containers must be performed by the individual assigned as the "dirty-hands" workers.

Field workers should avoid contact with any metal-containing objects during the sample collection period. In the case of unavoidable contact with metal-containing objects, the field workers must ensure that any objects which contact the collected sample, either directly or indirectly (including Tyvek coveralls, outer portion of gloves), are not contaminated from exposure. For example, if one worker is required to cover parts of a boat with plastic sheeting or contact a metal grid to prepare for the sample collection, clean Tyvek coveralls and appropriate gloves must be put on after this activity.

Other contamination which may occur during sample collection from airborne particulates, exhaust from nearby vehicles, and/or debris from disturbance of the sample collection location (such as removal of manhole cover) should be avoided. If possible, field workers should wait for the optimum time (low to zero winds, no nearby traffic, several minutes after the manhole lid is removed) before initiating the sample collection. If unavoidable during sample collection, the sample should be shielded from the source of contamination by the "clean hands" worker.

The procedure is subject to modification based on conditions encountered in the field. For example, if the dirty-hands person requires assistance from the clean-hands person, the clean-hands person will don a new set of clean sampling gear to become clean again. It is suggested that the team members begin with two pairs of gloves on, so that in case of accidental contamination, the outer gloves can be removed and the procedure continued without stopping to find a new pair of gloves.

All sample containers to be used should be labeled and positioned within easy reach of the sampling location. The outer bag that holds the clean sample bottles will be labeled with the sample ID, date collected, time collected, analyses to be performed, and the client name with an indelible sharpie (the clean sample bottle itself will not be labeled).

Mark the required information in the field notebook (workers' names, date, time of arrival at sample location, etc.). Both field workers must then put on "clean" sampling gear (includes Tyvek coveralls and non-talc gloves). The Tyvek coveralls contain metal parts (zipper). If these components have not been previously covered with Teflon tape in a clean environment, they must be put on prior to non-talc gloves.

The field workers start, by donning one pair of gloves from the "non-clean" bag of extra gloves. Making sure to cover metal rings and watches, they proceed by

applying the two pairs of "clean" non-talc gloves. This third pair of gloves is used to allow the workers to put on Tyvek without contamination of the "clean" gloves beneath. Next, the workers put on the Tyvek coveralls. After fully dressed, both workers remove the outer pair (3rd pair) of gloves. Each worker shall visually inspect the other to confirm the gear is properly covering all exposed sources of contamination.

Using a peristaltic pump to collect the sample will allow the least contact with the sample water. Attach the tubing to a notched metal-free pipe or wand to sample from shore. An in-line filter may be used with the pump for collecting samples for filtered metal analysis.

If the sample must be collected from a bridge, a weighted (plastic-lined weight) collection bottle may be used. If sample is collected from a boat, be aware of rust and fuel exhaust. The boat should be positioned down-wind from the sampling location.

Measure dissolved oxygen, specific conductance, temperature, and pH at the sampling location.

V. Attachments

None.

VI. Key Checks and Items

- Start downstream, work upstream.
- Avoid disturbance of bottom sediments as much as possible
- Log exact locations using permanent features
- Beware of hidden hazards
- Change gloves frequently as needed.

STANDARD OPERATING PROCEDURE G-4

Streamflow Measurements

I. Purpose

The purpose of this SOP is to provide general reference information for estimating the instantaneous discharge of flowing streams.

II. Scope

This SOP provides a description of field procedures, equipment, and calculations necessary to estimate the instantaneous discharge of streams using current meters to measure the velocity of flow. The SOP also covers constructing simple channel-control devices to expedite measuring the rate of flow with a current meter in a small shallow stream.

The SOP does not cover determining the stage-discharge relationships; therefore, methods to determine the stage or water level in streams are not covered. The SOP also does not cover instances where current-meter measurements must be made in deep water by suspending the meter from a bridge or other structure.

III. Procedures

A. Overview

Streamflow measurements are used to estimate the discharge of moving surface-water bodies. The simplest methods comprise using a current meter to measure the rate of flow in units such as feet per second and developing an estimate of the cross-sectional area in units such as square feet. Combined, they provide an estimate of the discharge, or volume rate of flow, of the stream.

The use of current meters to measure the flow velocity and the means of calculating the discharge are discussed below. There also is a discussion of the purpose and approach for modifying the channels of small streams in order to expedite measuring the flow velocity.

The information provided in this SOP primarily was derived from the USGS publication on measuring and computing streamflow (USGS 1982). Another good source of information is *Field Hydrogeology* (Brassington 1988).

B. Equipment

The following equipment is required:

- Current meter with wading rod and electronic counter (if available) to measure the relative velocity of the flow at different locations within the stream channel
- Stop watch to measure the increment of time over which meter rotations are counted
- Measuring tape or cable marked in even increments for determining the width of the stream and controlling the location where measurements are taken
- Waders (if necessary)

A current meter is an instrument used to measure the velocity of moving water in a surface stream. The current meter consists primarily of an impeller which, when placed in a moving stream of water, rotates at a rate that is proportional to the velocity of the flow of water passing by it. Current meters are available from the company equipment pool. Other types of meters are available but all serve the same purpose.

C. Taking Measurements

The current meter is used by suspending it in the stream and pointing it in the upstream direction. The assumption is that the stream to be measured is sufficiently shallow to wade in. The meter is attached to a special rod which is graduated in such units as centimeters and which allows the meter to be positioned in the stream at a known depth. The rate at which the impeller rotates is counted over a specified period of time, either by observing the rotations (for smaller meters and slow streams) or noting the number of rotations recorded by an electronic counter.

A Type AA Price current meter is standard for large streams. A Price pygmy meter should be used when the water depth is less than 1.5 feet. However, the two types of meters should not be used together in determining the total discharge of a stream at a single location in order to prevent inconsistencies in instrument operation from being introduced.

The tape or marked cable is stretched across the stream channel and anchored securely at each end. The total width of the stream is determined. Flow measurements are taken at known increments (even increments are best because it simplifies the subsequent calculations). There should be 10 to 20 measurements across a large stream, fewer across a small one. Preferably, no more than 5 percent of the total stream flow goes through an individual cross section. The data collected are used to calculate the discharge by the midsection method normally employed by the USGS.

Set the rod firmly on the stream bottom and hold it vertically at the desired mark on the tape. Point the meter upstream and stand to the side so that the flow around your legs does not affect the meter.

In theory, the average velocity of a stream occurs at a depth of 0.6 of the total stream depth measured downward from the surface. The velocity is measured here in the one-point method. If it is easier to set the meter at 0.5 of the total depth, a correction factor can be included in the subsequent calculations by multiplying the total flow by 0.95.

If the stream is more than 2.5 feet deep, then the two-point method is used. Measurements are taken at depths of 0.2 and 0.8 of the total stream depth. The measurements at 0.2 and 0.8 are averaged. Even if a pygmy meter is being used, the two-point method should be used unless the water depth is greater than 0.75 feet; otherwise, the velocity will be underestimated.

Allow the impeller rotation to settle down for a few seconds, then count the rotations over a 1-minute period. Do this twice so that a replicate number is available for averaging. Record the distance along the stream where the measurement was taken, the number of counts, the depth of the stream, and the depth of the meter.

The velocity of flow for each set of measurements is determined using tables provided with the current meter used.

D. Stream-Channel Configuration

A straight stretch of stream with a fairly constant depth is preferred for conducting streamflow measurements. This will maximize the likelihood that the streamlines are parallel to one another. There should be few if any rocks, holes, or structures in the stream. Preferably the depth of the section to be measured is greater than 0.5 feet and the velocity is greater than 0.5 feet per second.

For small, very shallow streams, it may be necessary to modify the stream configuration to increase the tendency for horizontal flow and reduce turbulence. This may be done be installing two parallel rows of cinder blocks, pressure-treated lumber, or other materials along the stream channel in the direction of flow. The bottom of the channel also should be as smooth as possible. Flow is directed into this channel by damming the stream on either side of the upper end of the constructed channel. The rate of flow then is measured about two-thirds of the way down the constructed channel where the flow effects of the ends of the channel would be minimized. A pygmy current meter may still be needed to measure flow in the channel. Note that it may be necessary to reconstruct the channel periodically if stormflow has caused the construction to shift.

Note that in a constructed channel, there will be some effects on flow induced by the side walls. In this case, the velocities will need to be adjusted according to the following:

- At the wall, the velocity will be 0.65 percent of that measured (i./e., actual velocity = 0.65 x measured velocity)
- At a distance to the wall equal to 0.25 of the depth of the channel, the velocity will be 90 percent of that measured
- At a distance to the wall equal to 0.50 of the depth of the channel, the velocity will be 95 percent of that measured
- At a distance to the wall equal to 1.0 of the depth of the channel, the velocity will be 100 percent of that measured

E. Calculating the Discharge

Put simply, the discharge is estimated by multiplying the average velocity of flow through the individual cross sections by their areas and summing the individual totals. The calculations can be performed directly on the data sheet.

The individual cross section is defined by the depth d_2, d_3, …d_n The discharge for the individual sections then are calculated using the equation:

$$q_x = v_x \left(\left(b_{x+1} - b_{x-1} \right) / 2 \right) d_x$$

where q_x = discharge through subsection x

v_x = mean velocity at vertical x

b_{x+1} = distance from initial point to preceding vertical

b_{x-1} = distance from initial point to next vertical

d_x = depth of water at vertical x

For example, the flow though the section with depth d_4 is calculated by:

$$q_4 = v_4 \left(\left(b_5 - b_3 \right) / 2 \right) d_4$$

At the ends the discharge is calculated by:

$$q_1 = v_1 \left(\left(b_2 - b_1 \right) / 2 \right) d_1$$

$$q_n = v_n \left(\left(b_n - b_{n-1} \right) / 2 \right) d_n$$

IV Key Items

- Ensure that the stream channel is reasonably straight and is not disrupted with boulders, holes, etc.
- Be sure that the current meter is working properly. The date of calibration should be checked.
- Measure the impeller-rotation counts over two 60-second intervals and average the two values.

V. References

Brassington, R. 1988. *Field Hydrogeology*. Geological Society of London Handbook Series. John Wiley and Sons, Inc. New York. 175 pp.

USGS. 1982. *Measurement and Computation of Streamflow. Volume I: Measurement of Stage and Discharge*. U.S. Geological Survey Water Supply Paper 2175. 284 pp.

STANDARD OPERATING PROCEDURE G-5

Sediment Sampling

I. Purpose

These general outlines describe the collection and handling of sediment samples during field operations.

II. Scope

Sediments occur in freshwater and marine environments such as streams/rivers, ponds/lakes, canals, ditches, wetlands, lagoons, and estuaries. Recently exposed sediment (due to low water levels) may also be sampled, but exposure to air could affect the characteristics of the sediment (for example, redox) and hence, the interpretation of the results of chemical or other analyses. The following methods are for physical, chemical, and toxicological sampling. The sediment sampling procedures generally describe the equipment and techniques needed to collect representative sediment samples. Always collect surface water quality samples prior to collecting sediment samples if sampling locations are located near to each other.

III. Equipment and Materials

- Sample collection device (hand corer, scoop, dredge, grab sampler, or other suitable device)
- Stainless steel spoon or spatula for media transfer
- Measuring tape
- Log book
- Personal protection equipment (rubber or latex gloves, boots, hip waders, etc.)
- Materials for classifying soils, particularly the percentage of fines
- Sample jars, including jars for grain size, total organic carbon, and pH, as appropriate
- Stainless steel or glass bowl for homogenization of sediment sample (not applicable for volatile organics)
- Rope to lower sediment grab or dredge
- Boat or canoe with U.S. Coast Guard-approved safety equipment

IV. Procedures and Guidelines

Sediment samples can be collected using one of three different types of equipment: (1) scoops, (2) corers and (3) dredges/grab samplers. Soil sampling equipment is generally not applicable to sediments because of the low cohesion of the medium. When selecting the appropriate sampling equipment, consider sampling location (edge or middle of lagoon), depth of water and sediment, sediment grain size (fineness), water velocity and analytes of interest.

Direct collection with the appropriate sample container may be appropriate in very low water or where sediment is exposed. Use dredges for hard or rocky substrates. They are heavy enough to use in high velocity streams. Use coring devices in quiescent waters, unless water depth precludes effective sample collection.

A. Scoops or Similar Equipment

Scooping is generally most useful around the margin or shore of the water body or by wading in shallow waters and where the anticipated sampling depth is shallow. Collect samples by facing the direction of flow and approach the location from the downstream direction. Take precautions not to disturb the bottom prior to scooping. Scoop the sample in the upstream direction of flow. Transfer sample to the appropriate sample container(s), using a clean non-reactive utensil.

B. Corers

Coring devices can be easily fabricated from many materials. Although stainless steel, glass or Teflon must be used for sampling extractable organics, volatile organics and inorganics, aggregate organics, petroleum hydrocarbons and oil & grease, other inexpensive material (e.g., PVC, carbon steel, etc.) may be used for inorganic non-metallics and metals. Some corers are simple "push tubes," whereas other more sophisticated models may be finned, gravity driven devices. A core may be useful for preserving the historical layering of sediments.

Upon descent, water displacement is minimal with core samplers, which minimizes the shock wave produced by other equipment such as dredges. The corer is an acceptable choice for sampling fine sediments in static waters, especially those containing trace organics and metals. Corer diameter, grain size and sample consistency will determine if the sample will remain in the corer upon withdrawal. Sample washout can be a problem and there are several ways to reduce or prevent it. The following steps outline the collection of samples with a coring device:

- Fit the leading edge of the corer with a nosepiece or core catcher that physically keeps the sample from slipping back out of the corer. The core catcher material must also be compatible with the analytes of interest.

- A second option is fit the top or back end with a check valve which creates negative pressure on the back of the sample as it is being pulled from the substrate and prevents surface water from washing out the top portion of the sample.
- Rotate the corer, if needed, as it is pushed into the sediment but do not rock the coring device back and forth
- Rotation improves penetration and prevents compaction of the sample as it is pushed to the full length of the corer.
- Upon withdrawal from the water surface, place a cap on the bottom to prevent the sample from sliding out.
- Corers can also be fitted with liners. This is advantageous if a complete core is desired that has not been in contact with the atmosphere. It is also advantageous if the coring device is not constructed of the proper material (e.g., PVC) and one of the analytes requires a sampler of inert construction (glass, stainless steel or Teflon).
- As the core is extruded, carefully remove the sample with a clean, non-reactive utensil and transfer into the appropriate sample container(s) or in a bowl if homogenization is required or if a specific depth fraction is required to be sampled.

C. Dredges or Grab Samplers

The three main types of devices used in freshwater are the Ekman, Peterson and Ponar. Heavier oceanographic dredges are used in marine and estuarine waters. The Peterson and Ponar dredges are suitable for hard or rocky substrates or deep water bodies. The Peterson and Ponar are virtually the same, except that the Ponar has been adapted with a top screen and side plates to prevent sample loss upon ascent. For this reason, the Ponar is the dredge of choice for rocky substrates. These dredges are heavy enough to use in streams with fast currents. Use the following method to collect a sediment sample:

- Open the jaws and place the cross bar into the proper notch.
- Lower the dredge to the bottom, making sure it settles flat.
- When tension is removed from the line, the cross bar will drop, enabling the dredge to close as the line is pulled upward during retrieval.
- Pull the sampler to the surface. Check to make sure the jaws are fully closed and that no sample was lost while lifting the dredge.
- Carefully open the jaws, remove the sample with a clean, non-reactive utensil and transfer the sample into the appropriate sample

container(s), label, preserve to 4°C with wet ice and complete field notes.

The Ekman is designed for sampling soft substrates (e.g., sand, silt or mud) in areas with little current and is used as follows:

- Open the spring-loaded jaws and attach the chains to the pegs at the top of the sampler.
- Lower the dredge to the bottom, making sure it settles flat.
- Holding the line taut, send down the messenger to close the jaws of the dredge.
- Pull the sampler to the surface. Check to make sure the jaws are fully closed and that no sample was lost while lifting the dredge.
- Carefully open the jaws, remove the sample with a clean, non-reactive utensil and transfer the sample into the appropriate sample container(s).

D. Sampling Procedures

1. Field personnel will start downstream and work upstream to prevent contamination of unsampled areas. In surface water bodies that are tidally influenced, sampling will be performed at low tide and under low flow conditions to minimize the dilution of possible contaminants. Sediment sampling activities will not occur immediately after periods of heavy rainfall.

2. Make a sketch of the sample area that shows important nearby river features and permanent structures that can be used to locate the sample points on a map. Whenever possible, include measured distances from such identifying features. Also include depth and width of waterway, rate of flow, type and consistency of sediment, and point and depth of sample removal (along shore, mid-channel, etc).

3. Transfer sample into appropriate sample jars with a stainless steel utensil. Be especially careful to avoid the loss of the very fine clay/silt particles when collecting the sample. The fine particles have a higher adsorption capacity than larger particles. Minimize the amount of water that is collected within the sample matrix. Decant the water off of the sample slowly and carefully to maximize retention of the very fine particles. The sampler's fingers should never touch the sediment since gloves may introduce organic interference into the sample. Classify the soil type of the sample using the Unified Soil Classification System, noting particularly the percentage of silt and clay.

4. Samples for volatile organics (and, if applicable, acid volatile sulfides/simultaneously extracted metals [AVS/SEM]) should

immediately be placed in jars. Rocks and other debris should be removed before placement in jars.

5. For channel sampling, be on the alert for submerged hazards (rocks, tree roots, drop-offs, loss silt and muck) which can make wading difficult.

6. Sample sediment for grain size (sieve only procedures are generally sufficient but hydrometer analyses may be warranted in some situations), TOC, and pH also, to give context to organic and inorganic data during the risk assessment.

7. Follow the site safety plan designed for the specific nature of the site's sampling activities and locations.

8. Decontaminate all sampling implements and protective clothing according to prescribed procedures.

V. Attachments

Sediment Log Form.

VI. Key Checks and Items

- Start downstream, work upstream.
- Log exact locations using permanent features.
- Beware of hidden hazards in the water column.

CH2MHILL

PROJECT NUMBER	BORING NUMBER
	SHEET 1 OF 1

SEDIMENT LOG

PROJECT : LOCATION : DATE:

WEATHER: DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

WATER LEVELS : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	#/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6"-6" (N)	CORE DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. OVM (ppm): Breathing Zone Above Hole
0.5						
1.0						
1.5						
2.0						
2.5						

Sampler Signature: _____ Date: _____

SOPs in this section:

H-1 Preparing Field Log Books
H-2 Water-Level Measurements
H-3 Aquifer Slug Testing
H-4 Trenching for Landfill Delineation
H-5 Buried Metal Investigations
H-6 Sampling Contents of Tanks and Drums
H-7 Disposal of Waste Fluids and Solids
H-8 Chain-of-Custody
H-9 Packaging and Shipping Procedures for Low-Concentration Samples
H-10 Equipment Blank and Field Blank Preparation
H-11 Civil Surveying
H-12 MEC Avoidance Procedure
H-13 MEC Avoidance During Vegetation Clearing
H-14 Downhole Geophysics

H. MISCELLANEOUS

STANDARD OPERATING PROCEDURE H-1

Preparing Field Log Books

I. Purpose

To provide general guidelines for entering field data into log books during site investigation and remediation field activities.

II. Scope

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

III. Equipment and Materials

- Log book
- Indelible pen

IV. Procedures and Guidelines

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

A. Procedures for Completing Field Log Books

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

- Project name
- Project manager's name
- Phone numbers of the company, supervisors, emergency response, etc.

3. All lines of all pages should be used to prevent later additions of text, which could later be questioned. Any line not used should be marked through with a line and initialed and dated. Any pages not used should be marked through with a line, the author's initials, the date, and the note "Intentionally Left Blank."

4. If errors are made in the log book, cross a single line through the error and enter the correct information. All corrections shall be initialed and dated by the personnel performing the correction. If possible, all corrections should be made by the individual who made the error.

5. Daily entries will be made chronologically.

6. Information will be recorded directly in the field log book during the work activity. Information will not be written on a separate sheet and then later transcribed into the log book.

7. Each page of the log book will have the date of the work and the note takers initials.

8. The final page of each day's notes will include the note-takers signature as well as the date.

9. Only information relevant to the subject project will be added to the log book.

10. The field notes will be copied and the copies sent to the Project Manager or designee in a timely manner (at least by the end of each week of work being performed).

B. Information to be Included in Field Log Books

1. Entries into the log book should be as detailed and descriptive as possible so that a particular situation can be recalled without reliance on the collector's memory. Entries must be legible and complete.

2. General project information will be recorded at the beginning of each field project. This will include the project title, the project number, and project staff.

3. Scope: Describe the general scope of work to be performed each day.

4. Weather: Record the weather conditions and any significant changes in the weather during the day.

5. Tail Gate Safety Talks: Record time and location of meeting, who was present, topics discussed, issues/problems/concerns identified, and corrective actions or adjustments made to address concerns/ problems, and other pertinent information.

6. Standard Health and Safety Procedures: Record level of personal protection being used (e.g., level D PPE), record air monitoring data on a regular basis and note where data were recording (e.g., reading in borehole, reading in breathing zone, etc). Also record other required health and safety procedures as specified in the project specific health and safety plan.

7. Instrument Calibration; Record calibration information for each piece of health and safety and field equipment.

8. Personnel: Record names of all personnel present during field activities and list their roles and their affiliation. Record when personnel and visitors enter and leave a project site and their level of personal protection.

9. Communications: Record communications with project manager, subcontractors, regulators, facility personnel, and others that impact performance of the project.

10. Time: Keep a running time log explaining field activities as they occur throughout the day.

11. Deviations from the Work Plan: Record any deviations from the work plan and document why these were required and any communications authorizing these deviations.

12. Heath and Safety Incidents: Record any health and safety incidents and immediately report any incidents to the Project Manager.

13. Subcontractor Information: Record name of company, record names and roles of subcontractor personnel, list type of equipment being used and general scope of work. List times of starting and stopping work and quantities of consumable equipment used if it is to be billed to the project.

14. Problems and Corrective Actions: Clearly describe any problems encountered during the field work and the corrective actions taken to address these problems.

15. Technical and Project Information: Describe the details of the work being performed. The technical information recorded will vary significantly between projects. The project work plan will describe the specific activities to be performed and may also list requirements for note taking. Discuss note-taking expectations with the Project Manager prior to beginning the field work.

16. Any conditions that might adversely affect the work or any data

obtained (e.g., nearby construction that might have introduced excessive amounts of dust into the air).

17. Sampling Information; Specific information that will be relevant to most sampling jobs includes the following:

    - Description of the general sampling area – site name, buildings and streets in the area, etc.
    - Station/Location identifier
    - Description of the sample location – estimate location in comparison to two fixed points – draw a diagram in the field log book indicating sample location relative to these fixed points – include distances in feet.
    - Sample matrix and type
    - Sample date and time
    - Sample identifier
    - Information on how the sample was collected – distinguish between "grab," "composite," and "discrete" samples
    - Number and type of sample containers collected
    - Record of any field measurements taken (i.e. pH, turbidity, dissolved oxygen, and temperature, and conductivity)
    - Parameters to be analyzed for, if appropriate
    - Descriptions of soil samples and drilling cuttings can be entered in depth sequence, along with PID readings and other observations. Include any unusual appearances of the samples.

C. Suggested Form at for Recording Field Data

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

V. Attachments

Example field notes

(47) MAY 12, 2003 EXAMPLE

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

0725 BB ~~CAL~~ (JS) CALIBRATES
PID: 101 ppm/100 ppm OK
PID MODEL #, SERIAL #

0730 BB CALIBRATES HORIBA METER
MODEL #, SERIAL #
→ LIST CALIBRATION RESULTS

0738 SURVEY CREW ARRIVES ON SITE
→ LIST NAMES

0745 BB HOLDS H+S TALK ON SLIPS, TRIPS, FALLS, TICKS + AIR MONITORING
JS + SURVEY CREW ATTEND
NO H+S ISSUES IDENTIFIED AS [illegible] "LEVEL D"

0755 JS CONDUCTS SITE-WIDE AIR MONITORING
ALL READINGS = 0.0 ppm 1'0

JS 5-12-03

MAY 12, 2003 EXAMPLE (3)

SITE 14 LTM
BREATHING ZONE (BZ)

0805 MOBILIZE TO WELL MW-22 TO SAMPLE, SURVEYORS SETTING UP AT SITE 17

0815 PM (PAUL PAPER PUSHER) CALLS AND INFORMS JS TO COLLECT GW SAMPLE AT WELL MW-14 TODAY FOR 24 hr TAT ANALYSIS OF VOC'S

0820 PURGING MW-22
→ RECORD WATER QUALITY DATA

JS 5-12-03

0843 COLLECT SAMPLE AT MW-22 FOR TOTAL TAL METALS AND VOC'S. NO DISSOLVED METALS NEEDED PER PM

0905 JS + BB MOBILIZE TO SITE 17 TO SHOW SURVEYORS WELLS TO SURVEY.

0942 MOBILIZE TO WELL MW-22 TO COLLECT SAMPLE

0950 CAN NOT ACCESS WELL MW-22 DUE TO BASE OPERATIONS; CONTACT PAUL PAPERPUSHER AND HE STATED HE WILL CHECK ON GAINING ACCESS WITH BASE CONTACT.

0955 MOBILIZE TO WELL MW-19

JS 5-12-03

STANDARD OPERATING PROCEDURE H-2

Water-Level Measurements

I. Purpose and Scope

The purpose of this procedure is to provide a guideline for the measurement of the depth to groundwater in piezometers and monitoring wells, even where a second phase of floating liquid (e.g., gasoline) is encountered, and on staff gages in surface-water bodies. This SOP includes guidelines for discrete measurements of static water levels and does not cover the use of continuously recording loggers (see SOP *Use of Data Loggers and Pressure Transducers)*.

II. Equipment and Materials

- Electronic water-level meter (Solinst® or equivalent) with a minimum 100-foot tape; the tape should have graduations in increments of 0.01 feet or less
- Interface probe (Solinst® Model 122 Interface Meter or equivalent)

III. Procedures and Guidelines

Verify that the unit is turned on and functioning properly. Slowly lower the probe on its cable into the piezometer or well until the probe just contacts the water surface; the unit will respond with a tone or light signal. Note the depth from a reference point indicated on the piezometer or well riser. Typically this is the top of the protective casing. If no reference is clearly visible, measure the depth to water from the northern edge of the riser. If access to the top of the riser is difficult, sight across the top of the locking casing adjacent to the measuring point, recording the position of the cable when the probe is at the water surface.

Measure the distance from this point to the closest interval marker on the tape, and record the water level reading in the logbook. Water levels will be measured to the nearest 0.01-foot. Also measure and record the three following readings: (1) the depth of the piezometer or well; (2) the distance from the reference point to the top of the protective; and (3) the distance to the surface of the concrete pad or to ground. The depth of the piezometer or well may be measured using the water-level probe with the instrument turned off.

Free product light or dense nonaqueous phase liquid may be present in the piezometer or well. If the presence of free product is suspected, the thickness of the product should be determined using appropriate equipment (e.g., Solinst® Model 122 Interface Meter). The depth to water also is determined with this equipment and the water-level meter should not be used in the piezometer or well as long as product is present. Typically, a constant sound is emitted from the device when

free product is encountered and an alternating on/off beep sound is emitted when water is encountered.

The apparent elevation of the water level in the well or piezometer is determined by measuring both the apparent depth to water and the thickness of free product. The corrected water-level elevation is calculated by the following equation:

$$WL_c = Wl_a + (\text{Free-product thickness} \times 0.80)$$

Where WL_c = Corrected water-level elevation

Wl_a = Apparent water-level elevation

0.80 = Typical value for the density of petroleum hydrocarbon products.

If free product is detected on the surface of the water in the piezometer or well, the value of sampling should be reconsidered because of the potential for contaminating the sampling equipment.

Staff gages may be installed in some surface-water bodies. These facilities typically are constructed by attaching a calibrated, marked staff gage to a wood or metal post, driving the post into the bottom of the surface-water body, and surveying the elevation of the top of the post to a resolution or 0.01-foot. The elevation of the water in the surface-water body then can be determined by reading off the distance the water level is from the top of the post. A shield or other protection may be needed to calm the fluctuations in water level if the gage is installed at a location exposed to wind or wave.

IV. Attachments

None.

V. Key Checks

- Before each use, verify that the battery is charged by pressing the test button on the water-level meter.
- Verify that the unit is operating correctly by testing the probe in distilled or de-ionized water. Leave the unit turned off when not in use.

STANDARD OPERATING PROCEDURE H-3

Aquifer Slug Testing

I. Purpose and Scope

The purpose of this procedure is to outline the equipment and methods that will be used to perform variable-head tests ("slug" tests) on piezometers and monitoring wells. The guidance covers use of both air and solid displacement methods.

II. Equipment and Materials

- Campbell Scientific, Inc., Model 21X datalogger or equivalent
- Druck pressure transducers or equivalent
- Well-testing assembly
  - Packer
  - Fittings for pressure transducers
  - Fittings for air supply
  - Release valve
- Compressed air
- Computer and associated equipment
- Solid displacement device with rope

III. Procedures and Guidelines

The tests to be performed are rising head tests. The tests are accomplished by lowering the head of water in the well and monitoring the recovery of the water level to the static water level. The water level will be lowered by one of two methods. One method is the use of an air displacement device. Alternatively, a solid displacement device removed from the well will be used.

The air displacement apparatus consists of a packer assembly, fittings to accommodate transducers and air pressurization, and a pressure-release valve. The packer is lowered into the upper portion of the monitoring well, secured in place and inflated, providing a seal between the apparatus and the inside of the well. Two fittings are provided for pressure transducers: one transducer is fed through the inside of the device and positioned below the water surface and the other is inserted to measure the air pressure inside the assembly. A third fitting is connected to the pressurized air supply, a compressed air tank.

The datalogger will be programmed to display the air pressure in units of head, the head measured by the submerged transducer, and the difference between the two. The difference between the two pressure transducers is the height of the water column on the submerged transducer. The readings are recorded in a field

notebook, and then the assembly is pressurized. The air pressure applied will be equivalent to 3 to 7 feet of head. The pressures are allowed to stabilize. The pressure of the air should not lower the water level to below the base of the bentonite seal installed in the well.

Each test is started by releasing the air pressure inside the assembly and allowing the water level to rise to the static water level. When the datalogger perceives a change in water level in the well above a preset trigger amount, it automatically begins to record the water levels and elapsed time. Each test will be terminated when the water level has recovered to at least 90 percent of the original equilibrium level before pressurization. Note that the test method cannot be used if the well is screened across or near the water table.

An alternate method of lowering using a solid displacement device to lower the water level. A single transducer will be installed in the well below the water table. A weighted solid displacement device is added to the well and the water level allowed to stabilize at the original static water level. The test is started by rapidly removing the displacement device, which causes a drop in the water level. The data logger begins recording the water level and elapsed time when the preset trigger amount is reached. Readings are taken as above, and the test stopped when the well has recovered to 90 percent of the original level.

At least two valid tests will be performed in each well. Additional tests will be required if there is some evidence that any of the tests were unacceptable.

At the end of each day, the test results will be transferred to a computer disk. The computer will be attached to the data logger and the data downloaded and checked for preliminary completeness.

IV. Attachments

None.

V. Key Checks and Preventive Maintenance

- Check that the packer assembly is in good condition and not leaking. Provide a repair kit including tape and clamps. Take additional packer assembly and other spare parts.
- Check the batteries for the datalogger and computer. Check that the computer disks containing the programs for the datalogger are packed. Include blank computer disks for file storage.
- Check the datalogger calculation of the well hydraulic conductivity at the end of each test to determine if these are consistent with expectations.

STANDARD OPERATING PROCEDURE H-4

Trenching for Landfill Delineation

I. Purpose

To provide reference material and general guidance on test pitting using a backhoe during landfill boundary confirmation activities.

II. Equipment and Materials

- Backhoe
- Shovels, picks, scoops
- Camera, slate (or other erasable material) board
- Plastic sheeting and stakes and/or sand bags to cover test pits and excavated soil
- Barricades to secure area around excavation
- Onsite decontamination pad
- Level D personnel protection equipment and onsite site safety officer

IV. Procedures and Guidelines

A. General Considerations

Test pits will be excavated along the landfill boundary as indicated by the results of soil borings and/or geophysical surveys.

The onsite crew will photograph any significant features exposed by the test pit. Photographs will include a slate board (or other marker) marked with (at a minimum) test pit number, date and time of photograph, description of feature. Other observations (including soil descriptions) will be recorded in the logbook.

Once test pitting is complete, the pits will be backfilled with the stockpiled soil and regraded to mimic the original ground surface contour.

B. Trenching Activities

1. Establish work zone according to the site safety plan.
2. Calibrate all air quality monitoring instruments.
3. Using a clean backhoe (decontaminated following SOP *Decontamination of Personnel and Equipment*), begin excavating

perpendicular to and just outside of the area defined as the landfill boundary during the geophysical survey. Carefully excavate towards the boundary, recording all observations in the logbook, until buried material is encountered. Remove only enough soil to identify the landfill boundary.

4. Monitor the air quality in the breathing zone at 5-minute intervals during trenching activities to ensure the proper level of respiratory protection in being worn by all field team members.

5. Photograph and document the trenching activities as appropriate. Backfill and regrade the test pit, discard plastic sheeting, decontaminate the backhoe, and set up at the next trenching location.

V. Attachments

None.

VI. Key Checks and Items

Ensure that staff are not allowed to enter the trench when it exceeds depth limitations specified by OSHA.

STANDARD OPERATING PROCEDURE H-5

Buried Metal Investigations

I. Purpose

To provide reference material and general guidance on test pitting around buried metal items.

II. Scope

Test pitting using a backhoe, excavating and overpacking buried drums, and obtaining representative soil samples from the test pits. Sampling wastes from buried drums and tanks are addressed in SOP *Sampling Contents of Tanks and Drums.*

III. Equipment and Materials

- Backhoe equipped with explosion shield, drum grappler, and 3-ft copper-beryllium (non-sparking) spike with 6-in collar (to puncture drums for sampling)
- Shovels, picks, scoops
- Camera, slate (or other erasable material) board
- Plastic sheeting and stakes and/or sand bags to cover test pits and excavated soil
- Barricades with flashers to secure excavation
- Overpack drums
- Onsite drum storage area (plastic sheeting surrounded by a locking privacy fence)
- Onsite decontamination pad
- Bagged lime to extinguish any acid fires
- Level C personnel protection equipment and onsite site safety officer
- Clean top soil or fill to "top off" test pits and return ground surface as close to the original configuration as possible
- Grass seed
- For dewatering areas prior to test pitting:
    - Liquid waste tank truck(s) equipped with pumping equipment

- Backhoe for berming and ditching needed to reroute flow from seep around excavation; sand bags to fortify ditch if needed
- Timber/mats to prevent heavy equipment from sinking

IV. Procedures and Guidelines

A. General Considerations

Test pits will be excavated around buried metal items using a backhoe. Dewatering may be necessary depending on site conditions.

The onsite crew will photograph any significant features exposed by the test pit. Photographs will include a slate board (or other marker) marked with (at a minimum) test pit number, date and time of photograph, description of feature. Other observations (including soil descriptions) will be recorded in the logbook.

Once test pitting is complete, the pits will be backfilled with the stockpiled soil. They will be topped off using clean fill/top soil and regraded to mimic the original ground surface contour. Excavated areas will be reseeded to minimize erosion.

The procedures described below are for both initial test pitting (i.e., preliminary test pitting to confirm the presence of buried metal at an anomaly) and additional test pitting (i.e., test pitting needed to remove buried metal and associated soil).

B. Procedures for Initial Investigations Around Buried Drums

1. Establish work zone according to the site safety plan.
2. Lay out plastic sheeting downwind of the test pit. This will be used for soils excavated from the test pit.
3. Using a clean backhoe (decontaminated following SOP *Decontamination of Personnel and Equipment*), begin excavating the area defined by the geophysical anomaly. Carefully excavate soil until the source of the anomaly is observed, recording all observations in the logbook. Remove only enough soil to quantify the need for any additional activities at that site. This requires determining the number, size, and type of each container.
4. If buried containers are not found, additional activities are not needed at that site. Photograph and document any significant features, postulate a reason for the anomaly (such as presence of sheet metal), backfill the test pit, discard plastic sheeting, decontaminate the backhoe, and set up on the next location.
5. If buried containers are found, additional investigations will be needed at that site. Photograph and document any significant

features. Cover the soil and the excavation with plastic, securing the ends with sandbags or stakes to prevent water from running on. Erect sufficient barricades (e.g., saw horse with reflective tape or flashers) to prevent any inadvertent intrusion into the area. Decontaminate the backhoe and move to the next location.

C. Additional Investigations Around Buried Drums

1. Set up work zones according to the site safety plan.
2. Set up an area for overpacking drums on plastic sheeting in the exclusion zone near the excavation. Based on initial test pits, have on hand sufficient overpack drums to contain what will be excavated from the test pit.
3. Remove plastic coverings from soil and excavation.
4. Begin cautiously excavating the soil from around the drum until it is loosed from the ground and the grappling hook (or the bucket of the backhoe, or a sling) can be used to transfer it to an overpack drum. The grappling hook is preferred because the backhoe operator can move the drum with little assistance from other personnel. Use of the backhoe requires rolling the drum and manhandling it into the overpack drum. A sling also requires manhandling of the drum.
5. Assign a number to the drum and affix the number of the test pit and the drum to the top and side of the overpack drum.
6. Collect a soil sample from the spoils pile that is representative of the soil excavated from around the drum.
7. Continue steps 4 through 6 until each drum is removed from the test pit. Backfill the excavation, discard plastic sheeting, decontaminate the backhoe, and set up on the next location.
8. Move the drums from the area of the test pit to the onsite drum storage area, after visible dirt has been removed from the exterior of the drums. Discard remaining plastic sheeting in drums.
9. Sample the contents of the excavated drums all at once, following SOP *Sampling Contents of Tanks and Drums.*

D. Additional Investigations Around Buried Tanks

1. Set up work zones according to the site safety plan.
2. Remove plastic coverings from soil and excavation.
3. Begin cautiously excavating the soil from around the tank until a sampling port is exposed. Affix the number of the test pit and the tank to the top of the tank, near the sampling port.

4. Collect a sample of the contents of the tank following SOP *Sampling Contents of Tanks and Drums.*

5. Excavate around the tank on all sides so that up to four soil samples representative of the soil excavated from around the tank can be collected. "Representative" means that samples are taken from above and below the water table, each side of the tank, and in areas where contamination is evident.

6. Backfill the excavation, marking the tank corners and the sampling port at the ground surface with stakes. Do not regrade since the tanks will be removed at a later date. Cover the excavation with the plastic sheeting and secure with the barricades. Decontaminate the backhoe, and set up on the next location.

E. Test Pitting Beneath a Pond

To investigate the anomaly detected beneath a pond, it will be necessary to isolate the area for test pitting by berming, dewatering the bermed portion of the pond and possibly rerouting around the excavation any seeps that may feed the pond. The water in the pond will be pumped as free board and into another portion of the pond; some may be pumped into tanks and stored onsite until test pitting activities are complete. If seeps are found to feed the pond, they also will be pumped to onsite tankers, if there is sufficient flow to require containment. Otherwise, they will be rerouted around the excavation. Excavated soil will be placed on plastic near the excavations since the soil and the water will be returned to the pond once test pitting activities are completed. After dewatering is accomplished, the test pitting activities (described in previous sections) can be performed. After test pit investigations are complete, the pond water stored in the onsite tanks will also be returned to the pond.

V. Attachments

None

VI. Key Checks and Items

- Ensure that test pitting is being performed at the proper location defined by the geophysical survey.
- Avoid perforating buried drums during excavation.
- Overpack all drums removed to ensure against leakage.
- Be sure that representative samples are collected from spoil piles and around tanks.

VII. Noteworthy Miscellaneous Information

- Plastic drums frequently contain strong acids or bases
- Corrugated drums commonly contain metal-plating wastes which can have some pretty nasty sludges containing acids and cyanide
- Fiberboard drums commonly contain food products and fall apart easily
- Stainless steel drums are expensive (about $500 each) and indicate a sincere effort to contain its contents
- On tanks, fill ports are usually straight and vents are usually curved (to prevent moisture from dripping into tanks) so it is important to know what you are trying to use as a sampling port
- Consider the location of the water table with respect to the tank; many tanks have anchors to prevent them from "floating"; these anchors include concrete slabs and vaults. Do not disturb any anchors that hold tanks down unless you have a plan for securing it afterwards
- Some tanks have cathodic protection so don't be alarmed if you observe cables on tanks
- Do not open valves on lower sides or bottoms of tanks
- If you suspect a tank contains leaded gasoline, remember that the metals precipitate, forming a sludge at the bottom
- Waste samples are treated as high hazard samples and will need double containment (clean "paint cans") for shipping and handling
- Do not add water to acids

STANDARD OPERATING PROCEDURE H-6

Sampling Contents of Tanks and Drums

I. Scope and Application

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

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

II. References

A. *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001, U.S. Environmental Protection Agency, Washington, D.C., 1987.

B. *Data Quality Objectives for Remedial Activities - Development Process*, EPA/540/G-87/003, U.S. Environmental Protection Agency, Washington, D.C., 1987.

C. Annual Book of ASTM Standards, *Standard Recommended Practices for Sampling Industrial Chemicals*, ASTM-E-300, 1986.

D. *Test Method for Evaluating Solid Waste*, SW-846, Volume II, Field Methods, Second Edition, U.S. Environmental Protection Agency, Washington, D.C., 1982.

E. U.S. Environmental Protection Agency, *Characterization of Hazardous Waste Sites – A Method Manual: Volume II, Available Sampling Methods*, USEPA Environmental Monitoring Systems Laboratory, Las Vegas, EPA-600/ 4-84-076, December, 1984.

F. *Environmental Surveillance Procedures*, Quality Control Program, Martin Marietta Energy Systems, ESH/Sub/87-21706/1, Oak Ridge, TN, September 1988.

III. Summary of Methods

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

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

IV. Comments

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

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

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

V. Required Equipment and Apparatus

A. **Health and safety equipment/materials**: As listed in the site safety plan.

B. **Sampling equipment**: COLIWASA, glass sample tubes, Kemmerer depth sampler, Bacon Bomb, gravity corer.

C. **Tools**: Rubber mallet, bung wrench, speed wrench with socket, etc., (all non-sparking), paint marker.

D. **Heavy equipment**: Backhoe equipped with explosion shield, drum grappler, and 3-foot copper-beryllium (non-sparking) spike with 6-inch collar (to puncture top of drums for sampling, if necessary).

E. **Sample Containers**: As specified in the field sampling plan.

VI. Procedures

A. Drums

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

1. Drums will be sampled on an area-by-area basis. Drums will be sampled after they have been placed in overpack drums but before they are transferred from the excavation to the onsite storage area.

2. Record, in logbook, all pertinent information from visual inspection of drum (e.g., physical condition, leaks, bulges, and labels). Label each drum with a unique identifying number.

3. If possible, stage drums for easy access.

4. If necessary, attach ground strap to drums and grounding point.

5. Remove any standing material (water, etc.) from container top.

6. Using non-sparking tools, carefully remove the bung or lid while monitoring air quality with appropriate instruments. If necessary (and as a last resort), the non-sparking spike affixed to the backhoe can also be used to puncture the drum for sampling. See Attachment D for method of drum opening. Record air-quality monitoring results.

7. When sampling a previously sealed vessel, a check should be made for the presence of bottom sludge. This is accomplished by measuring the depth to apparent bottom, then comparing it to the known interior depth.

8. Agitation to disrupt the layers and rehomogenize the sample is physically difficult and almost always undesirable. If the vessel is greater than 3 feet in depth (say, a 55-gallon drum), the appropriate sampling method is to slowly lower the sampling device (i.e., suction line of peristaltic pump, glass tube) in known increments of length. Discrete samples can be collected from various depths, then combined or analyzed separately. If the depth of the vessel is greater than the lift capacity of the pump, an at-depth water sampler, such as the Kemmerer or Bacon Bomb type, may be required.

9. Extract a representative sample from the drum using a glass rod, COLIWASA, Bacon Bomb, Kemmerer bottle, or gravity corer (See Attachments). Ensure that the entire depth of material is penetrated. Depending on the size of the opening of the drum, three to four takes should be collected from random locations across the drum surface, to ensure a representative sample. Any observed

stratification must be recorded in logbook, including number and thickness of the layers and a conceptualized sketch.

10. Record a visual description of the sample (e.g., liquid, solid, color, viscosity, and percent layers).

11. When possible, sampling equipment (like glass tubes) should be expendable and be left inside the drum for disposal with drum contents, once sampling is completed.

12. Place lid, bung, cap, etc., back in place on drum. Tighten hand tight. If necessary, the sampling port can be sealed using a cork.

13. Wipe up spilled material with lab wipes. Wipe off sample containers.

14. Mark the drum with a unique sample identification number and date using a paint marker.

15. Samples will be handled as high hazard samples. Samples will be placed in containers defined according to the analytical needs, wiped clean, and then packed in paint cans for shipping. Packaging, labeling, and preparation for shipment procedures will follow procedures as specified in the field sampling plan.

B. Underground Storage Tanks

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

2. Sampling team will locate a sampling port on the tank. Personnel should be wearing appropriate protective clothing at this time and carrying sampling gear.

3. Do not attempt to climb down into tank. Sampling MUST BE accomplished from the top.

4. Collect a sample from the upper, middle, and lower section of the tank contents with one of the recommended sampling devices.

5. If compositing is necessary, ship samples to laboratory in separate containers for laboratory compositing.

6. Samples will be handled as hazardous. Samples will be placed in appropriate containers and packed with ice in a cooler. Packaging, labeling, and preparation for shipment will follow procedures specified in the field sampling plan.

C. Tank Trailers or Above-Ground Storage Tanks

1. A sampling team of two is required. One will collect samples, the other will relay required equipment and implements.

2. Samples will be collected through the manhole (hatch) on top of the tanker or the fill port. Do not open valves at the bottom. Before opening the hatch, check for a pressure gauge or release valve. Open the release valve slowly to bring the tank to atmospheric pressure.

3. If tank pressure is too great, or venting releases large amounts of toxic gas, discontinue venting and sampling immediately. Measure vented gas with organic vapor analyzer and explosimeter.

4. If no release valve exists, slowly loosen hatch cover bolts to relieve pressure in the tank. (Again, stop if pressure is too great.)

5. Once pressure in tank has been relieved, open the hatch and withdraw sample using one of the recommended sampling devices.

6. Sample each trailer compartment.

7. If compositing is necessary, ship samples to laboratory in separate containers for laboratory compositing.

8. Samples will be handled as hazardous. Samples will be placed in appropriate containers and packed with ice in a cooler. Packaging, labeling, and preparation for shipment will follow procedures specified in the field sampling plan.

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

Drum

Glass tube	—	Procedure 1
COLIWASA	—	Procedure 2

Storage Tank and Tank Trailer

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

VII. Contamination Control

Sampling tools, instruments, and equipment will be protected from sources of contamination prior to use and decontaminated after use as specified in SOP *Decontamination of Personnel and Equipment*. Liquids and materials from decontamination operations will be handled in accordance with the waste management plan. Sample containers will be protected from sources of

contamination. Sampling personnel shall wear chemical resistant gloves when handling any samples. Gloves will be decontaminated or disposed of between samples.

VIII. Attachments

A. Collection of Liquid-Containerized Wastes Using Glass Tubes

B. Sampling Containerized Wastes Using the Composite Liquid Waste Sample (COLIWASA)

C. Sampling Containerized Wastes Using the Bacon Bomb Sampler

D. Gravity Corer for sampling Sludges in Large Containers

E. Construction of a Typical COLIWASA

F. Drum Opening Techniques and Equipment

IX. Field Checklist

_____ Sampling Instruments

_____ Tools

_____ Rubber Mallet

_____ Logbook

_____ Safety Glasses or Monogoggles

_____ Safety Shoes

_____ Ice/Cooler, as required

_____ Custody Seals, as required

_____ Chain-of-Custody Forms

_____ Drum Labels, as required

_____ Paint Marker, if drum sampling

_____ Black Indelible Pen

_____ Monitoring Instruments

____ Labels

____ Sampling and Analysis Plan

____ Health and Safety Plan

____ Decontamination Equipment

____ Lab Wipes

____ Lab Spatulas or Stainless Steel Spoons

____ Chemical Preservatives, as required

____ Appropriate Containers for Waste and Equipment

____ Duct Tape

____ Plastic Sheeting

Attachment A Collection of Liquid-Containerized Wastes Using Glass Tubes

Discussion

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

Uses

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

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

Procedures for Use

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

9. Remove the tube from the sample container and replace the tube in the drum, breaking it, if necessary, in order to dispose of it in the drum.

Optional Method (if sample of bottom sludge is desired)

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

Note:

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

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

Discussion

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

Uses

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

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

Procedures for Use

1. Check to make sure the sampler is functioning properly. Adjust the locking mechanism, if present, to make sure the neoprene rubber stopper provides a tight closure.

2. Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.

3. Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.

4. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the

closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.

5. Slowly withdraw the sampler from the waste container with one hand while wiping the sampler tube with a laboratory wipe with the other hand. A phase boundary, if present, can be observed through the tube.

6. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.

7. Unscrew the T-handle of the sampler and disengage the locking block.

Attachment C: Sampling Containerized Wastes using the Bacon Bomb Sampler

Discussion

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

Uses

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

Procedures for Use

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

Attachment D: Gravity Corer for Sampling Sludges in Large Containers

Discussion

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

Uses

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

Procedures for Use

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

Attachment E: Construction of a Typical COLIWASA

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

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

The sampler is assembled as follows:

a. Attach the swivel to the T-handle with the 3.18-cm (1-1/4 in) long bolt and secure with the 0.48-cm (3/16-in) National Coarse (NC) washer and lock nut.

b. Attach the PFTE stopper to one end of the stopper rod and secure with the 0.95-cm (3/8-in) washer and lock nut.

c. Install the stopper and stopper rod assembly in the sampling tube.

d. Secure the locking block sleeve on the block with glue or screw. This block can also be fashioned by shaping a solid plastic rod on a lathe to the required dimension.

e. Position the locking block on top of the sampling tube such that the sleeveless portion of the block fits inside the tube, the sleeve sits against the top end of the tube, and the upper end of the stopper rod slips though the center hole of the block.

f. Attach the upper end of the stopper rod to the swivel of the T-handle.

g. Place the sampler in the close position and adjust the tension on the stopper by screwing the T-handle in or out.

Attachment F: Drum Opening Techniques and Equipment [1]

I. Introduction

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

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

II. Manual Drum Opening

A. Bung Wrench

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

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

B. Drum Deheader

One means by which a drum can be opened manually when a bung is not removable with a bung wrench is by using a drum deheader. This tool is

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

constructed of forged steel with an alloy steel blade and is designed to cut the lid of a drum off or part way off by means of a scissors-like cutting action. A limitation of this device is that it can be attached only to closed head drums (i.e., DOT Specification 17E and 17F drums); drums with removable heads must be opened by other means.

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

C. Hand Pick or Spike

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

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

III. Remote Opening

A. Backhoe Spike

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

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

The spike should be decontaminated after each drum is opened to prevent cross contamination. Even though some splash or spray may occur when this method is used, the operator of the backhoe can be protected by mounting a large shatter-resistant shield in front of the operator's cage. This, combined with the normal sampling safety gear, should be sufficient to protect the operator. Additional respiratory protection can be afforded by providing the operator with an on-board airline system. The hole in the drum can be sealed with a cork.

B. Hydraulic Devices

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

C. Pneumatic Devices

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

IV. Summary

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

opening techniques and equipment will also safeguard personnel. The use of remote sampling equipment whenever feasible is highly recommended.

STANDARD OPERATING PROCEDURE H-7

Disposal of Waste Fluids and Solids

I. Purpose and Scope

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

II. Equipment and Materials

A. Fluids

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

B. Solids

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

III. Procedures and Guidelines

A. Methodology

Clean, empty drums or rolloffs or Baker® Tanks will be brought to the site by the drilling subcontractor for soil and groundwater collection and storage. The empty drums will be located at the field staging area and moved to drilling locations as required. To the extent possible, drill cuttings will be returned to boreholes to minimize the quantity of cuttings included in waste management procedures. The drums will be filled with excess drilling and well installation cuttings, capped,

sealed, and moved to the onsite drum storage area by the drilling subcontractor. The full drums will separate types of cuttings and material by media. The drums will be labeled as they are filled in the field and labels indicating that the contents are pending analysis.

The drum contents will be sampled to determine the disposal requirements. The drum sampling will be accomplished through the collection and submittal of composite samples, one sample per 10 drums containing the same media. Similar compositing will be performed in each rolloff to obtain representative sample(s). The compositing of the sample will be accomplished by collecting a portion of the material in each drum into a large sample container. When samples from each of the drums being sampled in a single compositing are collected, the sample will be submitted for full TCLP, ignitability, corrosivity, and reactivity analysis. Other parameters may be required by the disposing facility or necessary due to suspected contaminants at a site. The analysis will be used to determine the appropriate disposal options.

B. Labels

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

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

C. Fluids

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

D. Solids

The solid waste stream also will include drill cuttings and plastic sheeting used for decontamination pads, Tyveks, disposable sampling materials, and any other disposable material used during the field operations that comes in contact with

potentially contaminated material. These materials will be placed in designated drums.

E. Storage and Disposal

Non-media solid material (e.g., disposable sampling equipment, personal protective equipment, etc.) may be decontaminated in accordance with the Equipment Decontamination SOP and disposed of with normal trash.

All other solid waste and all hazardous waste will be disposed of at an offsite location in a manner consistent with applicable regulations. Transport and disposal will be performed by a commercial firm under subcontract.

The liquid wastes meeting acceptable levels of discharge contamination may be disposed of through the sanitary sewer system at the site. Prior to disposal to the sanitary sewer system, contract arrangements will be made with the appropriate authorities. Wastes exceeding acceptable levels for disposal through the sanitary sewer system will be disposed of offsite through contract with a commercial transport and disposal firm and in accordance with their characterization sample analysis.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

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

STANDARD OPERATING PROCEDURE H-8

Chain-of-Custody

I. Purpose

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

II. Scope

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

III. Definitions

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

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

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

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

IV. Responsibilities

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein. The Project Manager is responsible for ensuring that chain-of-custody procedures are implemented. The Project Manager also is responsible for determining that custody procedures have been met by the analytical laboratory.

Field Team Leader - The Field Team Leader is responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper or laboratory. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sample Personnel - It is the responsibility of the field sampling personnel to initiate chain-of-custody procedures, and maintain custody of samples until they are relinquished to another custodian, the sample shipper, or to a common carrier.

V. Procedures

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

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

A. Sample Identification

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

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

- Field Sampler(s),
- Contract Task Order (CTO) Number,
- Project Sample Number,
- Sample location or sampling station number,
- Date and time of sample collection and/or measurement,

- Field observations,
- Equipment used to collect samples and measurements, and
- Calibration data for equipment used

Measurements and observations shall be recorded using waterproof ink.

1. Sample Label

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

- Project - CTO Number.
- Station Location - The unique sample number identifying this sample.
- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 12/21/85).
- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.
- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name of the sampler.
- Remarks - Any pertinent additional information.

Using only the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing the analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site).

B. Chain-of-Custody Procedures

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

1. Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan and/or Field Standard Operating Procedures. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.

- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once developed, the photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographs will be stored in the project files. It is good practice to identify sample locations in photographs by including an easily read sign with the appropriate sample/location number.

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

2. Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record. A Chain-of-Custody Record example is attached. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below:

- Enter header information (CTO number, samplers, and project name).

- Enter sample specific information (sample number, media, sample analysis required and analytical method grab or composite, number and type of sample containers, and date/time sample was collected).

- Sign, date, and enter the time under "Relinquished by" entry.

- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used in this space (i.e., Federal Express).

- If a carrier is used, enter the airbill number under "Remarks," in the bottom right corner;

- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample-shipping package. Retain the copy with field records.

- Sign and date the custody seal, a 1-inch by 3-inch white paper label with black lettering and an adhesive backing. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.

- Place the seal across the shipping container opening so that it would be broken if the container were to be opened.

- Complete other carrier-required shipping papers.

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

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

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

VI. Quality Assurance Records

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

VII. Attachments

Chain of Custody Form

VIII. References

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

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Chain of Custody Form

Project Site	AOC E				Number of Containers	Analysis Requested												Project No.
Project Manager	Brett Doerr																	
Contact Tel No.	757-289-9246 (Adrienne Jones)																	Lab Batch/SDG ID
Contact Address	4350 W. Cypress Street, Suite 600, Tampa, FL 33607																	
Lab Name																		Lab Tel No./Fax No.
Lab Contact																		
Lab Address																		
Item	Sample ID	Station ID	Matrix	Date & Time Collected		MET_SO/CN	PCB_SO	PEST_SO	SVOC_SO	TL_SO	TOC_SO	TPH_SO_DRO/ORO	TPH_SO_GRO	VOC_SO	GRAIN_SIZE	TPH_W_GRO	VOC_W	Comments
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		

Sampled By:	Date/Time:	Custody Seal: Y / N	Relinquished By: Date/Time:
Shipped Via: UPS FedEx Hand	Other (Please specify):		
Samples Temperature and Condition Upon Receipt (for lab's use):			
Received By:	Date/Time:	Custody Seal: Y / N Relinquished By:	Date/Time:
Received By:	Date/Time:	Custody Seal: Y / N Relinquished By:	Date/Time:
Remarks:			

STANDARD OPERATING PROCEDURE H-9

Packaging and Shipping Procedures for Low-Concentration Samples

I. Purpose and Scope

The purpose of this guideline is to describe the packaging and shipping of low-concentration samples of various media to a laboratory for analysis.

II. Scope

The guideline only discusses the packaging and shipping of samples that are anticipated to have low concentrations of chemical constituents. Whether or not samples should be classified as low-concentration or otherwise will depend upon the site history, observation of the samples in the field, odor, and photoionization-detector readings.

If the site is known to have produced high-concentration samples in the past or the sampler suspects that high concentrations of contaminants might be present in the samples, then the sampler should conservatively assume that the samples cannot be classified as low-concentration. Samples that are anticipated to have medium to high concentrations of constituents should be packaged and shipped following procedures for dangerous-goods shipping specified by the intended shipper (e.g., Federal Express).

III. Equipment and Materials

- Coolers
- Clear tape
- "This Side Up" labels
- "Fragile" labels
- Ziplock bags or bubble wrap
- Ice
- Chain-of-Custody form (completed)
- Custody seals

IV. Procedures and Guidelines

A. Low-Concentration Samples

1. Prepare coolers for shipment:

    - Tape drains shut.

- Affix "This Side Up" labels on all four sides and "Fragile" labels on at least two sides of each cooler.
- Place mailing label with laboratory address on top of coolers.
- Fill bottom of coolers with about 3 inches of bubble wrap.

2. Arrange decontaminated sample containers in groups by sample number. Consolidate VOC samples into one cooler to minimize the need for trip blanks.
3. Affix appropriate adhesive sample labels to each container. Protect with clear label protection tape.
4. Seal each sample bottle within a separate ziplock plastic bag or bubble wrap, if available. Tape the bag around bottle. Sample label should be visible through the bag.
5. Arrange sample bottles in coolers so that they do not touch.
6. If ice is required to preserve the samples, cubes should be repackaged in zip-lock bags and placed on and around the containers.
7. Fill remaining spaces with bubble wrap.
8. Complete and sign chain-of-custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or the courier.
9. Close lid and latch.
10. Carefully peel custody seals from backings and place intact over lid openings (right front and left back). Cover seals with clear protection tape.
11. Tape cooler shut on both ends, making several complete revolutions with strapping tape. **Do not** cover custody seals.
12. Relinquish to Federal Express or to a courier arranged with the laboratory. Place airbill receipt inside the mailing envelope and send to the sample documentation coordinator along with the other documentation.

B. Medium- and High-Concentration Samples:

Medium- and high-concentration samples are packaged using the same techniques used to package low-concentration samples, with several additional restrictions. The sample handler must refer to instructions associated with the shipping of dangerous goods for the necessary procedures for shipping by Federal Express or other overnight carrier.

V. Attachments

None.

VI. Key Checks and Items

- Be sure laboratory address is correct on the mailing label
- Pack sample bottles carefully, with adequate bubble wrap or other packaging and without allowing bottles to touch
- Be sure there is adequate ice
- Include chain-of-custody form
- Include custody seals

STANDARD OPERATING PROCEDURE H-10

Equipment Blank and Field Blank Preparation

I. Purpose

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

II. Scope

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

III. Equipment and Materials

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

IV. Procedures and Guidelines

A. Decontaminate all sampling equipment that has come in contact with sample according to SOP *Decontamination of Personnel and Equipment.*

B. To collect an equipment blank for volatile analysis from the surfaces of sampling equipment other than pumps, pour blank water over one piece of equipment and into two 40-ml vials until there is a positive meniscus, then seal the vials. Note the sample number and associated piece of equipment in the field notebook as well as the type and lot number of the water used.

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

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

C. When collecting an equipment blank from a pump, run an extra gallon of deionized water through the pump while collecting the pump outflow into appropriate containers. Make sure the flow rate is low when sampling VOCs. If a Grundfos Redi-Flo2 pump with disposable tubing is used, remove the disposable tubing after sampling but before decon. When decon is complete, put a 3- to 5-foot segment of new tubing onto the pump to collect the equipment blank.

D. To collect a field blank, slowly pour ASTM Type II water directly into sample containers.

E. Document and ship samples in accordance with the procedures for other samples.

F. Collect next field sample.

V. Attachments

None.

VI. Key Checks and Items

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

STANDARD OPERATING PROCEDURE H-11

Civil Surveying

I. Purpose and Scope

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

II. Records and Definitions

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

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

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

III. Surveying

A. Horizontal Survey

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

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

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

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

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

B. Vertical Survey

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

- Instruments shall be pegged weekly or after any time it is dropped or severely jolted.

- Foresight and backsight distances shall be reasonably balanced and shall not be greater than 250 feet in length.
- No side shot shall be used as a beginning or ending point in another level loop.
- Rod readings shall be made to 0.01-foot and estimated to 0.005-foot.
- Elevations shall be adjusted and recorded to 0.01-foot.

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

C. Traverse Computations and Adjustments

Traverses will be closed and adjusted in the following manner:

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

D. Level Circuit Computations and Adjustments

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

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

E. Piezometer and Monitoring-Well Surveys

Piezometer and monitoring-well locations will be surveyed only after the installation of the protective casing, which is set in concrete. The horizontal

plane survey accuracy is ± 0.05-foot and is measured to any point on the protective-casing cover. The vertical plane survey must be accurate to ±0.01-foot. The following two elevations will be measured at piezometers and monitoring wells:

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

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

Grid Surveys

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

Exhibit A
STANDARDS FOR MODIFIED THIRD-ORDER PLANE SURVEYS

Traverse	
Max Number of bearing courses between azimuth checks	30
Astronomical bearings: standard error of results	6"
Azimuth closure at azimuth checkpoint not to exceed	20" $\sqrt{N}$
Standard error of the mean for length measurements	1 in 50,000
Position closure per loop in feet before azimuth adjustment	1:10,000
Leveling	
Levels error of closure per loop in feet	0.05 $\sqrt{M}$

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

STANDARD OPERATING PROCEDURE H-12

MEC Avoidance Procedure

I. Purpose and Scope

This document represents CH2M HILL's Standard Operating Procedures for MEC Avoidance. These policies and procedures are not all inclusive nor are they applicable in all situations. This SOP is not a stand-alone document and is to be used together with Work Plans (WP), other CH2M HILL SOPs, the Health and Safety Plan (HSP), applicable Federal, State, local regulations, and contract restrictions and guidance. MEC avoidance will be accomplished in areas that are suspected to contain UXO.

II. MEC/UXO Basic and General Safety Precautions

These basic safety precautions are the minimum MEC safety requirements required of all personnel on site. Other precautions and requirements are in other applicable MEC manuals.

Basic Considerations

The following should be taken into consideration when planning or conducting MEC avoidance support operations:

- SAFETY IS PARAMOUNT;
- Do not move or disturb unidentified items;
- Do not collect souvenirs;
- Do not smoke except in designated areas;
- Do not carry fire or spark producing devices into the site;
- All MEC operations will use the "Buddy" system;
- Prohibit non-essential personnel from visiting the site;

MEC Avoidance for Sampling and Drilling Operations

MEC avoidance operations may be required in support of soil sampling operations and the drilling of monitoring wells. Avoidance operations will consist of a team composed of two UXO qualified personnel. The team will consist of a UXO Technician III and a UXO Technician II or UXO Technician I. All MEC contacts and suspected MEC anomalies will be reported to the project manager who will in turn notify the onsite Safety Representative or local Explosive Ordnance Disposal (EOD) unit. The UXO Technicians will not physically interact with any known or suspected

MEC. The intent of the MEC Avoidance procedure is to ensure that project field task, typically the collection of environmental samples, can be completed without the unexpected encounter of MEC by field personnel.

Access Routes to Sampling Locations

Prior to sampling or well drilling crews going on site, the MEC team will conduct a reconnaissance of the sampling area. The reconnaissance will include locating the designated sampling or drilling location and insuring that it is free of anomalies. If anomalies are detected the point will be relocated as directed in the Work Plan. Once the designated point has been cleared, an access route for the sampling crews, vehicles and equipment will be cleared. The access route, at a minimum, will be twice the width of the widest vehicle and the boundaries will be clearly marked to prevent personnel from straying into un-cleared areas. If surface MEC is encountered, the MEC team will mark and report the item, and divert the approach path around the MEC. A magnetometer will be used to ensure there are no subsurface MEC within the approach path. If a subsurface magnetic anomaly is encountered, it will be assumed to be a possible MEC and the path diverted to avoid it.

Soil Sampling and Well Drilling Sites

The MEC team will clear a work site for soil samples and well drilling and clearly mark the boundaries. The area will be large enough to accommodate the drilling equipment and provide a work area for the crews. As a minimum, the cleared area will be a square, with a side dimension equal to twice the length of the largest vehicle or piece of equipment for use on site. If a pre-selected area indicates magnetic anomalies, a new sampling/drilling site will be chosen.

Avoidance Procedures for Borehole Sampling

If surface samples are required they will be obtained prior to the start of boring. The borehole procedures will be completed using a hand auger, powered auger or Direct Push Technology (DPT) equipment. The MEC Team will check the borehole with a down-hole magnetometer, from the surface at a minimum of every two feet, which will clear up to four feet below the last disturbed soil during each magnetometer survey. This will ensure a cleared zone of at least 2- feet below the split spoons, or augers during the 2 foot interval advancement. At each boring the minimum sampling depth for this survey procedure will be six feet below land surface to ensure that smaller items of MEC, undetectable from the surface, will be detected.

- **Hand Auger Procedures:** The hand auger will be advanced to the first sampling depth and the auger will be withdrawn. A clean auger bucket will be attached to the handle, returned to the borehole and a sample taken. At this point the MEC Team will check the borehole with a magnetometer and if no magnetic anomalies are found, the procedure repeated to obtain the required samples.

- **Power Auger Procedures:** The power auger will be advanced to the first sampling depth and the auger will be withdrawn. A clean hand auger will then be used to obtain the sample. The MEC Team will check the borehole with a

magnetometer and if no magnetic anomalies are found, the procedure repeated to obtain the required samples.

- **DPT Procedures:** The DPT rig will be positioned over the sampling point and the sampling completed to a maximum depth of two feet. The DPT rig will then move a minimum of 20 feet away from the sampling point to prevent the rig from influencing the magnetometer. The MEC Team will then check the borehole with a magnetometer and if no magnetic anomalies are found, the procedure repeated to obtain the required samples.

Avoidance Procedures for Monitoring Well Installation

Prior to drilling equipment being moved to the proposed site, the MEC team will have checked the designated site, using a magnetometer; to assure that the well location is anomaly free from the surface to a depth of two feet below land surface. If surface samples are required they will be obtained prior to the start of drilling. To complete the subsurface magnetometer checks, one of two methods may be used:

- Monitoring, at two-foot increments, during the actual well drilling operation. This will require the withdrawal of the drill rod or augers from the well and moving the drill rig a minimum of 20 feet away from the well location to prevent the rig from influencing the magnetometer, or

- Installing an offset monitoring hole within two feet of the well location. This monitoring hole can be installed by the MEC Team, with a hand or power auger, and monitored prior to the soil being disturbed at two-foot increments to the desired well depth or a minimum of six feet. This will then allow uninterrupted well installation and/or sampling to continue.

MEC Avoidance and Construction Support

MEC avoidance support normally consists of a two-man team consisting of a UXO Technician III (Team Leader) and a UXO Technician II. At sites where the expectation of encountering MEC is low the MEC support may only consist of the UXO Technician III as MEC safety escort. The intent of MEC avoidance is to detect and avoid MEC and UXO. The following paragraphs outline minimum procedures for the designated operations.

Location Surveys and Geophysical Escort

MEC escort for survey and geophysical operations consists of a visual surface search for MEC. Any UXO or MEC encountered will be marked, avoided, and reported to the appropriate authorities. Prior to driving stakes for grid corners or installing monuments the UXO Technician will search the location with a magnetometer. Any subsurface anomaly will be assumed to be MEC and an anomaly-free location chosen.

Trenching and Pit Excavations

Prior to trenching or excavation crews going on site, the MEC team will conduct a reconnaissance of the approach route to the site. The reconnaissance will include locating a clear path for the crews, vehicles and equipment. The approach path, at a minimum, will be twice the width of the widest vehicle. The boundaries of the

approach path will be clearly marked to prevent personnel from straying into un-cleared areas. If MEC is encountered, the MEC team will mark and report the item, and divert the approach path around the MEC. Personnel will be instructed to remain within the marked boundary limits. A magnetometer or appropriate geophysical instrument along with a visual survey will be used to search for surface and near surface anomalies within the approach path. If a magnetic anomaly is encountered, it will be assumed to be a possible MEC, it will be marked, the approach path diverted, and reported.

Excavation

During excavation operations the UXO Technician(s) will position themselves near (outside the reach of the swing) the earth moving machinery (EMM) (backhoe) where they can observe the excavation. If UXO or MEC is spotted the UXO Technician will signal the EMM operator to stop digging, move the bucket and place it on the ground outside the trench, and remove his hands from the controls. The UXO Technician will then investigate the MEC.

Heavy Equipment Operation

Heavy equipment safety will be in accordance with the SSHP.

Excavation Safety

Excavation safety will be in accordance with the SSHP.

Equipment

The minimum equipment requirements for this activity include:

- Level D PPE;
- EMM, (trenching & excavation);
- Schonstedt GA-52CX Magnetometer;

Table 1: Color Codes, MEC Avoidance

Color	*Used to Mark*
Red Pin Flag/Caution Tape	*Danger, identified suspect MEC/UXO, special precaution required*
White Pin Flag	*Boundary or temporary marker*
Green Paint	*Marking MEC-related scrap*

III. Guidance and References

The following are applicable guidance and references that are to be followed;

- EP 385-1-95a, Basic Safety Concepts and Considerations for Ordnance and Explosives Operations;
- EP 75-1-2, UXO Support during HTRW and Construction Activities;
- USA Safety and Health Program (SHP);
- OSHA, 29 CFR 1910, Occupational Safety and Health Standards;
- OSHA, 29 CFR 1926, Construction Standards;
- Applicable sections of EPA, 40 CFR Parts 260 to 299, Protection of Environment;
- Applicable sections of DOT, 49 CFR Parts 100 to 199, Transportation;
- USACE EM 385-1-1, Safety and Health Requirements Manual;
- USACE ER 385-1-92, Safety and Occupational Health Document Requirements for Hazardous Waste Remedial Actions;
- DoD 4145.26-M, Contractors' Safety Manual for Ammunition and Explosives;
- DoD 6055.9-STD, DoD Ammunition and Explosives Safety Standards;
- DoD 4160.21-M, Defense Reutilization and Marketing Manual;
- DA PAM 385-64, Ammunition and Explosives Safety Standards;
- AR 385-64, Ammunition and Explosives Safety Standards;
- AR 200-1, Environmental Protection and Enhancement;
- AR 385-10, The Army Safety Program;
- AR 385-16, System Safety Engineering and Management;
- AR 385-40 w/USACE supplement, Accident Reporting and Records;
- TM 9-1300-200, Ammunition General;
- TM 9-1300-214, Military Explosives;
- TM 60 Series Publications;
- CH2M HILL SOPs.

STANDARD OPERATING PROCEDURE H-13

MEC Avoidance during Vegetation Clearing

I. Purpose and Scope

This document represents CH2M HILL's Standard Operating Procedures for MEC Avoidance during Vegetation Clearing. These policies and procedures are not all inclusive nor are they applicable in all situations. This SOP is not a stand-alone document and is to be used together with Work Plans (WP), other CH2M HILL SOPs, the Health and Safety Plan (HSP), applicable Federal, State, local regulations, and contract restrictions and guidance. MEC avoidance will be accomplished in areas that are suspected to contain UXO.

II. PERSONNEL PROTECTIVE EQUIPMENT (PPE)

Level D PPE is required for all personnel engaged in Vegetation Removal Operations. Clothing includes but is not limited to:

- Coveralls or work clothing as prescribed;
- Work gloves, leather or canvas as appropriate;
- Safety Glasses;
- Hard Hats;
- Hearing protection, noise attenuators or ear plugs;
- Dust mask, as required by wind conditions and/or the presence of airborne particulate matter;
- Other PPE as needed. (i.e.; face shield, chainsaw chaps, etc.).

III. TEAM COMPOSITION

The Vegetation Removal Team will consist of three (3) qualified personnel as a minimum. These include:

- UXO Technician III;
- UXO Technician II or I; or
- Laborers.

UXO Technician III

The UXO Technician III is UXO qualified and directs the operation and other team personnel within the context of removal requirements. The UXO Technician III must be familiar with the equipment being utilized.

Operator or Laborer

The operator(s) will be qualified and trained on the equipment being utilized (i.e. chainsaw, weed eater, etc) and operate the equipment in a safe and efficient manner. The operator performs daily inspections and maintenance functions as required by the operator's manual. The operator will perform other duties as needed or directed.

IV. SAFETY

Safety is paramount, all personnel will observe those safety precautions/warnings that apply or may apply to vegetation removal operations. Those listed below are general in nature and personnel will need to review applicable publications for more specific safety precautions/warnings. Distances are the minimum required and will be adjusted as required by the specific MEC at the project site.

- Maintain 200 feet minimum from other teams;
- Distances may be increased by the as determined by site history, UXO items encountered, terrain features and other factors that may apply;
- Use equipment safety features;
- Safety precautions/warnings found in the operators manual/manufactures publications will be observed;
- Maintain 6 inches of ground clearance during removal operations;
- Communications will be maintained between the Team Leader and Operator(s) at all times;
- Maintain site control;
- Observe UXO safety precautions for items encountered or suspected;
- Ensure PPE is appropriate, serviceable and worn/used in a proper manner.

V. OPERATIONAL PROCEDURES

Personnel will not access the area within 10 feet of an operating piece of equipment. If at any time personnel enter closer than 10 feet the Operator will immediately stop, return the engine to idle speed and cease operations. A communications check with the all team personnel, prior to operations commencing, will be conducted. Hand signals will be devised and used as a means of communication. All team personnel must know these hand signals prior to operations commencing. This will be documented on the tailgate safety-briefing sheet each morning of operation and at each change of team personnel.

The UXO Technician III will direct the direction and manner in which the vegetation is to be removed. Prior to removal operations commencing a visual search/survey is conducted to determine the hazards that may be encountered including UXO, terrain slope, vegetation, wildlife, environmental concerns and PPE requirements. The UXO Technician III will perform a visual search for UXO, ordnance scrap, surface debris and any other obstruction/object that may pose a hazard to team personnel. Hazardous items, impassable terrain or vegetation that may effect operations will be marked and team personnel notified.

Team personnel are to ensure that a 6-inch ground clearance is maintained during removal operations. Those areas marked as hazards are to be avoided. The manner in which operations are accomplished will follow safe work practices and procedures. Areas of concern will be addressed to the Project Manager or to a SUXOS and/or UXOSO if present at other project sites on the former VNTR. .. MEC/UXO items encountered are marked and avoided. Notification of these items will be made to the appropriate personnel.

VI. Guidance and References

The following are applicable guidance and references, that are to be followed;

- CH2M HILL Health and Safety Plan. (HSP);
- Site Specific Health and Safety Plan (SSHSP);
- Occupational Safety and Health Administration (OSHA) Regulations;
- U.S. Army Corp of Engineers (USACE), EM 385-1-1;
- Operators Manual(s) and Manufactures Publications

STANDARD OPERATING PROCEDURE H-14

Downhole Geophysical Logging

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for methods of downhole geophysical logging that are commonly used in investigations. The methods covered in this procedure are: fluid resistivity, temperature, caliper, brine tracing, and video. Such methods as natural gamma, spontaneous potential, electric resistivity of geologic materials, and flow logging are not covered.

Downhole geophysical logging normally is subcontracted to professionals who are experienced, and their expertise should be relied upon. The procedure focuses on key aspects of the work that should be observed and documented.

II. Equipment and Materials

- Caliper logging tool
- Temperature logging tool
- Fluid resistivity logging tool
- Brine injection apparatus
- Fluid conductivity logging tool
- Video-camera logging tool
- Decontamination materials

III. Procedures and Guidelines

A. Fluid-Resistivity Logging

Fluid-resistivity logging provides a measurement of the resistivity of the borehole fluid between closely spaced electrodes in the probe. Abrupt and significant changes in fluid resistivity in the borehole may indicate the entry of groundwater of differing resistivity into the borehole via fractures and other openings in the geologic materials surrounding the borehole. The logging record is taken continuously in units of ohm-meters.

Fluid-resistivity logging should be run at slow speeds to assure the proper flow of water through the tool. As long a time as possible should be allowed between drilling and logging the borehole so that the fluid resistivity can equilibrate between borehole and surrounding geologic materials. The fluid-resistivity log should be one of the first logs run because other logging methods will disturb the water in the borehole.

The logging equipment should be adequately decontaminated before the first use on the site and between boreholes.

B. Temperature Logging

Temperature logs are the continuous records of the temperature of the water in a borehole. They can provide information on the source and movement of groundwater into and out of the borehole. Generally the temperature of the groundwater in the borehole will increase with depth with the geothermal gradient. Deviations from this general trend may indicate where groundwater is flowing up, down, into, or out of the borehole.

All temperature sensors have an inherent response lag, or time constant, so that the logging speed must be constant and slow enough that the temperatures are accurately reflected at the true depths on the log. The temperature log may be made using the same tool as the fluid-resistivity log. As long a time as possible should be allowed between drilling and logging the borehole so that the temperature can equilibrate between borehole and surrounding geologic materials. The temperature log should be one of the first logs run because other logging methods will disturb the water in the borehole.

The logging equipment should be adequately decontaminated before the first use on the site and between boreholes.

C. Caliper Logging

The caliper log is a record of the average diameter of the borehole. Caliper logs primarily are run to determine where fractures or other openings might intersect the borehole and whether or not squeezing or other effects may have reduced the diameter of the borehole.

A caliper log featuring arm-type devices is preferable to one featuring bow springs because of greater sensitivity of the arms. Logs should have at least 1 inch of chart width per inch of hole diameter to provide adequate sensitivity of recording. Several feet of casing should be logged so that the accuracy of the tool can be checked.

The logging equipment should be adequately decontaminated before the first use on the site and between boreholes.

D. Brine Tracing

Brine tracing is used to measure natural or artificially induced flow within a borehole. Data on borehole flow is related to well construction, vertical differences in hydraulic head within the open or screened interval in the well., and the relative magnitude or permeability of the water-bearing units open to the well. A slug of high-conductivity tracer such as a high concentration of sodium chloride is injected into the water column in the well and the movement of the slug is measured with a fluid-conductivity detector and timed. The depth at which any significant changes in brine concentration is noted that might indicate that the tracer is moving out of the borehole, or is suddenly diluted by groundwater moving into the borehole.

The assumption is that the tracer is in a solution that has a greater density than the water in the borehole. Therefore, the tracer typically is injected at the top of the water column. The tracer is sinking on its own due to the difference in density between the

tracer and the groundwater in the borehole; therefore, the rate of movement of the traces should not necessarily be considered the rate of vertical flow in the borehole. The dilution and movement are monitored by moving the detector slowly up and down through the tracer. Care is required so that the movement of the detector does not cause excessive spreading of the tracer; this effect can be minimized by using the smallest-diameter probe available.

The logging equipment should be adequately decontaminated before the first use on the site and between boreholes.

E. Video Logging

Video logging provides a real-time and recorded image of the actual conditions in the borehole. The video log typically is used to identify the depths of fractures and other openings in the borehole.

The log should be run at a sufficiently slow speed that features can be accurately recorded. The field geologist, if possible, should observe the logging image so that the operator can be directed to stop or reduce logging speed at any critical locations, such as intervals where flow may be occurring as indicated by the movement of particles in the borehole. If a nonaqueous phase liquid (NAPL), particularly one that floats on the surface, is present in the borehole, the image may be so deleteriously affected that the NAPL may have to be removed from the borehole before logging can be completed. The field geologist should obtain a copy of the video in VHS format while the operator is still in the field.

The logging equipment should be adequately decontaminated before the first use on the site and between boreholes.

IV. Attachments

- None

V. Key Checks and Preventive Maintenance

- Ensure that subcontractor follows their procedures, particularly those for calibration of the instruments and the rate of logging.
- Obtain copies of logs at the site.
- Temperature and fluid-resistivity logs should be run first so that the disturbance caused by the other logging methods does not disrupt the results of these two methods.
- Adequate development of the well is important so that fluids such as drilling mud that may have been used in the borehole do not provide false readings of changes in fluid resistivity.
- Decontaminate as necessary.

ATTACHMENT 2

Health and Safety Plan

CH2M HILL SAFETY AND HEALTH PLAN

(REFERENCE CH2M HILL SOP HSE&Q-220, *WRITTEN PLANS*)

This Safety and Health Plan will be kept on the site during field activities and will be reviewed as necessary. The plan will be amended or revised as project activities or conditions change or when supplemental information becomes available. The plan adopts, by reference, the Standards of Practice (SOPs) in the CH2M HILL *Corporate Health and Safety Program, Program and Training Manual*, as appropriate. In addition, this plan adopts procedures in the project Work Plan. The Site Safety Coordinator (SSC) is to be familiar with these SOPs and the contents of this plan. CH2M HILL's personnel and subcontractors must sign Attachment 1.

Project Information and Description

PROJECT NO: 180357 and 183719

CLIENT: United States Navy

PROJECT/SITE NAME: Former Naval Ammunition Support Detachment (NASD) and former Vieques Naval Training Range (VNTR), Puerto Rico

SITE ADDRESS: Vieques Island, Puerto Rico

CH2M HILL PROJECT MANAGER: Brett Doerr

CH2M HILL OFFICE: Virginia Beach, Virginia

DATE SAFETY AND HEALTH PLAN PREPARED: April 7, 2006

DATE(S) OF SITE WORK: April 2006 to April 2010

SITE ACCESS: All subject sites are located on Vieques Island, Puerto Rico.

Site Topography

The regional topography of Vieques consists generally of hills and valleys throughout the entire island. The western side of the island consists of gently rolling hills with a deeper soil profile than the eastern side's more exposed rugged terrain. The highest point on the western side of the island is found at Monte Pirate with an elevation of 1,000 feet, while the highest point on the eastern side is found at Cerro Matias with an elevation of 420 feet. The coastal areas have topography distinct from the inland terrain described above, with level terrain made up primarily of lagoons and mangrove swamps.

Prevailing Weather

The climate of Vieques is characterized as warm and humid (tropical-marine), with frequent showers occurring throughout the year. The temperature on Vieques is affected by the easterly trade winds blowing across the island year-round. This wind moderates the temperature throughout the year, causing an annual mean temperature of 77.9°F. The average annual rainfall on the island is approximately 36 inches, with extremes being 25 inches in the east and 45 to 50 inches in the west.

Site Description and History

The U.S. Navy previously occupied approximately 22,600 acres of the roughly 33,000 acres making up Vieques Island. The 22,600 acres include the following: the former Naval Ammunition Support Detachment (NASD), consisting of 8,000 acres along the westernmost tip of the island; the Eastern Maneuver Area (EMA), consisting of 11,000 acres located in the east-central portion of the island; and the Vieques Naval Training Range (VNTR), consisting of 3,600 acres along the eastern portion of the island. The EMA and VNTR are known as the Inner Range and extend to a limit of 3 miles from the shoreline. The area known as the Air Impact Area (AIA) is located within the VNTR, and was primarily used for gunfire and ordnance delivery training activities.

Vieques lies roughly 7 miles southeast of Naval Activity Puerto Rico (NAPR), formerly referred to as U.S. Naval Station Roosevelt Roads (NSRR), Puerto Rico. Figure 1-1 is a location map showing the location of Vieques relative to the island of Puerto Rico. The areas mentioned above function under the command of Commander Fleet Air Caribbean and Naval Forces Caribbean, with headquarters located at NAPR. Although the former NASD is on Vieques Island, this area is not part of the Facility under the Resource Conservation and Recovery Act (RCRA) (USEPA, Region II). The jurisdiction over scheduling all naval exercises in the Inner Range is the responsibility of the commanding officer of VNTR.

The U.S. Navy acquired approximately 79 percent of this island during World War II with the intention of building a base for allied fleets. Prior to 1971, the U.S. portion of the island was only used for small-scale artillery training. The main targets for the ship-to-shore and air-to-ground training were on the island of Culebra, approximately 9 miles north of Vieques. After 1971, all artillery training previously located on Culebra was aimed at targets on Vieques Island. The primary missions carried out today in the Inner Range portion of this installation include the Atlantic Fleet's ships, aircraft and marine forces, which carry out training in naval gunfire support (NGFS), air-to-ground (ATG) ordnance delivery, air-to-surface mine delivery, amphibious landings, small arms, artillery and tank fire, and combat engineering. No industrial or process operations are present in this area. Waste generated at the VNTR is from the maintenance of vehicles and equipment. This waste includes oils, lubricants, solvents, paints, batteries, and battery acid. These are disposed of offsite. The AIA portion of the Inner Range is used for treatment of retrograde (unserviceable) ordnance, which are classified as hazardous and regulated as a RCRA waste. These wastes are treated through open burning/open detonation (OB/OD) processes.

SWMU and AOC Descriptions for east (Former VNTR) and west (Former NASD)

Eastern Vieques Sites

Environmental Sites

This subsection provides a description of the 12 environmental sites (Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs)) that are currently undergoing investigations through the RCRA Facility Investigation (RFI) process, and the PI and PAOC sites that have been identified.

A Phase I RFI was conducted for the 12 SWMUs and AOCs and the Draft Phase I RFI Report was prepared (CH2M HILL, June 2004). Because several of the potential inorganic constituents (also referred to as metals) detected in site-specific soil samples are also commonly occurring in nature, a draft work plan for a background investigation of soil inorganics (CH2M HILL, March 2005) has been prepared and submitted for review. The results of this background investigation will be used to assess if the inorganic constituent levels detected in the site-specific soils are consistent with background conditions or indicative of releases from historical waste management activities.

The general locations of the 12 sites investigated during the Phase I RFI are shown in Figure 1-2 and brief descriptions of each are presented in Table 1. More detailed descriptions are presented below.

Sites that were identified as potential sites (i.e., PIs and PAOCs), based on analysis of facility records and aerial photo analysis during the Phase I RFI Work Plan development and the EBS (NAVFACENGCOM, April 2003), are not described in detail within this section. However, brief descriptions of these sites are provided in Table 1. Final determination of the need for further action and, if applicable, the scope of that further action, at each PI/PAOC site is currently under discussion among the stakeholder agencies.

SWMU-1 – Camp Garcia Landfill

According to the Navy Assessment and Control of Installation Pollutants (NACIP) Initial Assessment Study (IAS) Report, this SWMU was in operation from approximately 1954 to 1978 (Greenleaf/Telesca, 1984). While this SWMU was operational, it was an unlined landfill that was used to dispose of paper, corrugated containers, cans and food packaging material, rags, scrap metal, and yard waste. Municipal waste from both Camp Garcia and other areas of the VNTR was handled here. The SWMU 1 area, the Camp Garcia area, and the former VNTR are shown in Figure 1-2. Approximately 1,800 to 3,120 tons of waste were disposed of in the landfill, as noted in the IAS (Greenleaf/Telesca, 1984).

During operation of the landfill, the trench method of disposal was employed and land clearing was kept to a minimum to avoid erosion problems at the site. A bulldozer was used to dig a trench into which materials were disposed. The trench was then covered with about 6 inches of soil to control blowing of litter. The landfill was closed in 1978 and a 2 foot thick soil cover was placed over the landfill.

The landfill managed waste from a maximum of approximately 150 individuals, depending on military exercises. An aerial photo analysis of the landfill indicated that the fill area extended over an area of approximately 50 acres (Lockheed Martin, 1999). The landfill is currently vegetated with dense grasses and trees. A gravel road was constructed down the center of the landfill in the mid-1980s. During the visual site inspection (VSI), no signs of erosion or stresses on vegetation were observed (PREQB-Vargas, 1995). No documentation was found regarding releases of hazardous constituents from the landfill. Several areas of debris (fill material) were observed in 2004 during the clearing of transects for the Phase I RFI. Debris observed included galley (kitchen) waste (cans, bottles, forks, knives), metal pipes, and a small metal tank.

Information regarding the nature and extent of potential contamination at SWMU 1 can be found in the Draft Phase I RFI Report (CH2MHILL, June 2004). A background study will be

accomplished to provide background soil inorganics data to compare with site specific data, and then a recommendation of whether additional data are necessary or sufficient data exist to perform risk assessments. Background data will not be used to eliminate constituents from the quantitative risk assessments, but will be used to help determine when the nature and extent of inorganic constituents have been adequately delineated.

Additional investigation is recommended in the Draft Phase I RFI Report to further define the extent of the northern and southern boundaries of the landfill, as identified by the geophysical data collected at SWMU-1. The scope of this activity, as well as any other action necessary, will be determined following the completion of the background investigation.

SWMU-2 – Fuels Off-Loading Site

SWMU-2 is located in the Camp Garcia area, and is the former location of four aboveground fuel storage tanks. The tanks consisted of two 20,000-gallon tanks, and two 30,000-gallon tanks. These tanks became operational in 1953 and were removed between 1978 and 1979. The refueling process took place every 3 months, and consisted of pumping fuel through an 8-inch submarine line to each of these tanks from a barge. Prior to initiating this refueling process, seawater had to be flushed from the submarine line. The following fuel types were stored at this site during the operational period: diesel fuel, unleaded gasoline, aviation gas (AVGAS), and jet propellant (JP)-5 fuel. The sludge that developed in these tanks was removed by a private contractor to be disposed of on the main island.

The site is overgrown with grass and small shrubs, with only minimal signs of previous activity. During the VSI, there were no signs of previous releases to either the soil or the water, but no release controls were identified (PREQB-Vargas, 1995). During the site visit conducted on February 2, 2000, no signs of the tanks or piping were present. Only the steel supports for the pipeline for the loading area were present.

Information regarding the nature and extent of potential contamination at SWMU 2 can be found in the Draft Phase I RFI Report (CH2MHILL, June 2004). The soil inorganics data from the background investigation will be compared to the soil inorganics concentrations detected at SWMU 2 to assess whether the constituent concentrations exceeding the screening levels are site-related or consistent with background conditions. Should the levels exceed background levels, the data will be assessed to determine whether additional site-specific data are necessary or whether sufficient data exist to make a no further action determination for the site. The scope of this activity, as well as any other action necessary, will be determined following the completion of the background investigation.

SWMU-4 - Waste Areas of Building 303

Building 303 was established as a storage area at Camp Garcia for batteries when it was erected in the 1960s. The SWMU 4 waste areas located in Building 303 comprised a spent battery accumulation area; a catch basin for hydraulic oil; a cleaning/decreasing basin; and a rags, absorbent, and grease storage area, which were designated as AOCs C, D, and E, respectively, per the classifications in the 1988 RCRA Facility Assessment (RFA) (A.T. Kearney, 1988) and the 1995 Revised RFA (PREQB-Vargas, 1995) reports. The 1988 RFA and the PREQB revised RFA Report both recommended no further action for all four sites included as SWMU 4.

The 1988 RFA Report referred to the spent battery accumulation areas as being inside Building 303, where batteries and battery acid were stored prior to disposal offsite on Naval Station Roosevelt Roads (NSRR). The acid from spent batteries was stored in a plastic container prior to offsite shipment. Facility personnel stated that this was also the approximate area where spent batteries were stored. During the VSI, there were no batteries/acid at this location (PREQB-Vargas, 1995). This area contained no visible signs of leakage on the concrete floor from previous storage of these materials.

The catch basin for hydraulic oil, approximately 5 feet long and 6 inches wide, is an area inside Building 303 designed to catch any hydraulic oil that may have dripped from the tanks above. During the VSI, there were no signs of leakage on the cement floor under the basin (PREQB-Vargas, 1995).

The cleaning basin was a square metal container, approximately 24 inches long, 18 inches wide, and 12 inches deep, used to hold solvents for the cleaning and degreasing of parts. The unit was formerly located inside Building 303.

The conclusion drawn from examinations of the Spent Battery Accumulation Area was that the potential for migration of waste or accumulated liquids to the soil, groundwater or surface water is very low, as stated in the PREQB 1995 revised RFA Report. During the 1995 revised RFA, no batteries or acid were present at this location, nor were there visible signs of acid leakage on the concrete floor from previous storage of these materials.

The exposure potential from this SWMU is considered minimal, as stated in the PREQB 1995 revised RFA Report. Another site visit was conducted February 2000 during which no staining or signs of contamination were observed on the concrete floor.

An additional building adjacent to Building 303 was identified in 2000. This building was used as a battery accumulation area and was designated as "Corrosive Materials Storage." In the past it contained spent batteries and battery acid. Another small building was identified adjacent to Building 303, and was designated as "Flammable Storage." It had been used for the storage of rags, adsorbent material, and grease contained in barrels.

Information regarding the nature and extent of potential contamination at SWMU 4 can be found in the Draft Phase I RFI Report (CH2MHILL, June 2004). The soil inorganics data from the background investigation will be compared to the soil inorganics concentrations detected at SWMU 4 to assess whether the constituent concentrations exceeding the screening levels are site-related or consistent with background conditions. Should the levels exceed background levels, the data will be assessed to determine whether additional site-specific data are necessary or whether sufficient data exist (including data for the other constituents detected [e.g., SVOCs] to assess potential ecological and human health risks. The scope of this activity, as well as any other action necessary, will be determined following the completion of the background investigation.

SWMU-5 - Spent Battery Accumulation Area

This SWMU is located in the Inner Range portion of Observation Post 1 (OP-1) and is similar to SWMU 4. However, the batteries and battery acid were stored outside on a gravel driveway. According to the PREQB 1995 revised RFA Report, the acid from these batteries was typically emptied into plastic containers and shipped to NSRR. During the VSI, there

were nine batteries stored at this site on the gravel driveway. There were no signs of any spills or leaks from these batteries, but no release controls were identified at this SWMU (PREQB - Vargas, 1995).

Based on the site visit conducted on February 2, 2000, release controls (plastic storage trays) for battery storage were in place, but no batteries were present. Although the startup date for SWMU 5 is unknown, the SWMU remained active through May 2003. During the January 2004 site visit, no signs of activity were evident at SWMU 5. No batteries were observed at the site. The plastic trays observed in 2000 had been removed as part of the closure of the former VNTR.

Information regarding the nature and extent of potential contamination at SWMU 5 can be found in the Draft Phase I RFI Report (CH2MHILL, June 2004). The soil inorganics data from the background investigation will be compared to the soil inorganics concentrations detected at SWMU 5 to assess whether the constituent concentrations exceeding the screening levels are site-related or consistent with background conditions. Should the levels exceed background levels, the data will be assessed to determine whether additional site-specific data are necessary or whether sufficient data exist to make a no further action determination for the site. The scope of additional investigations at this site, as well as any other action necessary, will be determined following the completion of the background investigation.

SWMU-6/7 - Waste Oil and Paint Accumulation Area

The PREQB 1995 revised RFA Report indicates that this area was used by the Seabees as a storage area for waste oil and paint. The waste oil at this location was containerized in 55-gallon drums, and the paint was stored in small containers. Tires and two drums of lubricating oil were present at this site. The waste oil and tires were temporarily stored on a grassy area awaiting shipping offsite to NSRR. The PREQB 1995 revised RFA Report states that this area became active in 1978, and was still active in 1988. During the VSI, there were visible signs of oil leakage onto the ground from the drums, and there were no release controls present (PREQB-Vargas, 1995). Based on the site visit conducted on February 2, 2000, this area was no longer active, and no waste was observed. The site consists of a concrete slab and a small chain-link cage area.

According to the 1988 and 1995 RFA Reports, SWMU 7 was another waste oil accumulation area outside Building 303 (Kearney, 1988; PREQB-Vargas, 1995). However, after interviewing onsite Navy personnel, it was determined that there was only one waste oil area; therefore, the combined area will hereafter be referred to as SWMU 6/7, a single SWMU.

Information regarding the nature and extent of potential contamination at SWMU 6/7 can be found in the Draft Phase I RFI Report (CH2MHILL, June 2004). The soil inorganics data from the background investigation will be compared to the soil inorganics concentrations detected at SWMU 6/7 to assess whether the constituent concentrations exceeding the screening levels are site-related or consistent with background conditions. Should the levels exceed background levels, the data will be assessed to determine whether additional site-specific data are necessary or whether sufficient data exist (including data for the other constituents detected [e.g., pesticides]) to assess potential ecological and human health risks.

The scope of additional investigations at this site, as well as any other action necessary, will be determined following the completion of the background investigation.

SWMU-8 – Waste Oil Accumulation Area

This particular accumulation area is located outside the generator building at OP-1 on Cerro Matias. According to the 1988 RFA Report, this area contained drums that stored both waste lubricants and oils. These drums were stored on bare soil prior to being shipped offsite to NSRR. The accumulation area began operation in approximately 1978, and was still active at the time of the 1988 RFA. During the VSI, minimal spills of lubricating oil were present in the area of the drums, but there were no release controls visible (PREQB-Vargas, 1995). Based on the site visit conducted on February 2, 2000, release controls were in place, and no leaks or spills were observed. Waste oil was stored in plastic containers and then transported to NSRR.

Information regarding the nature and extent of potential contamination at SWMU 8 can be found in the Draft Phase I RFI Report (CH2MHILL, June 2004). The soil inorganics data from the background investigation will be compared to the soil inorganics concentrations detected at SWMU 8 to assess whether the constituent concentrations exceeding the screening levels are site-related or consistent with background conditions. The scope of additional investigations at this site, as well as any other action necessary, will be determined following the completion of the background investigation.

SWMU-10 – Sewage Treatment Lagoons

According to the 1988 RFA and the PREQB 1995 revised RFA reports, the sewage treatment lagoons for Camp Garcia began service when the adjacent pump station was installed in the early 1950s. These lagoons were divided into two stages for the treatment of domestic waste. Four unlined lagoons were utilized in this process, including two that received the waste, and two that were considered polishing lagoons. Following waste treatment in the polishing lagoons, the remaining liquid was applied to land. Due to the small number of Seabees and civilians (45 people) using the sanitary facilities on a daily basis, the amount of domestic waste generated was small. There were no signs of release at this SWMU, although environmental sampling had not occurred at the time of the 1995 revised RFA (PREQB-Vargas, 1995). During the site visit conducted on February 2, 2000, the four lagoons were overgrown with vegetation and no longer active.

Information regarding the nature and extent of potential contamination at SWMU 10 can be found in the Draft Phase I RFI Report (CH2MHILL, June 2004). The soil inorganics data from the background investigation will be compared to the soil inorganics concentrations detected at SWMU 10 to assess whether the constituent concentrations exceeding the screening levels are site-related or consistent with background conditions. Should the levels exceed background levels, the data will be assessed to determine whether additional site-specific data are necessary or whether sufficient data exist (including data for the other constituents detected [e.g., pesticides]) to assess potential ecological and human health risks. The scope of additional investigations at this site, as well as any other action necessary, will be determined following the completion of the background investigation.

SWMU-12 - Solid Waste Collection Unit Area (formerly AOC B)

This area was formerly referred to as AOC B. However, according to the Consent Order, it was decided that this area should be a SWMU, and was consequently identified as SWMU 12. The collection area contained storage devices used to containerize garbage prior to its disposal at the Vieques Island landfill. The containers used to store this garbage comprised: wooden boxes, wooden trailers, and both metal dumpsters and cans. During the VSI, only a wooden trailer was visible at this site (PREQB-Vargas, 1995). During the site visit conducted on February 2, 2000, two wooden trailers were sighted; the trailers were potentially filled with garbage and parked on a bend in the road below OP 1.

Information regarding the nature and extent of potential contamination at SWMU 12 can be found in the Draft Phase I RFI Report (CH2M HILL, June 2004). The soil inorganics data from the background investigation will be compared to the soil inorganics concentrations detected at SWMU 12 to assess whether the constituent concentrations exceeding the screening levels are site-related or consistent with background conditions. Should the levels exceed background levels, the data will be assessed to determine whether additional site-specific data are necessary or whether sufficient data exist to make a no further action determination for the site. The scope of additional investigations at this site, as well as any other action necessary, will be determined following the completion of the background investigation.

AOC A – Diesel Fuel Fill Pipe Area

According to the 1988 RFA and the 1995 PREQB revised RFA reports, this area contained a pipe used to fill the underground storage tank (UST) located at OP - 1 on Cerro Matias. The UST, as well as the fill pipe, were first put into service in approximately 1978. This site contained a 6-foot by 6-foot area of soil around the fill pipe. During the VSI, this area of soil appeared to be stained with fuel from spills during previous refueling procedures. Because the tank was located 25 feet southwest and downgradient of the fill pipe, this staining did not appear to be coming from the tank. There were no release controls found at this site (PREQB-Vargas, 1995).

The UST was replaced with a new UST in 1997. The closure report indicated that four samples were collected after the lines and tank were removed. The 1997 UST replacement at the site did not indicate the presence of any petroleum-related constituents. Prior to the land transfer in April 2003, the new UST was removed and six subsurface soil samples were collected around its former location. In addition, four subsurface soil samples were collected along the bottom of the fuel line that connected the UST to a generator.

Information regarding the nature and extent of potential contamination at AOC A can be found in the Draft Phase I RFI Report (CH2MHILL, June 2004). The proposed path forward for AOC A is currently being evaluated and discussed among the stakeholder agencies.

AOC F – Rock Quarry

According to the 1988 RFA and the 1995 PREQB revised RFA reports, this site is located southwest of the former Camp Garcia landfill, where the gravel that the Navy used for roads and other construction purposes was quarried. However, during the VSI, used tires and some paper waste were visible at this location (PREQB-Vargas, 1995). During the site

visit conducted on February 2, 2000, no signs of tires or paper waste were observed. The quarry did not appear to be active.

Information regarding the nature and extent of potential contamination at AOC F can be found in the Draft Phase I RFI Report (CH2MHILL, June 2004). The soil inorganics data from the background investigation will be compared to the soil inorganics concentrations detected at AOC F to assess whether the constituent concentrations exceeding the screening levels are site-related or consistent with background conditions. Should the levels exceed background levels, the data will be assessed to determine whether additional site-specific data are necessary or whether sufficient data exist to make a no further action determination for the site. The scope of additional investigations at this site, as well as any other action necessary, will be determined following the completion of the background investigation.

AOC G – Pump Station and Chlorination Building at Sewage Lagoons

This site, which is located at Camp Garcia, became active in the 1950s. After approximately 30 years of service, this building was shut down due to the decrease in activity at the base. The main purpose of this building was to pump and chlorinate domestic waste. The building was constructed with concrete, and built partially below grade. During the VSI, stains were visible on the concrete due to previous overflowing of the unit. However, there were no signs of damage to the grassy area in general vicinity (PREQB-Vargas, 1995). During the site visit conducted on February 2, 2000, no staining was observed on the chlorination building. The site is inactive and overgrown with vegetation.

Information regarding the nature and extent of potential contamination at AOC G can be found in the Draft Phase I RFI Report (CH2MHILL, June 2004). The soil inorganics data from the background investigation will be compared to the soil inorganics concentrations detected at AOC G to assess whether the constituent concentrations exceeding the screening levels are site-related or consistent with background conditions. Should the levels exceed background levels, the data will be assessed to determine whether additional site-specific data are necessary or whether sufficient data exist (including data for the other constituents detected [e.g., pesticides]) to assess potential ecological and human health risks. The scope additional investigations, as well as any other action necessary, will be determined following the completion of the background investigation.

Photo-identified (PI) and Potential Area of Concern (PAOC) Sites

During the development of the Description of Current Conditions Report (CH2M HILL, 2001) and the EBS (NAVFACENGCOM, 2003), several additional potential environmental sites were identified based on the review of historical aerial photos and facility records.

There were a total of 24 PAOC and 23 PI sites identified in the EBS as shown on Figure 1-3. The EBS Report was reviewed and a site visit was accomplished in September 2001 at many of the PI sites. PI/PAOC sites are described in Table 1. A Draft Phase I RFI Report (CH2M HILL, June 2004) was developed that further described the 47 PI/PAOC sites and separated them into 6 categories, but none were investigated during the Phase I RFI. The Draft Phase I RFI Report, which is currently under regulatory review, proposed eight of the PI/PAOC sites for a Phase I RFI. A Phase I RFI Work Plan for the eight PI/PAOC was developed and submitted in November 2004 (CH2M HILL, November 2004), and is currently under regulatory review. A Technical Subcommittee Meeting was held on June

21-22, 2005 during which the technical approach for investigation at the eight PI/PAOC sites was concurred upon.

Western Vieques Sites

Environmental Sites

This subsection provides a description of the ERP and MRP sites currently under investigation on western Vieques. Sites that were investigated under the PA/SI and recommended for No further Action are not discussed in this section. However, descriptions and status of these sites, as well as sites for which remedial investigations (RIs) are being conducted, are provided in Table 2 and locations are shown on Figure 1-4.

SWMU 4 – Former Open Burn/Open Detonation Site

SWMU 4 is an inactive OB/OD site identified at the western end of NASD during the EBS. The site was reportedly used for thermal destruction and burning of retrograde munitions from 1969 to 1979. Other explosive materials disposed at SWMU 4 included material from the rework of munitions (e.g., loose powder and primers), ordnance items from the torpedo shop at NSRR, and flares and cartridge-activated devices (Greenleaf, 1984).

Based on the results of the EBS, a phased MEC RI, following the CERCLA process, was conducted to meet the following objectives: 1) identify the specific location of the former OB/OD pits that were not previously documented, 2) characterize the nature and extent of the MEC items in the vicinity of the OB/OD pits to evaluate the extent of the "kick out" area, 3) evaluate the explosives safety risk of the MEC items identified on-site, and 4) develop an MEC RI Report for the site.

The results of the explosive exposure hazard risk evaluation show that based on current site conditions, with the site fence in place, the explosive exposure hazard risk for the proposed trail, recreational beach, and roadway is high. The exposure risk of the road at SWMU 4 is currently more moderate due to the limited access created by the fence. The explosive exposure hazard risk for the wildlife management area and medium intensity land reuse areas is low. There is no explosive exposure hazard in the vicinity of the proposed wildlife observation tower because it is beyond the expected limits of MEC. Removal or reconfiguration of the current fence line would alter the exposure risk for the various land reuse areas.

A digital geophysical survey was conducted over an 87 acre area that identified approximately 23,700 buried metallic anomalies (NAEVA, 2003). The survey identified 16 potential OB/OD pits that were later confirmed by the MEC RI. The density of metallic items decreased with distance from the center of the OB/OD pits. Based on the findings of the MEC investigation, the potential aerial extent of the MEC at SWMU 4 is approximately 180 acres.

A total of 11,211 metallic items were removed from the surface or subsurface and inspected during the MEC RI. Approximately 16 percent, or 1,792, of the items removed were found to contain high explosives. Consistent with the geophysical survey results, the highest density of the MEC items occurred in the vicinity of the OB/OD pits and decreased with distance

away from the pits. Over 90 percent of the MEC items recovered were 20mm or small arms. Less than 8 percent of the items recovered during the investigation were larger than 30mm and all were found within 1,000 feet of the OB/OD pits. Ordnance-related scrap (ORS) accounted for approximately 50 percent of the metallic anomalies investigated at SWMU 4.

The Expanded PA/SI identified constituents in soil above regulatory screening criteria (CH2M HILL, 2000). A Draft RI Work Plan was submitted on June 2004 and is currently under review by regulatory agencies. A separate Draft MEC Remedial Investigation Report has been submitted to further assess the environmental impacts from the MEC (CH2M HILL, 2004). The fence installed around the perimeter of the site restricts potential human exposure routes, including direct contact, dermal exposure, and ingestion. Potential receptors include explosive ordnance disposal/unexploded ordnance (EOD/UXO) workers, recreational users, fishermen, wildlife refuge workers, terrestrial wildlife, and aquatic wildlife.

Currently SWMU 4 is managed by the FWS and is classified as a wildlife refuge. The road accessing the site from the east is gated. FWS is in the process of preparing a Comprehensive Conservation Plan/Environmental Impact Statement (CCP/EIS) for the Vieques National Wildlife Refuge that will provide long-term guidance for the management and public use of these lands. It is anticipated that future land use scenarios for western Vieques and the SWMU 4 area will be addressed in the CCP. The future land use of the SWMU 4 property will not be finalized until the CCP is completed, the date of which is anticipated by FWS to be 2005 or 2006. Following the completion of the Environmental RI for SWMU 4 and the preparation of the CCP, the final remedial action alternatives for the OB/OD site will be presented in an FS. The timing for implementing the final remedy at the site will be based on a prioritization of the site, using DOD protocol, along with the other MRSs at Vieques.

SWMU 6 – Former Mangrove Disposal Site

The Mangrove Disposal Site is located in the ocean-side mangrove swamp in Laguna Arenas along Highway 200 on the former NASD. There is no known history of permits pertaining to this site. The disposal site was in use during the 1960s and 1970s, and was used as a disposal area for general facility wastes. Waste discarded at the site comprised empty containers of lubricants, oil, solvents, and paints; broken glass; and rubble. A CH2M HILL inspection team in conjunction with an MEC avoidance team also identified ordnance items and solid waste from the base galley, such as pieces of broken glass and china.

The site is adjacent to an access road for public beaches farther west in this part of the island. A fence separates the site from Highway 200, thereby limiting access. While the physical appearance of the waste items may diminish the aesthetic appeal of the site, the waste does not pose an unacceptable risk to human health or ecological receptors, and no further investigations or actions were recommended for the site in the Draft RI Report (CH2M HILL, April 2004). However the report is still under regulatory review. Further, as a conservative measure, taking into account the potential for hazardous constituents to be present in the waste material, an Engineering Evaluation/Cost Analysis (EE/CA) is being conducted to assess various alternatives to control and monitor or remove the waste.

Information regarding the nature and extent of contamination and the risk assessment conclusions for SWMU 6 can be found in the Draft RI Report (CH2M HILL, April 2004).

SWMU 7 – Former Quebrada Disposal Site

SWMU 7 is located within the north central portion of the former NASD, immediately south of Highway 200, and includes a steep embankment and bottom of an ephemeral stream. The site was reportedly used for waste disposal between the early 1960s and late 1970s. The Navy ceased facility wide operations on the former NASD on April 30, 2001. The land transfer was completed on May 1, 2001, and the Navy has had no presence at the main operational area since that date. The main operational area of the former NASD sat largely undisturbed from May 2001 until early 2003 when the MOV began utilizing a small number of existing buildings for public works vehicle storage and maintenance activities. No activity at SWMU 7 has been reported since the late 1970s.

The ephemeral stream varies from 20 to 30 feet wide and 10 to 20 feet deep. More than 1,500 cubic yards of material are estimated to be present at the site (Greenleaf, 1984). Material disposed at the site included tires, sheet metal, drums, cans, bottles, batteries, and construction rubble. No known hazardous waste disposal occurred at this site.

The concentrations of inorganics in soil samples collected downgradient of the site were either less than or comparable to background concentrations, suggesting that surface runoff is not transporting inorganic contamination from the source area.

A visual site survey was conducted by a UXO avoidance team, and a magnetometer survey was conducted within the proposed sampling area as part of the UXO avoidance survey that was conducted as a safety measure prior to intrusive sampling during the expanded PA/SI (CH2M HILL, 2000). No live ordnance and explosives (OE) were identified at SWMU 7. The site is currently covered by dense vegetation. Information regarding the nature and extent of potential contamination at SWMU 7 can be found in the Draft RI Report (CH2M HILL, March 2004)

The risk assessment for the RI concluded that the site-related constituent levels do not pose an unacceptable risk to human health or to ecological receptors, based on existing and future land use. However the report is still under regulatory review. Further, as a conservative measure, taking into account the potential for hazardous constituents to be present in the waste material, an EE/CA is being conducted to assess various alternatives to control and monitor or remove the waste.

AOC E – Former Underground Storage (UST) Tank Site 2016

AOC E is located within the public works area of the former NASD at the former location of a UST near the northwest corner of Building 2016. The former UST was a 550-gallon, single-wall, steel waste oil tank. The piping system associated with the UST consisted of single-wall steel pipes. The UST was installed in 1970 to store waste oil generated from vehicle maintenance activities that take place in Building 2016. As part of UST removal activities, the former UST and associated piping were removed. In addition, soil samples were collected and submitted for laboratory analysis; the soil samples contained TPH concentrations ranging from 568 to 1,790 milligrams per kilogram (mg/kg).

The site was transferred from the PREQB UST program to the CERCLA program in 2000 as part of the closure of the NASD. Information regarding the nature and extent of contamination and potential risks posed by the contamination can be found in the Draft RI/FS Report for AOC E (CH2M HILL, February 2004). The risk assessment concluded that the site soils and groundwater do not pose an unacceptable risk for industrial use. The site groundwater, if extracted for consumptive use, would pose an unacceptable risk. However, the groundwater aquifer is unsuitable for use as a source of drinking water due to high concentrations of sodium and chloride ions (USGS, 1989). A multi-phase vacuum extraction (MPE) pilot study was performed at AOC E in June, July, and August 2002 to evaluate the effectiveness of this technology in mitigating the free phase hydrocarbon product accumulation.

Based on agency review of the Draft RI/FS Report, additional sampling of groundwater and soils was requested by USEPA. A sampling and analysis plan was submitted to the regulatory agencies on August 23, 2004. Additional groundwater sampling was accomplished but the proposed soil sampling was postponed until further regulatory review of the proposed sampling approach could be completed. The additional groundwater samples were collected in August 2004. The soil sampling component of the sampling and analysis plan is currently in the review process.

AOC H – Abandoned Former Power Plant

AOC H is located on the north side of Route 200 just east of the public works area. It consists of an abandoned power plant that operated from 1941 to 1943. The power plant building was reportedly used for fire-fighter training from the 1960s through the 1980s. Fire-fighting activities reportedly consisted of placing diesel fuel on tires and igniting the tires inside the building. The diesel fuel was stored in a 2,000- to 3,000-gallon above ground storage tank (AST) located on the western side of the power plant building.

Information regarding the site conditions at AOC H and the risk assessment conclusions can be found in the Draft RI Report for AOC H (CH2M HILL, April 2004), which is still under regulatory review. The human health and ecological risk assessments concluded that the site does not pose an unacceptable risk to human health and the environment from site-related constituents.

AOC I – Asphalt Plant

AOC I is located on the south side of Route 200 just west of the north gate and consists of two former asphalt truck parking/loading containment areas and the location of two former diesel ASTs. Operations at the plant were conducted from the 1960s until 1998.

The EBS, the Expanded PA/SI Phase II, and the August/September 2004 RI produced 47 surface soil samples, 33 subsurface soil samples, and 7 groundwater samples. Information regarding the nature and extent of contamination at AOC I can be found in the Interim RI Report (CH2M HILL, January 2005). Based on the information provided in the Interim RI Report, additional monitoring well installation was proposed in the Supplemental RI Work Plan (CH2M HILL, January 2005). This Work Plan is currently under regulatory review.

AOC J – Asphalt Plant

AOC J encompasses an area of approximately 1.2 acres. The area was used as a solid waste disposal site associated with construction staging activities. The depth of disposal appears to be 2 to 4 feet deep (ERM, 2000). It was used between the mid-1960s and 1973, after which the waste was removed from the site and placed in a municipal landfill off base. During a site visit conducted by CH2M HILL on September 14, 2000, 106-mm shell casings and 20-mm ammunition boxes were observed. Site visits during the EBS indicated there was visible debris consisting of scrap metal from construction equipment, shell casings, glass fragments, and wood waste (ERM, 2000).

Information on the nature and extent of potential contamination and the risk assessment conclusions for AOC J can be found in the Draft RI Report (CH2M HILL, April 2004). The risk assessment for the RI concluded that the site-related constituent levels do not pose an unacceptable risk to human health or to ecological receptors, based on existing and future land use. However the report is still under regulatory review. Further, as a conservative measure, taking into account the potential for hazardous constituents to be present in the waste material, an EE/CA is being conducted to assess various alternatives to control and monitor or remove the waste.

AOC R – Former Operations/Staging Area

AOC R is located in the public works area of the former NASD and consists of an area used as a construction staging area and public works operational area used from about 1965 to 1971. The large concrete pad at the site was present before the Navy owned the area and can be seen in 1937 aerial photographs. In the late 1960s, a carpentry shop and enlisted club were located at the pad. Light vehicle maintenance activities such as oil changes were conducted near the pad to the northwest. Additionally, a large AST was once located near the pad.

The Expanded PA/SI at AOC R included the collection of 34 surface soil samples (CH2M HILL, 2002). Because elevated levels of several constituents (relative to regulatory screening criteria) were identified during the Expanded PA/SI, the site was recommended for an RI. The Draft Work Plan for the RI was submitted for regulatory review in April 2004. After the discovery of several munitions items at the onset of the RI activities, the Work Plan was revised to add UXO avoidance procedures and resubmitted to the agencies in February 2005. Regulatory comments were submitted to the Navy in June 2005.

Environmental Sites Recommended For No further Action

The results of both Expanded PA/SIs for the Former NASD recommended a total of nine sites for No Further Action in the No Further Action Report for Nine Sites (CH2M HILL, May 2003). The No Further Action recommendation was based on several data sources including: review of historical aerial photos, interviews with former employees, review of archived records, and site inspections. In addition, samples were collected at the sites and analyzed for: inorganics, VOCs, SVOCs, PCBs, and pesticides. Furthermore, a quantitative human health risk assessment and a qualitative ecological survey were completed for each site. The human health risk assessment concluded the sites did not pose an unacceptable risk to human health. The nine sites recommended for No further Action are presented in Table 2.

TABLE 1
Status of Environmental Sites in Eastern Vieques, PR

Site Designation	Description of Site	Investigative Status/Recommendations Under Regulatory Review
SWMU-1	Camp Garcia Landfill (EMA)	Draft Phase I RFI Report recommends further evaluation of extent of landfill boundaries (CH2M HILL, June 2004). The RFI Work Plan for SWMU 1 will be prepared following regulatory approval of the Final Background Investigation Report.
SWMU-2	Fuels Off-Loading Site	Draft Phase I RFI Report recommends background investigation for comparison to site-specific data (CH2M HILL, June 2004).
SWMU-4	Waste Areas of Building 303 (Camp Garcia), including: – Spent Battery Accumulation Area – Catch Basin for Hydraulic Oil – Cleaning/Degreasing Basin – Rags, absorbent and grease storage area	Draft Phase I RFI Report recommends background investigation for comparison to site-specific data (CH2M HILL, June 2004).
SWMU-5	Spent Battery Accumulation Area located at Observation Post 1 (OP-1)	Draft Phase I RFI Report recommends background investigation for comparison to site-specific data (CH2M HILL, June 2004).
SWMU-6	Waste Oil and Paint Accumulation Area (Seabees Area at Camp Garcia). To include any releases from the adjacent Lubricating Oil Storage Area	Draft Phase I RFI Report recommends background investigation for comparison to site-specific data (CH2M HILL, June 2004).
SWMU-7	Waste Oil Accumulation Area (outside Building 303 at Camp Garcia)	Draft Phase I RFI Report recommends background investigation for comparison to site-specific data (CH2M HILL, June 2004).
SWMU-8	Waste Oil Accumulation Area (Inner Range at OP-1)	Draft Phase I RFI Report recommends background investigation for comparison to site-specific data (CH2M HILL, June 2004).
SWMU-10	Sewage Treatment Lagoons (Camp Garcia)	Draft Phase I RFI Report recommends background investigation for comparison to site-specific data (CH2M HILL, June 2004).
SWMU-12	Solid Waste Collection Unit Area (OP-1)	Draft Phase I RFI Report recommends background investigation for comparison to site-specific data CH2M HILL, June 2004).
AOC-A	Diesel Fuel Fill Pipe Area (OP-1)	Draft Phase I RFI Report recommends no further action (CH2M HILL, June 2004).
AOC-F	Rock Quarry (Camp Garcia)	Draft Phase I RFI Report recommends background investigation for comparison to site-specific data (CH2M HILL, June 2004).
AOC-G	Pump Station and Chlorination Building at Sewage Lagoons (Camp Garcia)	Draft Phase I RFI Report recommends background investigation for comparison to site-specific data (CH2M HILL, June 2004).
PI-1	Within LIA. Interviews and records indicate former location of an aircraft-strafing target and water production well for residents prior to Navy activities. No evidence of hazardous waste or hazardous material or petroleum storage or	Drat Phase I RFI Report recommends transfer to MRP (CH2M HILL, June 2004).

TABLE 1
Status of Environmental Sites in Eastern Vieques, PR

Site Designation	Description of Site	Investigative Status/Recommendations Under Regulatory Review
	disposal was observed. Non-explosive munitions were observed throughout the site (NAVFACENGCOM, 2003).	
PI-2	Interviews and records indicate existing water production well and former small arms range. No evidence of munitions, hazardous waste, hazardous material, or petroleum storage or disposal was observed (NAVFACENGCOM, 2003).	Drat Phase I RFI Report recommends transfer to MRP (CH2M HILL, June 2004).
PI-3	Interviews and records indicate former water production well and former small arms range. No evidence of munitions, hazardous waste, hazardous material, or petroleum storage or disposal was observed (NAVFACENGCOM, 2003).	Drat Phase I RFI Report recommends transfer to MRP (CH2M HILL, June 2004).
PI-4	Interviews and records indicate location of former helicopter maintenance area, barracks, and a mess hall. Observed several large segments of concrete culverts/pipes and concrete foundation slabs with a septic vault box to the south of the concrete slabs. Observed two large, rectangular, bermed areas formerly used for fuel bladder storage (from interviews). No evidence of munitions, hazardous waste, hazardous material, or petroleum disposal was observed (NAVFACENGCOM, 2003).	Drat Phase I RFI Report recommends Phase I RFI (CH2M HILL, June 2004).
PI-5	Surface water drainage from the runway area; interviews and records indicate historically the location of the fire department and temporary tents; beach matting was installed in the area in the past. No evidence of munitions, hazardous waste, hazardous material, or petroleum storage or disposal was observed (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends No Further Action (CH2M HILL, June 2004).
PI-6	Interviews and records indicate ASTs and facilities associated with the former location of the site drinking water system. Observed the following facilities: – several intact ASTs (Photos 11 and 12) and one storage tank without ends – a concrete building containing electric pumps (Photo 13) – a small vehicle washpad and water well pump house (photo 14) – a ground transformer near the washpad – a concrete pad that could potentially have contained PCB-containing transformers (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends comparison of site data to background investigation results (CH2M HILL, June 2004).

TABLE 1
Status of Environmental Sites in Eastern Vieques, PR

Site Designation	Description of Site	Investigative Status/Recommendations Under Regulatory Review
PI-7	Interviews and records indicate southern portion was formerly a quarry and tar disposal area, northern portion was a communications facility. At the south end of the southern portion of the site, staff observed large quantities of construction debris, including utility poles, scrap metal, and concrete. No evidence of hazardous waste, hazardous material, or petroleum disposal or storage was observed in this location. No items of concern identified in northern portion of site (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends Phase I RFI (CH2M HILL, June 2004).
PI-8	Interviews and records indicate former motor pool maintenance area located south of the main road. Past storage and potential storage of hazardous materials and petroleum products. Observed a large area with dark colored/stained soils (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends comparison of site data to background investigation results (CH2M HILL, June 2004).
PI-9	East site: Interviews and records indicate area used for the on-loading and off-loading of munitions, and for the disposal of ordnance-related scrap metal (non-hazardous or explosive). Observed numerous shell casings and the remains of metal tire ramps. No evidence of hazardous waste, hazardous material, or petroleum disposal or storage was observed in this location (NAVFACENGCOM, 2003). West site: Interviews and records indicate area used for storage of munitions in earthen berms and possible OB/OD activities. No evidence of hazardous waste, hazardous material, or petroleum disposal or storage was observed in this location (NAVFACENGCOM, 2003).	Draft Phase I RFI recommends transfer of site to MRP; MRS site Inspection to be completed (CH2M HILL, June 2004).
PI-10	Interviews and records indicate site of a possible former sewage-drying lagoon. Observed two rectangular openings in the forest partially surrounded by the remains of low earthen berms. Dark colored soils were observed on portions of the enclosed areas. Evidence of limited solid waste disposal in immediate vicinity (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends comparison of site data to background investigation results (CH2M HILL, June 2004).
PI-11	Interviews and records indicate pump house used for the former wastewater treatment system and/or salt water supply system. Observed a diesel engine in a vegetated area adjacent to the station and a stained area immediately under the outfall of an open pipe projecting from the side of the pump house (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends comparison of site data to background investigation results (CH2M HILL, June 2004).
PI-12	Interviews and records indicate water production well prior to 1970s, private residence prior to 1940s. Not observed from ground due to inaccessibility. Observed during helicopter overflight; no potential contamination identified (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends No Further Action (CH2M HILL, June 2004).

TABLE 1
Status of Environmental Sites in Eastern Vieques, PR

Site Designation	Description of Site	Investigative Status/Recommendations Under Regulatory Review
PI-13	Interviews indicate firing point for rocket-related ordnance in the 1950s-1960s. No evidence of contamination observed (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends a munitions site inspection to confirm no munitions present (CH2M HILL, June 2004).
PI-14	Interviews indicate possible disposal area for scrap metal, ammunition boxes, shell casings, and miscellaneous debris. Observed a partially cleared area with possible deposited material, but no evidence of metal debris or other waste (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends a munitions site inspection to confirm no munitions present (CH2M HILL, June 2004).
PI-15	Interviews indicate possible observation post or a small arms range (SAR). This site consists of a low-lying area that has been disturbed by cattle. Observed one discarded compressor cylinder and a practice bomb, but observed no other indications of disposal activities (NAVFACENGCOM, 2003).	Draft Phase I RFI recommends transfer of site to MRP (CH2M HILL, June 2004).
PI-16	Interviews indicate potential use of area for the disposal of munitions. No evidence of human disturbance was observed at this site (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends transfer of site to MRP (CH2M HILL, June 2004).
PI-17	Interviews and records indicate area was historically used for landing exercises and might have been used as a target area or munitions storage area. No evidence of human disturbance was observed at this site (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends transfer of site to MRP (CH2M HILL, June 2004).
PI-18	Interviews indicate potential SAR. Observed an area that had recently been cleared of vegetation. No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed.	Draft Phase I RFI Report recommends a munitions site inspection to confirm no munitions present (CH2M HILL, June 2004).
PI-19	Observed an area that had recently been cleared of vegetation. No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends a munitions site inspection to confirm no munitions present (CH2M HILL, June 2004).
PI-20	Interviews and records indicate area used as observation point during landing exercises conducted at PI-21, and potentially used as a quarry in the past. No evidence of prior disposal activities or other contamination observed (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends No Further Action. (CH2M HILL, June 2004).
PI-21	Interviews and records indicate possible location of a former artillery firing point. Observed the remains of small sheet metal structure, with pipes protruding from the embankment. An area of dark-colored or stained soil was also observed immediately below the outlet of the pipes (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends comparison of site data to background investigation results (CH2M HILL, June 2004).

TABLE 1
Status of Environmental Sites in Eastern Vieques, PR

Site Designation	Description of Site	Investigative Status/Recommendations Under Regulatory Review
PI-22	Interviews and records indicate area used for landing exercises and offloading of equipment. Observed three empty drums, automotive parts, a possible storage area, and scattered fragments of metal. No direct evidence of a release (stained soils, stressed vegetation) was observed (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends comparison of site data to background investigation results (CH2M HILL, June 2004).
PI-23	Interviews and records indicate former water production well and observation post. No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed (NAVFACENGCOM, 2003).	Draft Phase I RFI recommends No Further Action (CH2M HILL, June 2004).
PAOC-I	Building 401, interviews and records indicate former power plant and mechanics shop northeast of Bldg. 303 at Camp Garcia (structure still exists). No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends No Further Action (CH2M HILL, June 2004).
PAOC-J	Interviews and records indicate former vehicle maintenance area at Camp Garcia immediately north of the main road (all structures were demolished prior to 1980). Interviewees not aware of any hazardous waste or hazardous material releases at site; no evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed during site inspection (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends Phase I RFI (CH2M HILL, June 2004).
PAOC-K	Interviews and records indicate former wash rack area north of main road (structure demolished prior to 1980). No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends Phase I RFI (CH2M HILL, June 2004).
PAOC-L	Interviews and records indicate former paint and transformer storage area (structure still exists). Interviewees not aware of any hazardous waste or hazardous material releases at site; no evidence of PCB, hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed during site inspection (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends Phase I RFI (CH2M HILL, June 2004).
PAOC-M	Interviews and records indicate former dispatch office, fuel facility, and sleeping quarters (Building 4503, demolished 1991). No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends No Further Action (CH2M HILL, June 2004).

TABLE 1
Status of Environmental Sites in Eastern Vieques, PR

Site Designation	Description of Site	Investigative Status/Recommendations Under Regulatory Review
PAOC-N	Records indicate former fuel farm and filling station (demolished 1992). Interviews indicate that this area is the current location of the Camp Garcia refueling station. Interviews also indicate no releases occurred at this facility. No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed during the site inspection (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends Phase I RFI (CH2M HILL, June 2004).
PAOC-O	Interviews and records indicate former boiler room in the heat plant building (Building 238 Camp Garcia (CG), demolished 1989). No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends No Further Action (CH2M HILL, June 2004).
PAOC-P	Interviews and records indicate former water treatment facility pumphouse (Building 500CG, demolished 1989). No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends No Further Action (CH2M HILL, June 2004).
PAOC-Q	Interviews and records indicate former boiler house in heat plant building (Building 607, demolished 1984). No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends No Further Action (CH2M HILL, June 2004).
PAOC-R	Interviews and records indicate former boiler house in heat plant building (Building 617, demolished 1984). No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends No Further Action (CH2M HILL, June 2004).
PAOC-S	Records indicate former POL pipeline (demolished 1984). Interviews indicate that this area is the current location of the Camp Garcia refueling station. Interviews also indicate no releases occurred at this facility. No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed during the site inspection (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends Phase I RFI (CH2M HILL, June 2004).
PAOC-T	Interviews and records indicate former public works grounds contractor storage shed (Building 305, demolished 1991). No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends No Further Action (CH2M HILL, June 2004).

TABLE 1
Status of Environmental Sites in Eastern Vieques, PR

Site Designation	Description of Site	Investigative Status/Recommendations Under Regulatory Review
PAOC-U	NEW PAOC – Vehicle Maintenance area just north of Building 303 at Camp Garcia. Current and historic storage of hazardous waste, hazardous material, and petroleum products. Some staining of soil outside of building near container storage pallets (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends Phase I RFI (CH2M HILL, June 2004).
PAOC-V	NEW PAOC – Interviews indicate storage of leaking transformer, possible PCB contamination Two soil samples collected, one constituent detected which was below screening criteria (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends No Further Action (CH2M HILL, June 2004).
PAOC-W	NEW PAOC – Observed area of pooled, discolored water adjacent to the main road from Camp Garcia to PI-21. No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed. Site Interviewees had no knowledge of past activity (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends No Further Action (CH2M HILL, June 2004).
PAOC-X	NEW PAOC – Quebrada (intermittent stream channel) located north from the main road and west from Camp Garcia, adjacent to the former vehicle maintenance area. Observed an automobile body, tires, scrap metal, and construction-related solid waste and debris (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends comparison of site data to background investigation results (CH2M HILL, June 2004).
PAOC-Y	NEW PAOC – Observed a large metal object on the east side of the roadway. No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed. Site personnel had no knowledge of past activity (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends transfer of site to MRP (CH2M HILL, June 2004).
PAOC-Z	NEW PAOC – Observed an overturned tractor-trailer on the north side of the roadway. No evidence of hazardous waste, hazardous material, petroleum, or munitions storage or disposal was observed. Site personnel had no knowledge of past activity (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends transfer of site to MRP (CH2M HILL, June 2004).
PAOC-AA	Small Arms Range (SAR) No. 1, used for conducting training with rifles and pistols (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends transfer of site to MRP (CH2M HILL, June 2004).
PAOC-BB	SAR No. 2, used for conducting training with pistols (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends transfer of site to MRP (CH2M HILL, June 2004).
PAOC-CC	SAR No. 3, used for conducting training with automatic rifles and machine guns (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends transfer of site to MRP. (CH2M HILL, June 2004).

TABLE 1
Status of Environmental Sites in Eastern Vieques, PR

Site Designation	Description of Site	Investigative Status/Recommendations Under Regulatory Review
PAOC-DD	SAR No. 4, used for conducting training with hand and rifle grenades (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends transfer of site to MRP (CH2M HILL, June 2004).
PAOC-EE	Site of former storage of munitions in earthen berms (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends a munitions site inspection to confirm no munitions present (CH2M HILL, June 2004).
PAOC-FF	Site of former artillery gun placement (NAVFACENGCOM, 2003).	Draft Phase I RFI Report recommends a munitions site inspection to confirm no munitions present (CH2M HILL, June 2004).

TABLE 2
Status of IR Sites in Western Vieques, PR

Site Name	Description and Period of Operation	Status
SWMU-4 Inactive OB/Waste Explosive Detonation Range*	Thermal destruction of unserviceable munitions ~1965-1980	Draft RI Work Plan submitted (CH2M HILL, June 2004). Regulatory review underway
SWMU-5 Drone Fuel Disposal Site	At this location in 1975, a one-time disposal of 7,000 lbs. of fuel from leaking drones into a low spot in a road near Magazine #422, which drained into the ephemeral stream via the drainage ditch. The fuel contained inhibited red fuming nitric acid (IRFNA) and mixed amine fuels (MAF-4).	PAHs in soils do not present human health risk above acceptable levels. Proposed for No Further Action in Draft Final No Further Action Report for Nine Sites. (CH2M HILL, May 2003).
*SWMU-6 Mangrove Disposal Site	Disposal of trash (lubricants, oils, solvents, and paint) ~1965-1980	Draft Remedial Investigation/Feasibility Study Report submitted that recommends No Further Action based on potential risk (CH2M HILL, April 2004). Regulatory review underway. Draft EE/CA for debris removal being prepared.

TABLE 2
Status of IR Sites in Western Vieques, PR

Site Name	Description and Period of Operation	Status
SWMU-7 Quebrada Disposal Site	Disposal of trash (lubricants, oils, solvents, and paint) ~1965-1980	Draft Remedial Investigation/Feasibility Study Report submitted that recommends No Further Action based on potential risk (CH2M HILL, March 2004). Regulatory review underway. Draft EE/CA for debris removal being prepared.
SWMU-10 Waste Paint and Solvent Disposal Ground	This area was allegedly used for the open dumping of waste paints and solvents During the mid-1970s.	No further investigation of soil or groundwater is necessary. No Further Action recommended in the No Further Action Report for Nine Sites. (CH2M HILL, May 2003).
SWMU-14 Wash Rack (near Building 2016)	SWMU 14 comprises a washrack and former oil/water separator that were in use from the late 1970s until 2000. The area was primarily used for cleaning Navy vehicles.	No further investigation of soil or groundwater is necessary. NFA recommended in the No Further Action Report for Nine Sites. (CH2M HILL, May 2003).
SWMU-15 Waste Transportation Vehicle Storage Area	Location where a Navy truck was parked that reportedly contained numerous drums of a waste labeled as caustic and drums containing napalm	No further investigation of soil or groundwater is necessary. NFA recommended in the No Further Action Report for Nine Sites. (CH2M HILL, May 2003).
AOC-B Wastewater Treatment Plant and Disposal Ground	Domestic sewage, aeration/chlorination treatment with flows to disposal lagoons. ~1983-2000	No further investigation of soil or groundwater is necessary. NFA recommended in the No Further Action Report for Nine Sites. (CH2M HILL, May 2003).
AOC-C Drainage Ditch Near Transportation Shop	Possible spills of petroleum-related substances.	No further investigation of soil or groundwater is necessary. NFA recommended in the No Further Action Report for Nine Sites. (CH2M HILL, May 2003).
AOC-E Former Waste Oil UST at Bldg. 2016	Waste oil UST - contaminated soil found during removal of UST	Initial RI activities completed; Work Plan Addendum for additional RI activities submitted (CH2M HILL, August , 2004). Regulatory review underway.

TABLE 2
Status of IR Sites in Western Vieques, PR

Site Name	Description and Period of Operation	Status
AOC-F Enlisted Men's Club UIC Septic Tank	Septic tank, closed in 1997. Inorganics in soil exceeded standards	No further investigation of soil or groundwater is necessary. NFA recommended in the No Further Action Report for Nine Sites. (CH2M HILL, May 2003).
AOC-H Abandoned Power Plant	Operated 1941-1943; AST; used for Fire Fighter training ~1960s-1980s	Draft Remedial Investigation/Feasibility Study Report submitted that recommends No Further Action (CH2M HILL, April 2004). Regulatory review underway.
AOC-I Asphalt Plant	Former AST storage area stained with asphalt emulsion.	Initial RI activities completed; Supplemental Work Plan for additional RI activities submitted (CH2M HILL, January, 2005). Regulatory review underway.
AOC-J Former Operations/Staging Area Disposal Site	Solid and potentially hazardous waste disposal site ~1965-1973	Draft Remedial Investigation/Feasibility Study Report submitted that recommends No Further Action (CH2M HILL, April 2004) Regulatory review underway.
AOC-K Water Well in Main Operations Area	Well used for potable water between 1941 and 1979. Well was rehabilitated in 1997 for a USGS investigation and benzene was detected above regulatory MCL levels. Re-sampled and benzene was not detected.	NFA recommended in the No Further Action Report for Nine Sites. (CH2M HILL, May 2003).
AOC-L. Former Septic Vault	Suspected use for treatment and disposal of Sanitary sewage in the 1940s	Risk to human health resulting from conservative evaluation assumed for exposure to AOC L is low and within background levels. NFA recommended in the No Further Action Report for Nine Sites. (CH2M HILL, May 2003).
AOC-R Former Staging and Operations Area*	Construction staging and Public Works operations; AST; vehicle maintenance ~1965-1971	Revised RI/FS Work Plan submitted (CH2M HILL, January 2005). Regulatory comments received June 2005.

*Indicates site on DOI property

Anegada

British Virgin Islands

U.S. Virgin Islands

Virgin Gorda

Tortola

San Juan

Culebra

St. Thomas

St. John

U.S. Naval Activity Puerto Rico

VIEQUES

PUERTO RICO

WEST VIEQUES (Former NASD)

EAST VIEQUES (Former VNTR)

St. Croix

N

Scale in Miles

0 15

Figure 1-1
Regional Location Map
Master Health and Safety Plan, Vieques Island, Puerto Rico

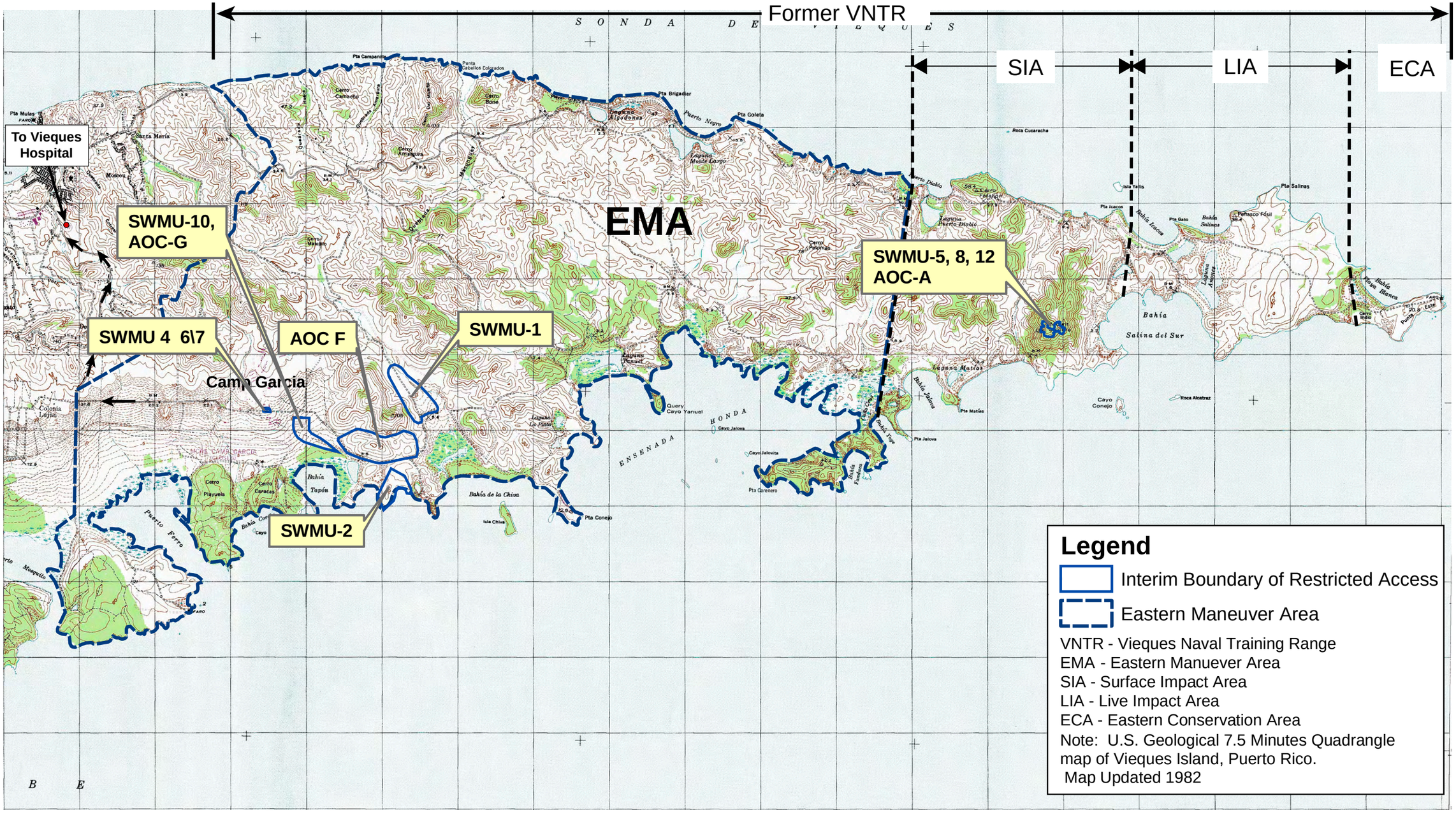
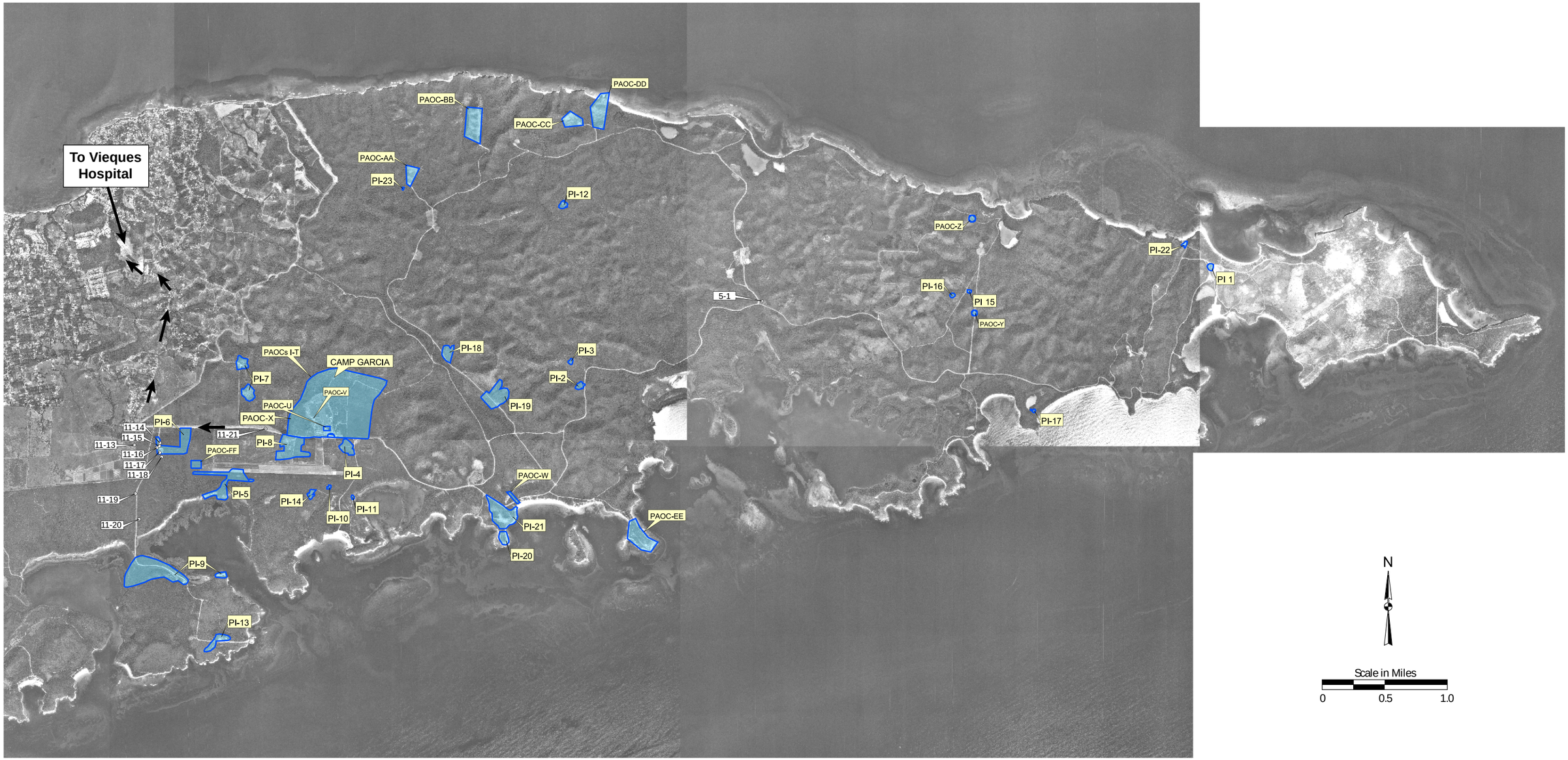


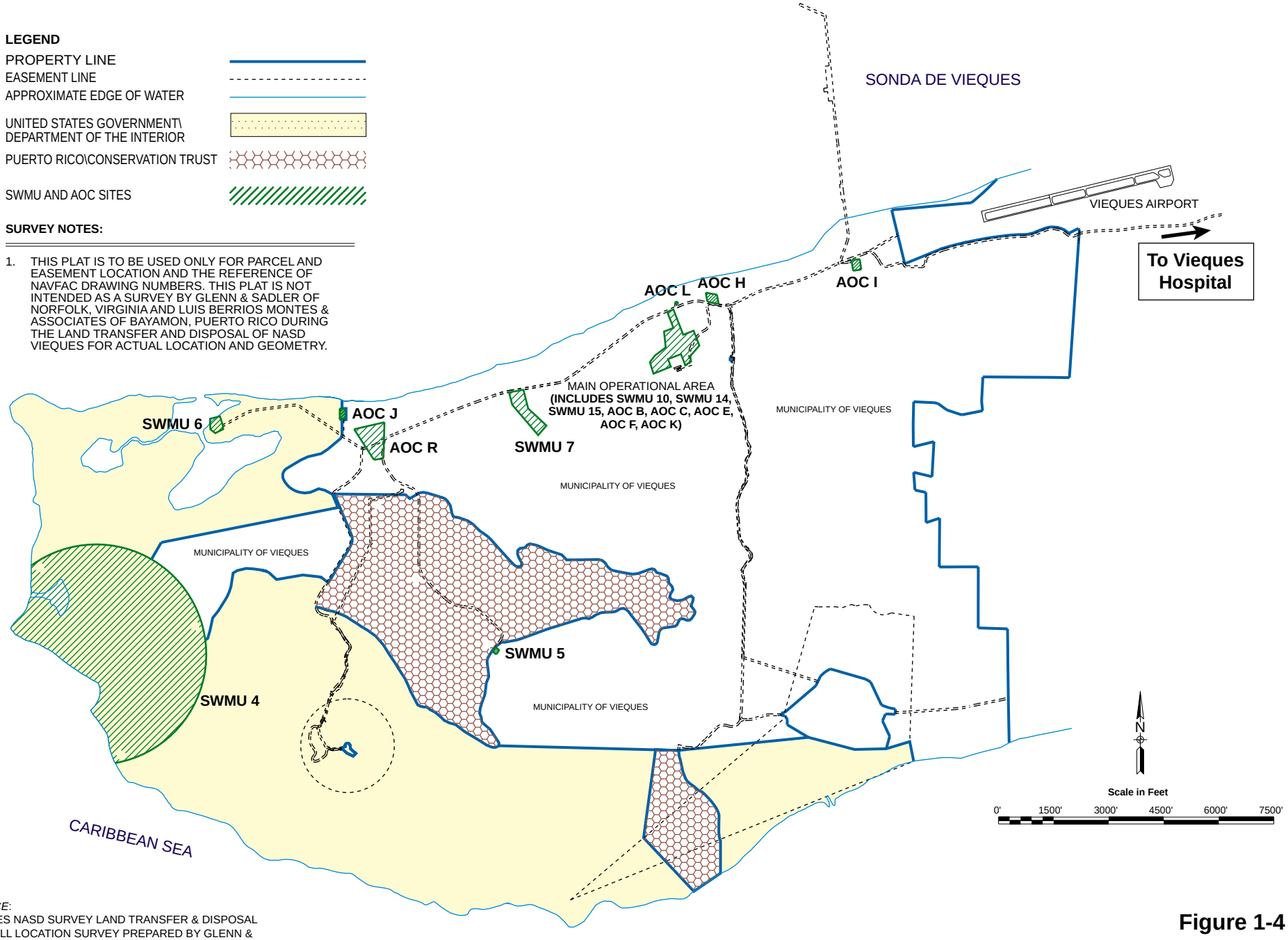
Figure 1-2
East Vieques Consent Order Sites
Master Health and Safety Plan, Vieques, Puerto Rico



Developed from: NAVFACENGCOM, 2003

Notes: Production Wells [5-1, 11-13, 11-14, 11-15, 11-16, 11-17, 11-18, 11-19, 11-20, 11-21]

Figure 1-3
PI and POAC Sites
Master Health and Safety Plan, Vieques, Puerto Rico



SOURCE:
VIEQUES NASD SURVEY LAND TRANSFER & DISPOSAL OVERALL LOCATION SURVEY PREPARED BY GLENN & SADLER AND LUIS BERRIOS MONTES & ASSOCIATES

Figure 1-4
NASD Sites
Master Health and Safety Plan, Vieques, Puerto Rico

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1 Tasks to be Performed Under this Plan

1.1 Description of Tasks

Refer to project documents (i.e., Work Plan) for detailed task information. A health and safety risk analysis (Section 1.2) has been performed for each task and is incorporated in this plan through task-specific hazard controls and requirements for monitoring and protection. Tasks other than those listed below require an approved amendment or revision to this plan before tasks begin. Refer to Section 8.2 for procedures related to "clean" tasks that do not involve hazardous waste operations and emergency response (Hazwoper).

1.1.1 Hazwoper-Regulated Tasks

- Surface geophysical surveys
  - Magnetic
  - Electromagnetic
- Monitoring well installation
- Groundwater sampling
- Aquifer testing
- Surface soil sampling
- Subsurface soil sampling
- Hand auguring
- Surveying
- Investigation-derived waste (drum) sampling and disposal

1.1.2 Non-Hazwoper-Regulated Tasks

Under specific circumstances, the training and medical monitoring requirements of federal or state Hazwoper regulations are not applicable. It must be demonstrated that the tasks can be performed without the possibility of exposure in order to use non-Hazwoper-trained personnel. Prior approval from the Health and Safety Manager (HSM) is required before these tasks are conducted on regulated hazardous waste sites

1.2 Task Hazard Analysis

(Refer to Section 2 for hazard controls)

POTENTIAL HAZARDS	TASKS									
	Test pit/ excavation	Drilling, geoprobe, and well installation & abandonment	Groundwater monitoring, aquifer testing	Surface water and sediment sampling using a boat	Surface water and sediment sampling from the shore or water	Hand augering	Surveying	IDW drum sampling and disposal	Observation of loading material for offsite disposal	Remediation & construction oversight
Flying debris/objects	X	X		X	X	X		X	X	X
Noise > 85dBA	X	X		X					X	X
Electrical	X	X	X	X						X
Suspended loads	X	X		X					X	X
Buried utilities, drums, tanks	X	X				X				X
Slip, trip, fall	X	X	X	X	X	X	X	X	X	X
Back injury	X	X	X	X	X	X		X		X
Confined space entry	X						X			X
Trenches / excavations	X									X
Visible lightning	X	X	X	X	X	X	X	X	X	X
Vehicle traffic									X	X
Elevated work areas/falls	X				X					X
Fires	X	X			X			X		X
Entanglement		X				X				
MPPEH/MEC	X	X	X	X	X	X	X			X
Drilling		X								
Heavy equipment	X	X		X					X	X
Working near water					X					
Working from boat				X						
IDW Drum Sampling								X		

1.3 Activity Hazard Analysis for Unexploded Ordnance Operations

Table B-1 shows hazards analysis, and Table B-2 shows inspection requirements.

TABLE B-1
Hazards Analysis

Principal Steps	Potential Hazards	Recommended Controls
Surveying and establishing boundaries and grids	Accidental detonation of explosives	Personnel involved will attend a site-specific MEC recognition class prior to the commencement of any site activities.
		UXO personnel will escort non-UXO-qualified personnel at all times.
		Mark and avoid MEC.
		UXO Technician will check location with magnetometer prior to driving stakes.
	Wildlife, slips, trips, falls, insects, poisonous plants, use of hand tools	Refer to the Activity Hazard Analysis for section of this SSHP.
Clearing and grubbing	Accidental detonation of explosives	Personnel involved will attend a site-specific MEC recognition class prior to the commencement of any site activities.
		Be alert and mark all MEC located.
		Only clear and grub to within 4 inches of the ground surface.
		UXO trained personnel will escort non-UXO-qualified personnel at all times.
		UXO Technician will conduct surface sweeps with magnetometers or other suitable geophysical instrumentation to identify MEC.
Anomaly reacquisition	Accidental detonation	MPPEH/MEC will not be handled nor touched.
		Personnel in the immediate vicinity of MEC operations will be kept to the minimum necessary for safe operations, but no less than two UXO technicians.
		Do not subject MEC to heat, shock, or friction.
		Only hand excavation permitted when within 1 ft of MEC.
		Magnetometers will be used frequently to pinpoint the location of MEC.
	Non-UXO personnel	Establish exclusion zone (EZ); post warning signs, maintain site control.
		Stop all MEC operations when non-UXO-qualified personnel are within the EZ.

TABLE B-1
Hazards Analysis

Principal Steps	Potential Hazards	Recommended Controls
Clearing and Grubbing of vegetation	Cutting tools, chain saws, weed cutters	Eye, hand, foot, and hearing protection, (Level D). Face shield and chaps will be worn by chain saw operations. Personnel using chain saws, cutting tools, and weed cutters must provide safe distance between workers and be cautious of tools.

Only the UXO subcontractor will transport MEC material and explosives.

TABLE B-2
Inspection Requirements

Equipment to be Used	Inspection Requirements	Training Requirements
Vehicles Fire extinguishers First aid kits Demolition materials Explosives Blocking, bracing, and cushioning materials Manual hand tools Mechanized equipment EMM Geophysical instrumentation Global Positioning System instrumentation PPE Communications equipment	Daily preventive maintenance and operational checks First aid kits Calibration of geophysical instrumentation	40-hour qualification per 29 CFR 1910.120 8-hour refresher UXO personnel EOD trained Tailgate safety meetings Site-specific orientation Lead awareness training Poison oak awareness training

2 Hazard Controls

This section provides safe work practices and control measures used to reduce or eliminate potential hazards. These practices and controls are to be implemented by the party in control of either the site or the particular hazard. CH2M HILL employees and subcontractors must remain aware of the hazards affecting them regardless of who is responsible for controlling the hazards. CH2M HILL employees and subcontractors who do not understand any of these provisions should contact the SSC for clarification.

In addition to the controls specified in this section, Project-Activity Self-Assessment Checklists are contained in **Attachment 6**. These checklists are to be used to assess the adequacy of CH2M HILL and subcontractor site-specific safety requirements. The objective of the self-assessment process is to identify gaps in project safety performance, and prompt for corrective actions in addressing these gaps. Self-assessment checklists should be completed early in the project, when tasks or conditions change, or when otherwise specified by the HSM. The self-assessment checklists, including documented corrective actions, should be made part of the permanent project records, and should be promptly submitted to the HSM.

- Project-specific frequency for completing self-assessments:
  Complete self-assessment every month throughout the duration of this project.

2.1 Project-Specific Physical (Safety) Hazards

The main physical or safety hazards posed to CH2M HILL personnel during project activities are:

- Confined space entry
- Thermal (heat) stress
- Noise
- Explosion and fire
- Utilities
- Heavy equipment
- Fall hazards
- Ordnance

The health and safety control measures for these hazards are outlined in Section 2.3 of this plan, General Health and Safety Hazards.

2.1.1 MPPEH/MEC (Explosives Usage and Munitions Response (MR) SOP, HSE&-610)

MPPEH includes MEC, Chemical Warfare Material (CWM), MEC-contaminated soils and groundwater, range maintenance, ordnance demilitarization (Demil), and demining. MEC may be encountered during field activities. Sites potentially contaminated with MEC will be screened by the UXO Technicians prior to and during field activities.

Site Personnel who are potentially exposed to hazards associated with MEC activities shall follow the requirements described in this section regardless of the company performing the MEC operation. Personnel knowledgeable (UXO Technician) of MEC safety precautions must observe these precautions at all times. They must also advise others in the vicinity of proper precautions for the protection of all personnel in an MEC danger area.

- This is an avoidance tasking; therefore MPPEH/MEC will not be touched, handled, identified, transported, stored or disposed of.
- Electronic equipment capable of emitting electromagnetic radiation (such as radios or cellular phones) shall not be activated in the vicinity of known or suspected electrically initiated ordnance.
- Munitions having no color-coding, incomplete color-coding, or improper color-coding are not uncommon, so color coding should not be relied on as a positive identification of ordnance.
- Inhalation of, and skin contact with, smoke, fumes, and vapors of explosives and related hazardous materials shall be avoided.
- MEC that has been exposed to fire or detonation must be considered extremely hazardous. Chemical and physical changes may have occurred to the contents, which render it more sensitive than when in its original state.
- Ordnance shall be approached from the side because munitions may contain an ejection hazard, shaped charge explosive jet hazard, rocket motor, or fuzing sensitive to movement.
- Unnecessary personnel must not remain in the vicinity of MEC.
- Ordnance items must be considered armed and dangerous.
- Fired ammunition or ordnance should not be considered safe.
- Souvenirs shall not be collected.

MEC Avoidance Procedures. MEC avoidance operations will be required in areas that have been known to have MEC on Vieques. Avoidance operations will consist of site survey for surface/subsurface MEC, establishing and marking operational team's lead-in pathways where necessary, and down-hole monitoring by UXO Technician using appropriate geophysical detection instrumentation. If MEC is unexpectedly encountered, no attempt to move or dispose of the item(s) will be made. Contact with MEC is PROHIBITED. The UXO Technician (UXOT) will mark and secure the area until designated authority is on the scene, and notify the CH2M HILL Project Manager. In the event of MEC discovery, the UXO

Technician will ensure that all on-site personnel are evacuated to outside the 1250 foot exclusion zone. This distance may be adjusted appropriately, depending on the identity of MEC.

UXO avoidance will be performed in conjunction with all field activities at areas suspected of having MEC. All UXO avoidance procedures performed by the UXO-qualified subcontractor will conform to NSWCDL SOP No. C8M-0800-001-00 Change C.

Access routes to sampling locations. Prior to sampling or well drilling crews on site, the UXO Technician will conduct a visual reconnaissance of the sampling area and the lead-in path to it. Previously cleared areas will not require magnetometer investigation. Any areas not previously designated as clear will be swept with the lead-in path clearly marked. Any heavily vegetated areas will be circumvented whenever possible. Once on the bore-hole or well drilling site, the UXOT will sweep with magnetometer and designate the required drilling/DPT site(s), and proceed with the prescribed monitoring technique with the down-hole Schonstedt (or equivalent). Upon detection of anomalies, drilling/DPT will halt, and relocate to another site designated by the UXO Technician.

An access (lead-in) route, if needed, will be a minimum of twice the width of the widest vehicle and the boundaries will be clearly marked to prevent personnel from straying into non-cleared areas. The sampling site will also be of dimensions that measure at least twice the length of the longest vehicle on site to accommodate vehicle turnarounds. If surface MEC is encountered, the UXO Technician will mark and report the item, and divert the approach path around the MEC. A magnetometer will be used to ensure there are no subsurface MEC with the approach path. If a subsurface magnetic anomaly is encountered, it will be assumed to be a possible MEC and the path diverted to avoid it.

An initial work/controlled access area of 200 feet will be established as an Exclusion Zone (EZ). Upon any discovery of surface MEC, a default EZ of 1250 feet will be established, and all personnel on-site, or non-essential personnel within 1250 feet of the site will evacuate to preferably protected spaces (intervening walls, inside buildings, etc.), if available, outside that distance.

Well Drilling Sites. The UXO Technician will visually sweep and ensure a clear area for well drilling site selection and clearly mark the boundaries. The area will be large enough to accommodate the drilling equipment and provide a work area for the crews. The cleared area will be a square, with a minimum side dimension equal to twice the length of the largest vehicle or piece of equipment for use on site. Upon magnetometer monitoring, a site is found to contain any anomalies, an alternate sampling/drill site will be chosen.

A controlled area/initial Exclusion Zone (EZ) of 200 feet radius from the work site will be maintained. Only essential personnel will be allowed access to this zone during operations. The UXO Technician will ensure work stoppage until this zone is free of non-essential personnel. Upon the unexpected discovery of suspected MEC, work will immediately cease. The UXO Technician will not remain in the area any longer than required to ensure evacuation of all personnel to outside the 1250 foot EZ.

Monitoring Well installation. Prior to drilling equipment being moved to the proposed site, the UXO Technician will have checked the designated site, using a magnetometer or

equivalent, to assure that the well location is anomaly free to a depth of one foot. If surface samples are required they will be obtained prior to the start of drilling.

To complete the subsurface magnetometer checks, one of two methods may be used;

- Monitoring at 1 foot increments, during the actual well drilling operation. This will require the withdrawal of the drill rod or augers from the well and moving the drill rig a minimum of 20 feet away from the well location to prevent the rig from influencing the magnetometer , or

- Installing an offset monitoring hole within a two foot diameter area encompassing the well location. This monitoring hole can be installed by the UXO Technician with a hand or power auger, and monitored at one foot increments to the desired well depth.

Avoidance Procedures in Areas Suspected to have MEC, for Vegetation Removal and Subsurface Borings

Work will entail UXO personnel clearing an area prior to vegetation clearing, and identifying any hazardous or potentially hazardous ordnance related items. Work will also entail clearing subsurface sampling locations prior to any intrusive work. Surface soil may be collected with a hand auger or direct-push rig from 0 to 2 feet bls. A downhole metal detector shall be used to clear the borehole during sample collection. Subsurface soil samples will also be collected using a geoprobe rig or hollow stem auger rig. A downhole metal detector shall also be used to clear the soil prior and during the advancement of the geoprobe rods or augers. Monitoring wells will be advanced using a drill rig. Drilling locations shall be cleared prior to and during the hollow stem auger or air rotary drilling. Borings shall be cleared from surface to a maximum depth of 10 feet bls or bedrock, whichever occurs first.

A UXO Technician III and a UXO Technician II (or approved team) will conduct the UXO avoidance activities associated with the investigation. The UXO team will use a Schonstedt metal detector (or equivalent) and a downhole metal detector capable of operating at a maximum depth of 10 feet bls during the survey to locate subsurface anomalies. Items identified will be flagged during the survey and any item or area deemed potentially hazardous for treading will be delineated to the on-site field staff.

CONTACT WITH MEC IS PROHIBITED

A daily (pre-work) meeting will be conducted and documented. This briefing will contain the planned daily activities and those hazards associated with the work. This briefing will be conducted by the UXO Technician. This documentation will be retained as part of the site records.

2.2 General Hazards

2.2.1 General Hazards and Housekeeping

(Reference CH2M HILL SOP HSE&Q-209, General Practices)

- Site work will be performed during daylight hours whenever possible. Work conducted during hours of darkness will require enough illumination intensity to read a newspaper without difficulty.
- Hearing protection must be worn in areas where one needs to shout to hear someone within 3 feet.
- Good housekeeping must be maintained at all times in all project work areas.
- Common paths of travel should be established and kept free from the accumulation of materials.
- Keep access to aisles, exits, ladders, stairways, scaffolding, and emergency equipment free from obstructions.
- Provide slip-resistant surfaces, ropes, and/or other devices to be used.
- Stairs or ladders are generally required when there is a break in elevation of 19 inches or more.
- Specific areas should be designated for the proper storage of materials.
- Tools, equipment, materials, and supplies shall be stored in an orderly manner.
- As work progresses, scrap and unessential materials must be neatly stored or removed from the work area.
- Containers should be provided for collecting trash and other debris and shall be removed at regular intervals.
- All spills shall be quickly cleaned up. Oil and grease shall be cleaned from walking and working surfaces.

2.2.2 Hazard Communication

(Reference CH2M HILL SOP HSE&Q-107, Hazard Communications)

The SSC is to perform the following:

- Complete an inventory of chemicals brought onsite by CH2M HILL using Attachment 2.
- Confirm that an inventory of chemicals brought onsite by CH2M HILL subcontractors is available.
- Request or confirm locations of Material Safety Data Sheets (MSDSs) from the client, contractors, and subcontractors for chemicals to which CH2M HILL employees potentially are exposed.
- Before or as the chemicals arrive onsite, obtain an MSDS for each hazardous chemical.
- Label chemical containers with the identity of the chemical and with hazard warnings, and store properly.
- Give employees required chemical-specific HAZCOM training using Attachment 3.

2.2.3 Shipping and Transportation of Chemical Products

(Reference CH2M HILL's Procedures for Shipping and Transporting Dangerous Goods)

Chemicals brought to the site might be defined as hazardous materials by the U.S. Department of Transportation (DOT). All staff who ship the materials or transport them by road must receive CH2M HILL training in shipping dangerous goods. All hazardous materials that are shipped (e.g., via Federal Express) or are transported by road must be properly identified, labeled, packed, and documented by trained staff. Contact the HSM or the Equipment Coordinator for additional information.

2.2.4 Manual Lifting

(Reference CH2M HILL SOP HSE&Q-112, Lifting (Manual))

- Proper lifting techniques must be used when lifting any object.
  - Plan storage and staging to minimize lifting or carrying distances.
  - Split heavy loads into smaller loads.
  - Use mechanical lifting aids whenever possible.
  - Have someone assist with the lift, especially for heavy or awkward loads.
  - Make sure the path of travel is clear prior to the lift.

2.2.5 Slips, Trips and Falls

- Institute and maintain good housekeeping practices.
- Pick up tools and debris in the work area.
- Walk or climb only on equipment surfaces designed for personnel access.
- Be aware of poor footing and potential slipping and tripping hazards in the work area.

2.2.6 Fire Prevention

(Reference CH2M HILL SOP HSE&Q-208, Fire Prevention and Control)

- Fire extinguishers shall be provided so that the travel distance from any work area to the nearest extinguisher is less than 100 feet. When 5 gallons or more of a flammable or combustible liquid is being used, an extinguisher must be within 50 feet. Extinguishers must:
  - be maintained in a fully charged and operable condition,
  - be visually inspected each month, and
  - undergo a maintenance check each year.
- The area in front of extinguishers must be kept clear.
- Post "Exit" signs over exiting doors, and post "Fire Extinguisher" signs over extinguisher locations.
- Combustible materials stored outside should be at least 10 feet from any building.
- Solvent waste and oily rags must be kept in a fire resistant, covered container until removed from the site.
- Flammable/combustible liquids must be kept in approved containers, and must be stored in an approved storage cabinet.

2.2.7 Electrical

(Reference CH2M HILL SOP HSE&Q-206, Electrical)

- All temporary wiring, including extension cords, must have ground fault circuit interrupters (GFCIs) installed.
- Extension cords must be:
  - equipped with third-wire grounding.
  - covered, elevated, or protected from damage when passing through work areas.
  - protected from pinching if routed through doorways.
- Electrical power tools and equipment must be effectively grounded or double-insulated UL approved.
- Electrical power tools, equipment, and cords are to be inspected for damage before use. If damaged, they should be tagged and removed from service.
- Operate and maintain electrically powered equipment according to manufacturers' instructions.
- Protect all electrical equipment, tools, switches, and outlets from elements.
- Only qualified personnel are to work on energized electrical circuits and equipment. Only authorized personnel are permitted to enter high-voltage areas.
- Properly label switches, fuses, and breakers.
- All 120-volt, single phase 15 and 20 ampere receptacle outlets on construction sites which are not part of the permanent building wiring must be equipped with ground-fault circuit interrupters (GFCIs) for personnel protection.
- All portable electric generator receptacles must be effectively grounded by bonding the receptacle grounding wire to the generator frame.

2.2.8 Ladders

(Reference CH2M HILL SOP HSE&Q-214, Stairways and Ladders)

- Ladders must be inspected by a competent person for visible defects prior to each day's use. Defective ladders must be tagged and removed from service.
- Portable ladders must extend at least 3 feet above landing surface.
- User must face the ladder when climbing; keep belt buckle between side rails.
- User must use both hands to climb; use rope to raise and lower equipment and materials.
- Straight and extension ladders must be tied off to prevent displacement.
- Ladders that may be displaced by work activities or traffic must be secured or barricaded.
- Fixed ladders $\geq$ 20 feet in height must be provided with fall protection devices.
- Stepladders are to be used in the fully opened and locked position.
- Users are not to stand on the top two steps of a stepladder; nor are users to sit on top or straddle a stepladder.
- Straight and extension ladders must be positioned at such an angle that the ladder base to the wall is one-fourth of the working length of the ladder.

2.2.9 Heat and Cold Stress

(Reference CH2M HILL SOP HSE&Q-211, Heat and Cold Stress)

Preventing and Treating Heat Stress

- Drink 16 ounces of water before beginning work. Disposable cups and water maintained at 50°F to 60°F should be available. Under severe conditions, drink 1 to 2 cups every 20 minutes, for a total of 1 to 2 gallons per day. Take regular breaks in a cool, shaded area. Do not use alcohol in place of water or other nonalcoholic fluids. Decrease intake of coffee and caffeinated soft drinks during working hours.
- Acclimate yourself by slowly increasing workloads (e.g., do not begin with extremely demanding activities).
- Use cooling devices, such as cooling vests, to aid natural body ventilation The devices add weight, so their use should be balanced against efficiency.
- Use mobile showers or hose-down facilities to reduce body temperature and cool protective clothing.
- Conduct field activities in the early morning or evening and rotate shifts of workers, if possible.
- Provide adequate shelter/shade to protect personnel against radiant heat (sun, flames, hot metal).
- Maintain good hygiene standards by frequently changing clothing and showering.
- Monitor buddy for signs of heat stress. Persons who experience signs of heat rash or heat cramps should consult the SSC to avoid progression of heat-related illness.
- Those who experience heat syncope (sudden fainting), heat exhaustion (hot, pale, clammy/moist skin), or heat stroke (red, hot, dry skin; loss of consciousness) must be cooled down immediately and provided cool water or sports drink. Persons who experience heat syncope or heat exhaustion should also seek medical attention as soon as possible. Persons who experience heat stroke must get immediate medical attention.

Monitoring Heat Stress

These procedures should be considered when the ambient air temperature exceeds 70°F, the relative humidity is high (>50 percent), or when workers exhibit symptoms of heat stress.

The heart rate (HR) should be measured by the radial pulse for 30 seconds, as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 100 beats/minute, or 20 beats/minute above resting pulse. If the HR is higher, the next work period should be shortened by 33 percent, while the length of the rest period stays the same. If the pulse rate still exceeds 100 beats/minute at the beginning of the next rest period, the work cycle should be further shortened by 33 percent. The procedure is continued until the rate is maintained below 100 beats/minute, or 20 beats/minute above resting pulse.

Preventing and Treating Cold Stress

- Be aware of the symptoms of cold-related disorders, and ***wear proper clothing for the anticipated fieldwork.***
- Consider monitoring the work conditions and adjusting the work schedule using guidelines developed by the U.S. Army (wind-chill index) and the National Safety Council (NSC).
- ***Wind-Chill Index*** is used to estimate the combined effect of wind and low air temperatures on exposed skin. The wind-chill index does not take into account the body

part that is exposed, the level of activity, or the amount or type of clothing worn. For those reasons, it is used only as a guideline to warn workers when they are in a situation that can cause cold-related illnesses.

- ***NSC Guidelines for Work and Warm-Up Schedules*** can be used with the wind-chill index to estimate work and warm-up schedules for fieldwork. The guidelines are not absolute; ***workers should be monitored for symptoms of cold-related illnesses***. If symptoms are not observed, the work duration can be increased.
- Persons who experience signs of incipient frost bite (frost nip) or incipient hypothermia (generally cold, shivering) should consult the SSC to avoid progression of cold-related illness.
- Persons who experience signs of frost bite (discolored, waxy, resilient skin) or hypothermia (low body temperature characterized by uncontrollable shivering, weakness, apathy, etc.) must be warmed and provided warm fluids (not hot, and no caffeinated drinks), and must get immediate medical attention.

2.2.10 Compressed Gas Cylinders

(Reference CH2M HILL SOP HSE&Q-314, Welding and Cutting)

- Valve caps must be in place when cylinders are transported, moved, or stored.
- Cylinder valves must be closed when cylinders are not being used and when cylinders are being moved.
- Cylinders must be secured in an upright position at all times.
- Cylinders must be shielded from welding and cutting operations and positioned to avoid being struck or knocked over; contacting electrical circuits; or exposed to extreme heat sources.
- Cylinders must be secured on a cradle, basket, or pallet when hoisted; they may not be hoisted by choker slings.

2.2.11 Procedures for Locating Buried Utilities

Local Utility Mark-Out Service

Name: Madeline Rivera/NAVFAC – Atlantic, Vieques Field Office, Phone: (787) 865-4152, Ext. 460; and Oscar Diaz/FWS, Vieques, Phone: (787) 741-2138.

- Where available, obtain utility diagrams for the facility.
- Review locations of sanitary and storm sewers, electrical conduits, water supply lines, natural gas lines, and fuel tanks and lines.
- Review proposed locations of intrusive work with facility personnel knowledgeable of locations of utilities. Check locations against information from utility mark-out service.
- Where necessary (e.g., uncertainty about utility locations), excavation or drilling of the upper depth interval should be performed manually.
- Monitor for signs of utilities during advancement of intrusive work (e.g., sudden change in advancement of auger or split spoon).
- When the client or other onsite party is responsible for determining the presence and locations of buried utilities, the SSC should confirm that arrangement.

2.2.12 Working Near Water

When working near water, and there is a risk of drowning:

- U.S. Coast Guard-approved personal flotation devices (PFDs), or life jacket, provided for each employee will be worn.
- PFDs will be inspected before and after each use. Defective equipment will not be used.
- Sampling and other equipment will be used according to the manufacturers' instructions.
- A minimum of one life-saving skiff will be provided for emergency rescue.
- A minimum of one ring buoy with 90 feet of 3/8-inch solid-braid polypropylene (or equal) rope will be provided for emergency rescue.

2.2.13 Working on Water

- Safe means of boarding or leaving a boat or a platform will be provided to prevent slipping and falling.
- Boat/barge must be equipped with adequate railing.
- Employees should be instructed on safe use.
- Work requiring the use of a boat will not take place at night or during inclement weather.
- The boat/barge must be operated according to U.S. Coast Guard regulations (speed, lightning, right-of-way, etc.).
- The engine should be shut off before refueling; do not smoke while refueling.

2.2.14 IDW Drum Sampling

Personnel are permitted to handle and/or sample drums containing investigation-derived waste (IDW) only; handling or sampling other drums requires a plan revision or amendment approved by the CH2M HILL HSM. The following control measures will be taken when sampling drums containing IDW:

- Minimize transportation of drums.
- Sample only labeled drums or drums known to contain IDW.
- Use caution when sampling bulging or swollen drums. Relieve pressure slowly.
- If drums contain, or potentially contain, flammable materials, use non-sparking tools to open.
- Picks, chisels, and firearms may not be used to open drums.
- Reseal bung holes or plugs whenever possible.
- Avoid mixing incompatible drum contents.
- Sample drums without leaning over the drum opening.
- Transfer the content of drums using a method that minimizes contact with material.
- PPE and air monitoring requirements specified in Sections 4 and 5 must address IDW drum sampling.
- Spill-containment procedures specified in Section 7 must be appropriate for the material to be handled.

2.2.15 Confined Space Entry

(Reference CH2M HILL SOP HSE&Q-203, Confined Space Entry)

No confined space entry will be permitted. Confined space entry requires additional health and safety procedures, training, and a permit. If conditions change such that confined-space entry is necessary, contact the HSM to develop the required entry permit.

When planned activities will not include confined-space entry, permit-required confined spaces accessible to CH2M HILL personnel are to be identified before the task begins. The SSC is to confirm that permit spaces are properly posted or that employees are informed of their locations and hazards.

2.2.16 Working Around Material Handling Equipment

- Never approach operating equipment from the rear. Always make positive contact with the operator, and confirm that the operator has stopped the motion of the equipment.
- Never approach the side of operating equipment; remain outside of the swing and turning radius.
- Maintain distance from pinch points of operating equipment.
- Because heavy equipment may not be equipped with properly functioning reverse signal alarms, never turn your back on any operating equipment.
- Never climb onto operating equipment or operate contractor/subcontractor equipment.
- Never ride contractor/subcontractor equipment unless it is designed to accommodate passengers; equipped with firmly attached passenger seat.
- Never work or walk under a suspended load.
- Never use equipment as a personnel lift; do not ride excavator buckets or crane hooks.
- Always stay alert and maintain a safe distance from operating equipment, especially equipment on cross slopes and unstable terrain.

2.3 Biological Hazards and Controls

2.3.1 Snakes

No poisonous snakes are indigenous to Puerto Rico.

2.3.2 Poison Ivy and Poison Sumac

Poison ivy, poison oak, and poison sumac typically are found in brush or wooded areas. They are more commonly found in moist areas or along the edges of wooded areas. Become familiar with the identity of these plants. Wear protective clothing that covers exposed skin and clothes. Avoid contact with plants and the outside of protective clothing. If skin contacts a plant, wash the area with soap and water immediately. If the reaction is severe or worsens, seek medical attention.

2.3.3 Ticks

Ticks typically are in wooded areas, bushes, tall grass, and brush. Ticks are black, black and red, or brown and can be up to one-quarter inch in size. Wear tightly woven light-colored clothing with long sleeves and pant legs tucked into boots; spray **only outside** of clothing

with permethrin or permanone and spray skin with only DEET; and check yourself frequently for ticks.

If bitten by a tick, grasp it at the point of attachment and carefully remove it. After removing the tick, wash your hands and disinfect and press the bite areas. Save the removed tick. Report the bite to human resources. Look for symptoms of Lyme disease or Rocky Mountain spotted fever (RMSF). Lyme: a rash might appear that looks like a bullseye with a small welt in the center. RMSF: a rash of red spots under the skin 3 to 10 days after the tick bite. In both cases, chills, fever, headache, fatigue, stiff neck, and bone pain may develop. If symptoms appear, seek medical attention.

2.3.4 Bees and Other Stinging Insects

Bees and other stinging insects may be encountered almost anywhere and may present a serious hazard, particularly to people who are allergic. Watch for and avoid nests. Keep exposed skin to a minimum. Carry a kit if you have had allergic reactions in the past, and inform the SSC and/or buddy. If a stinger is present, remove it carefully with tweezers. Wash and disinfect the wound, cover it, and apply ice. Watch for allergic reaction; seek medical attention if a reaction develops. "Knock-down" shall be provided to teams working in heavy under-brush or overgrown areas.

2.3.5 Bloodborne Pathogens

(Reference CH2M HILL SOP HSE&Q-202, Blood-borne Pathogens)

Exposure to bloodborne pathogens may occur when rendering first aid or CPR, or when coming into contact with landfill waste or waste streams containing potentially infectious material. Exposure controls and PPE are required as specified in CH2M HILL SOP HS-202, *Bloodborne Pathogens*. Hepatitis B vaccination must be offered before the person participates in a task where exposure is a possibility.

2.3.6 Other Anticipated Biological Hazards

The following paragraphs identify the potential hazards associated with flora and fauna at the EMA. If additional concerns are identified, they will be added to this HASP.

Hazardous Flora

Incidence of contact by individuals to poisonous/thorny plants is high, especially during surface water and sediment sampling activities; therefore, bare skin should be covered (i.e., long pants and shirt, steel toe boots, leather or cotton gloves, safety glasses, and head protection) as much as practical when working in forested or densely vegetated areas. Personnel should avoid entering an area in the direct path of known poisonous flora; a secondary route should be selected. Care should also be taken when walking in such areas as uneven terrain or vines may present a tripping hazard.

While attempting to cut into dense underbrush, hazards exist from the sharp machete and gas-powered weed cutter. Therefore, care should be taken when using such devices. (Note: Hearing protection, steel toe boots, gloves, and safety glasses are required when using weed cutters.) All rashes and other injuries will be reported to the SHSO as soon as they are known.

Several plants on Vieques are known to be skin irritating. They include:

Comocladia dodonaea

- *Comocladia dodonaea* - Commonly known as Christmas-bush, this is a fairly small shrub that has waxy looking leaves that have a small spine at the end of each of them. The leaves can vary in color from green to yellow to red. The sap and residue on the leaves contain a chemical similar to those found in poison ivy but in a higher concentration.

Croton discolor

- *Croton discolor* – This plant is a fairly large bush (up to 7 ft. tall) that looks like it is drying out and doesn't have long to live. There are two species on the island, but both look very similar and have very hairy leafs. The leaves have a tendency to stick to your clothing because of the hairs of the leaves.

Tragia volubilis

- *Tragia volubilis* - This plant is commonly known as Pica-Pica, as well as Cowitch. It is a vine that, if cut or disturbed, will release hairs that can cause skin irritations.

- *Malpighia fucata* – Commonly known as palo bronco, this evergreen shrub (or small tree) is identified by its opposite, blunt-pointed leaves. Upper leaf surfaces are green and lower surfaces are a paler green with many yellowish, needle-like hairs. Flowers have white/pink petals.

- *Cordia rupicola* – This is a small shrub with red fruit. Previously thought to be endemic to Puerto Rico and known only from one area, it has recently been reported from the island of Anegada's wooded hills among low dense brush.

Pictetia aculeate

- *Pictetia aculeate* – Commonly known as tachuelo, gumbo limbo, or turpentine tree, this tree has a reddish, peeling bark and produces an intenely aromatic resin not unlike the pine tree resins that are used to produce true turpentine.

Hippomane Mancinella - Occasional evergreen canopy or subcanopy tree (10-20 m) and an integral component of the vegetation that fringes the sandy coastline. Appreciated for the shade it provides along harsh and hot tropical beaches, this species is at the same time a dangerous one, due to the large quantities of caustic sap contained in its leaves, twigs, bark, and fruit. It's sap produces lesions similar to chemical burns.

Ricinus Communis (Castor Bean) - The "stalked leaves consist of usually **eight** radiating, pointed leaflets with slightly serrated edges and prominent central veins. Many varieties are green, but some are reddish brown."(Cooper and Johnson) The flowers are green and inconspicuous, but pink or red in the pigmented varieties. Many stamens are near the base and branching pistils are near the top of the flower. The soft-spined fruits containing attractively **mottled seeds** are distinctive features of the plant. The seeds from the castor bean plant, *Ricinus communis*, are poisonous to people, animals and insects. One of the main toxic proteins is **"ricin"**, named by Stillmark in 1888 when he tested the beansí extract on red blood cells and saw them agglutinate.

Hazardous Fauna

Mosquitoes and sand flies pose a nuisance and physical hazard to field personnel; they distract workers, leading to accidents, and pose a physical threat by transmitting live microorganisms. Sand fly bites that are repeatedly scratched can cause secondary infections. Avoiding the use of perfumes and scented deodorants and donning light colored clothing is preferable. The use of Avon's "Skin So Soft" or other insect repellent is encouraged

The potential exists to come in contact with other dangerous insects. These include centipedes, fire ants, bees, wasps, hornets, mites, fleas, and spiders. All personnel should perform "checks" on each other periodically and at the end of the work shift, especially when working in grassy or forested areas. All insect bites must be reported to the SSC.

No poisonous snakes are indigenous to Puerto Rico, only nonpoisonous snakes such as the Boa Constrictor. Feral (wild) dogs and cats have been observed.

Mongooses, rats, and mice have been documented to (potentially) carry rabies. There is some evidence that mongooses can be infected with the rabies virus in an attenuated form, allowing them to carry and spread the virus for considerable time before succumbing to the disease. Any observed unusual behavior by mongooses and other mammals must be reported. Signs of rabies can be characterized in two forms. Furious rabies exhibits agitation and viciousness followed by paralysis and death. Dumb rabies exhibits lethargy and paralytic symptoms followed by death. Behavioral indicators for both include fearlessness and change in nocturnal/diurnal rhythms.

Working in wet or swampy areas unprotected shall not be allowed because of the presence of a variety of etiologic (disease-causing) agents. Contact with surface water will be kept to a minimum. There have been several incidents of infection by schistosomes (blood flukes) from contact with surface water. The aquatic snail vector, *Australorbis Glabratus*, transmits the schistosomes into surface waters, predominantly drainage ditches. Even momentary contact (especially in the presence of blisters, cuts, and open sores) with contaminated surface water is sufficient to acquire an infection. Accidental skin contact requires that the area be washed with isopropyl alcohol (as directed by SSC). Symptoms of infection are fever, diarrhea, itchy skin, and central nervous system (CNS) damage. Schistosomiasis is hard to treat; once established in its host, it may remain for several years.

Prior to initiating site activities, each individual shall be questioned as to any known sensitivities to the previously mentioned organisms or agents.

Dengue Fever and Other Illnesses

According to the Centers for Disease Control, **Dengue Fever** is primarily a viral infection transmitted by mosquito bites in residential areas. The mosquitoes are most active during the day, especially around dawn and dusk, and are frequently found in and around human habitations. The illness is flu-like and characterized by sudden onset, high fever, severe headaches, joint and muscle pain, and rash. The rash appears 3 to 4 days after the onset of fever. Since no vaccine or specific treatment exists, prevention is important. To reduce mosquito bites, travelers should wear clothes that cover most of the body. Travelers should also take insect repellent with them to use on any exposed areas of skin. The most effective

repellent is DEET (N,N-diethyl meta-toluamide). Avoid applying high-concentration DEET (greater than 35 percent) products to the skin and refrain from applying repellent to portions of the hands that are likely to come in contact with the eyes and mouth. Rarely, toxic reactions or other problems have developed after contact with DEET. Please note that p**ersonnel performing water sampling should refrain from using DEET because the breakdown products can show up as false positive results in lab analysis.** For greater protection, clothing can be soaked in or sprayed with permethrin, which is an insect repellent licensed for use on clothing. If applied according to directions, permethrin will repel insects from clothing for several weeks.

Traveler's Diarrhea is the most frequent health problem for travelers. It can be caused by viruses, bacteria, or parasites which are found universally throughout the region. Transmission is most often through contaminated food or water. Purchase food and beverages from vendors that are professional. Avoid small roadside stands and drink bottled beverages when possible. The use of over-the-counter or prescriptions medications can reduce the length of the attack.

Hepatitis A is a viral infection of the liver transmitted by the fecal oral route; through direct person to person contact; from contaminated water, ice, or shellfish; or from fruits or uncooked vegetables contaminated through handling. Symptoms include fatigue, fever, loss of appetite, nausea, dark urine, jaundice, vomiting, aches and pains, and light stools. No specific therapy exists, and only supportive care is available. The virus is inactivated by boiling or cooking to 85 degrees centigrade for 1 minute; therefore, eating thoroughly cooked foods and drinking only treated water serve as general precautions. CDC recommends hepatitis A vaccine as a precaution. When sampling wastewater, or wastewater lagoon soils, wear gloves and decontaminate all sampling tools and any items immersed very carefully.

2.3.7 Fire ant bites

Fire ants typically build mounds on the land surface that are usually easy to identify. Avoid disturbing these mounds. A bite from a fire ant can be painful but rarely is life threatening. However, it is possible that the bite could cause an allergic reaction. If bitten, check for symptoms of an allergic reaction such as weakness, nausea, vomiting, dizziness, or shortness of breath. If symptoms appear, seek medical attention.

2.4 Radiological Hazards and Controls

Refer to CH2M HILL's Corporate Health and Safety Program, Program and Training Manual, and Corporate Health and Safety Program, Radiation Protection Program Manual, for standards of practice in contaminated areas.

Hazards	Controls
None Known	None Required

2.5 Contaminants of Concern

Specific contaminants of concern (COCs) are unknown at this time because only limited field work has been done at the site. Because live ordnance has been used at the site, the presence of explosive compounds such as trinitrotoluene (TNT) is possible in at least one location. However, the following three contaminants have been detected at a site (SWMU 3) on Vieques Island:

- Benzene
- Chloroform
- Selenium

Although SWMU 3 is not being investigated as part of this project, all samples will be analyzed for these three contaminants. Other contaminants of potential concern (COPCs) include the following general categories of waste:

- Paints/Adhesives
- Waste Solvents/Fuels
- Spent Batteries/Battery Acid
- Waste Oils

2.5.1 Paint/Adhesives

There are various kinds of paints and adhesives. Generally, the main health concern is from volatile organic compounds (VOCs). The physical hazard associated with this group is flammability. Many symptoms of overexposure to VOCs exist, including: mucous membrane irritation, coughing, nausea and vomiting, dizziness, confusion, and unconsciousness.

2.5.2 Waste Solvents/Fuels

The greatest physical hazard associated with many solvents is a result of their flammability. Solvents may cause dermatitis and dry skin (with prolonged exposure), and are poisonous if ingested. Inhalation causes narcosis, a feeling of light-headedness, dizziness or euphoria, as well as headaches and nausea. Long-term exposure from ingestion or inhalation can lead to kidney and liver damage.

Contact with lighter fuels causes rapid drying of the skin, leading to chapping, cracked skin, and dermatitis. Vapors are irritating to eyes, nose, and throat. Inhalation leads to dizziness, nausea, and headaches. Ingestion is poisonous, causes damage to central nervous system, kidneys, and liver.

2.5.3 Spent Batteries/Battery Acid

Skin and eyes can be burned from direct contact with acid. Inhaled acid fumes can burn the respiratory tract, including mouth, nose, throat, and lungs. Lungs burned with acid fumes often develop pulmonary edema, a condition where the lungs fill with fluid, making breathing difficult.

2.5.4 Waste Oils

Waste oils will cause skin irritation from prolonged contact, and are generally toxic if ingested. The physical hazard associated with oil is due to combustibility.

The data presented in a chemical/material data sheet reflect the chemical and toxicological properties of the specific compound in a pure, non-diluted state. As such, when these compounds are detected in environmental media (i.e, soil, groundwater, sediment, and surface water), the hazards are anticipated to be substantially less than those associated with exposure to "pure" compounds. The data presented in these data sheets will, therefore, be utilized as reference information when questions arise as to a constituent's chemical and toxicological properties or measures for emergency response.

2.5.5 Contaminants of Concern

(Refer to Project Files for more detailed contaminant information)

Contaminant	Location and Maximum[a] Concentration (ppm)	Exposure Limit[b]	IDLH[c]	Symptoms and Effects of Exposure	PIP[d] (eV)
Benzene	GW: SB: SS:	1 ppm	500 Ca	Eye, nose, skin, and respiratory irritation; headache; nausea; dermatitis; fatigue; giddiness; staggered gait; bone marrow depression	9.24
Chloroform	GW: SB: SS:	2 ppm	500 Ca	Dizziness, mental dullness, nausea, confusion, disorientation, headache, fatigue, eye and skin irritation, anesthesia, enlarged liver	11.42
Selenium	GW: SB: SS:	0.2 mg/m^3	1 mg/m^3	Irritation eyes, skin, nose, throat; visual disturbance; headache; chills; fever; bronchitis; metallic taste; garlic breath; GI disturbance; dermatitis; eye, skin burns	NA
Sulfuric Acid (Battery Acid)	GW: SB: SS:	1 mg/m^3	15 mg/m^3	Irritation eyes, skin, nose, throat; pulmonary edema; bronchitis; dental erosion; eye, skin burns; dermatitis	NA
Toluene	GW: SB: SS:	50 ppm	500	Eye and nose irritation, fatigue, weakness, confusion, dizziness, headache, dilated pupils, excessive tearing, nervousness, muscle fatigue, paresthesia, dermatitis, liver and kidney damage	8.82

Footnotes:

[a] Specify sample-designation and media: SB (Soil Boring), A (Air), D (Drums), GW (Groundwater), L (Lagoon), TK (Tank), S (Surface Soil), SL (Sludge), SW (Surface Water).

[b] Appropriate value of PEL, REL, or TLV listed.

[c] IDLH = immediately dangerous to life and health (units are the same as specified "Exposure Limit" units for that contaminant); NL = No limit found in reference materials; CA = Potential occupational carcinogen.

[d] PIP = photoionization potential; NA = Not applicable; UK = Unknown.

2.6 Potential Routes of Exposure

Dermal: Contact with contaminated media. This route of exposure is minimized through proper use of PPE, as specified in Section 4.	**Inhalation:** Vapors and contaminated particulates. This route of exposure is minimized through proper respiratory protection and monitoring, as specified in Sections 4 and 5, respectively.	**Other:** Inadvertent ingestion of contaminated media. This route should not present a concern if good hygiene practices are followed (e.g., wash hands and face before drinking or smoking).

3 Project Organization and Personnel

3.1 CH2M HILL Employee Medical Surveillance and Training

(Reference CH2M HILL SOPs HSE&Q-113, Medical Monitoring, and HE&Q- 110, Training)

The employees listed below are enrolled in the CH2M HILL Comprehensive Health and Safety Program and meet state and federal hazardous waste operations requirements for 40-hour initial training, 3-day on-the-job experience, and 8-hour annual refresher training. Employees designated "SSC" have completed a 12-hour site safety coordinator course, and have documented requisite field experience. An SSC with a level designation (D, C, B) equal to or greater than the level of protection being used must be present during all tasks performed in exclusion or decontamination zones. Employees designated "FA-CPR" are currently certified by the American Red Cross, or equivalent, in first aid and CPR. At least one FA-CPR designated employee must be present during all tasks performed in exclusion or decontamination zones. The employees listed below are currently active in a medical surveillance program that meets state and federal regulatory requirements for hazardous waste operations. Certain tasks (e.g., confined-space entry) and contaminants (e.g., lead) may require additional training and medical monitoring.

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Employee Name	Office	Responsibility	SSC/FA-CPR
Field teams will be determined on a task by task basis and listed in the task specific HSP Addendum.			

3.2 Field Team Chain of Command and Communication Procedures

3.2.1 Client

Contact Name: Madeline Rivera, Vieques Site Manager, NAPR
Phone: (787) 865-4152 ext. 460
Facility Contact Name: N/A
Phone: N/A

3.2.2 CH2M HILL

Project Manager: Brett Doerr/VBO
Health and Safety Manager: Michael Goldman/ATL
Field Team Leader: Determined on a task-by-task basis

Site Safety Coordinator: Determined on a task-by-task basis

SSC is responsible for contacting Field Team Leader and Project Manager. In general, Project Manager will contact client. The Health and Safety Manager should be contacted as appropriate.

3.2.3 CH2M HILL Subcontractors

(Reference CH2M HILL SOP HSE&Q 215, Contracts, Subcontracts and HSE&Q Management Practices)

Subcontractor: To be determined for Drilling, Surveying, and Surface Geophysics.
Subcontractor Contact Name: N/A
Telephone: N/A

Certain subcontractors (drilling, remedial and construction contractors) are required to be pre-qualified for safety by completing the **Subcontractor Safety Performance Questionnaire (Attachment 4).** The subcontractors listed above are covered by this HSP and must be provided a copy of this plan. However, this plan does not address hazards associated with the tasks and equipment in which the subcontractor has expertise (e.g., drilling, excavation work, electrical). Subcontractors are responsible for the health and safety procedures specific to their work, and are required to submit these procedures to CH2M HILL for review before the start of field work by following the **Subcontractor Safety Procedure Criteria** specific to their work **(Attachment 5)**. Subcontractors must comply with the established health and safety plan(s). The CH2M HILL SSC should verify that subcontractor employee training, medical clearance, and fit test records are current and must monitor and enforce compliance with the established plan(s). CH2M HILL's oversight does not relieve subcontractors of their responsibility for effective implementation and compliance with the established plan(s).

CH2M HILL should continuously endeavor to observe subcontractors' safety performance. This endeavor should be reasonable, and include observing for hazards or unsafe practices that are both readily observable and occur in common work areas. CH2M HILL is not responsible for exhaustive observation for hazards and unsafe practices. In addition to this level of observation, the SSC is responsible for confirming CH2M HILL subcontractor performance against both the subcontractor's safety plan and applicable self-assessment checklists**. Self-assessment checklists** contained in **Attachment 6** are to be used by the SSC to review subcontractor performance.

Health and safety related communications with CH2M HILL subcontractors should be conducted as follows:

- Brief subcontractors on the provisions of this plan, and require them to sign the Employee Signoff Sheet included in Attachment 1.

- Request subcontractor(s) to brief the project team on the hazards and precautions related to their work.

- When apparent non-compliance/unsafe conditions or practices are observed, notify the subcontractor safety representative and require corrective action; the subcontractor is responsible for determining and implementing necessary controls and corrective actions.

- When repeat non-compliance/unsafe conditions are observed, notify the subcontractor safety representative and stop affected work until adequate corrective measures are implemented.

- When an apparent imminent danger exists, immediately remove all affected CH2M HILL employees and subcontractors, notify subcontractor safety representative, and stop affected work until adequate corrective measures are implemented. Notify the Project Manager and HSM as appropriate.

- Document all oral health and safety related communications in project field logbook, daily reports, or other records.

3.2.4 Contractors

(Reference CH2M HILL SOP HS-215, Contracts, Subcontracts and HSE&Q Management Practices.)

Contractor: Not applicable at this time.
Contractor Contact Name: N/A
Telephone: N/A

This plan does not address contractors that are contracted directly to the client or the owner. CH2M HILL is not responsible for the health and safety or means and methods of the contractor's work, and we must never assume such responsibility through our actions (e.g., advising on health and safety issues). In addition to this plan, CH2M HILL staff should review contractor safety plans so that we remain aware of appropriate precautions that apply to us. Except in unusual situations when conducted by the HSM, CH2M HILL must never comment on or approve contractor safety procedures. Self-assessment checklists contained in Attachment 5 are to be used by the SSC to review the contractor's performance ONLY as it pertains to evaluating our exposure and safety.

Health and safety-related communications with contractors should be conducted as follows:

- Request the contractor to brief CH2M HILL employees and subcontractors on the precautions related to the contractor's work.
- When an apparent contractor non-compliance/unsafe condition or practice poses a risk to CH2M HILL employees or subcontractors:
  - Notify the contractor safety representative
  - Request that the contractor determine and implement corrective actions
  - If needed, stop affected CH2M HILL work until contractor corrects the condition or practice. Notify the client, Project Manager, and HSM as appropriate.

- If apparent contractor non-compliance/unsafe conditions or practices are observed, inform the contractor safety representative. Our obligation is limited strictly to informing the contractor of our observation; the contractor is solely responsible for determining and implementing necessary controls and corrective actions.
- If an apparent imminent danger is observed, immediately warn the contractor employee(s) in danger and notify the contractor safety representative. Our obligation is limited strictly to immediately warning the affected individual(s) and informing the contractor of our observation; the contractor is solely responsible for determining and implementing necessary controls and corrective actions.
- Document all oral health and safety related communications in project field logbook, daily reports, or other records.

4 Personal Protective Equipment (PPE)

(Reference CH2M HILL SOP HSE&Q- 117, Personal Protective Equipment and, HSE&Q-121, Respiratory Protection)

PPE Specifications [a]

Task	Level	Body	Head	Respirator [b]
General site entry Surveying Observation of material loading for offsite disposal Oversight of remediation and construction	D	Work clothes; steel-toe, leather work boots; work glove.	Hardhat [c] Safety glasses Ear protection [d]	None required
Surface water sampling Aquifer testing Sediment sampling Surface soil sampling Hand augering Geoprobe boring	Modified D	Work clothes or cotton coveralls **Boots:** Steel-toe, chemical-resistant boots OR steel-toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Safety glasses Ear protection [d]	None required
Groundwater sampling Soil boring Investigation-derived waste (drum) sampling and disposal	Modified D	**Coveralls:** Uncoated Tyvek® **Boots:** Steel-toe, chemical-resistant boots OR steel-toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] Safety glasses Ear protection [d]	None required.
Tasks requiring upgrade	C	**Coveralls:** Polycoated Tyvek® **Boots:** Steel-toe, chemical-resistant boots OR steel-toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] Ear protection [d] Spectacle inserts	APR, full face, MSA Ultratwin or equivalent; with GME-H cartridges or equivalent[e].

Reasons for Upgrading or Downgrading Level of Protection

Upgrade[f]	Downgrade
• Request from individual performing tasks. • Change in work tasks that will increase contact or potential contact with hazardous materials. • Occurrence or likely occurrence of gas or vapor emission. • Known or suspected presence of dermal hazards. • Instrument action levels (Section 5) exceeded.	• New information indicating that situation is less hazardous than originally thought. • Change in site conditions that decreases the hazard. • Change in work task that will reduce contact with hazardous materials.

[a] Modifications are as indicated. CH2M HILL will provide PPE only to CH2M HILL employees.
[b] No facial hair that would interfere with respirator fit is permitted.
[c] Hardhat and splash-shield areas are to be determined by the SSC.
[d] Ear protection should be worn when conversations cannot be held at distances of 3 feet or less without shouting.
[e] Cartridge change-out schedule is at least every 8 hours (or one work day), except if relative humidity is > 85%, or if organic vapor measurements are > midpoint of Level C range (refer to Section 5)--then at least every 4 hours. If encountered conditions are different than those anticipated in this HSP, contact the HSM.
[f] Performing a task that requires an upgrade to a higher level of protection (e.g., Level D to Level C) is permitted only when the PPE requirements have been approved by the HSM, and an SSC qualified at that level is present.

5 Air Monitoring/Sampling

Personal air monitoring will occur during drilling of soil borings and monitoring wells as described on the table below. Monitoring will occur initially and periodically during the tasks, as determined by the SCC.

5.1 Air Monitoring Specifications

Instrument	Tasks	Action Levels[a]		Frequency [b]	Calibration
PID: OVM with 10.6eV lamp or equivalent	Sites with Organic contamination	0 – 1 ppm >1 – 5 ppm > 5 ppm	Level D Level C Evacuate work area and contact HSM	Initially and periodically during task	Daily
Detector Tube: Drager benzene specific 0.5/c (0.5 to 10 ppm range) with pre-tube, or equivalent	When positive PID indications >1 ppm	<0.5 ppm 0.5-1 ppm >1 ppm	Level D Level C Evacuate work area and contact HSM	Initially and periodically when PID/FIB >1 ppm	Not applicable

[a] **Action levels apply to sustained breathing-zone measurements (2 minute duration) above background.**
[b] The exact frequency of monitoring depends on field conditions and is to be determined by the SSC; generally, every 5 to 15 minutes if acceptable; more frequently may be appropriate. Monitoring results should be recorded. Documentation should include instrument and calibration information, time, measurement results, personnel monitored, and place/location where measurement is taken (e.g., "Breathing Zone/MW-3", "at surface/SB-2", etc.).

5.2 Calibration Specifications

(Refer to the respective manufacturer's instructions for proper instrument-maintenance procedures)

Instrument	Gas	Span	Reading	Method
PID: OVM, 10.6 or 11.8 eV bulb	100 ppm isobutylene	RF = 1.0	100 ppm	1.5 lpm reg T-tubing
PID: MiniRAE, 10.6 eV bulb	100 ppm isobutylene	CF = 100	100 ppm	1.5 lpm reg T-tubing

5.3 Air Sampling

Sampling, in addition to real-time monitoring, may be required by other Occupational Safety and Health Administration (OSHA) regulations where there may be exposure to certain contaminants. Air sampling typically is required when site contaminants include lead, cadmium, arsenic, asbestos, and certain VOCs. Contact the HSM immediately if these contaminants are encountered.

Method Description

N/A

Personnel and Areas

Results must be sent immediately to the HSM. Regulations may require reporting to monitored personnel. Results reported to:

HSM: N/A
Other: N/A

6 Decontamination

(Reference CH2M HILL SOP HSE&Q-506, Decontamination)

The SSC must establish and monitor the decontamination procedures and their effectiveness. Decontamination procedures found to be ineffective will be modified by the SSC. The SSC must ensure that procedures are established for disposing of materials generated on the site. When sampling SWMU 10, former wastewater lagoons, be sure to wear gloves and decontaminate sampling tools very carefully. Avoid direct contact with soils or water.

6.1 Decontamination Specifications

Personnel	Sample Equipment	Heavy Equipment
• Boot wash/rinse • Glove wash/rinse • Outer-glove removal • Body-suit removal • Inner-glove removal • Respirator removal • Hand wash/rinse • Face wash/rinse • Shower ASAP • Dispose of PPE in municipal trash, or contain for disposal • Dispose of personnel rinse water to facility or sanitary sewer, or contain for offsite disposal	• Wash/rinse equipment • Solvent-rinse equipment • Contain solvent waste for offsite disposal	• Power wash • Steam clean • Dispose of equipment rinse water to facility or sanitary sewer, or contain for offsite disposal

6.2 Diagram of Personnel-Decontamination Line

No eating, drinking, or smoking is permitted in contaminated areas and in exclusion or decontamination zones. The SSC should establish areas for eating, drinking, and smoking. Contact lenses are not permitted in exclusion or decontamination zones.

Figure 6-1 illustrates a conceptual establishment of work zones, including the decontamination line. Work zones are to be modified by the SSC to accommodate task-specific requirements.

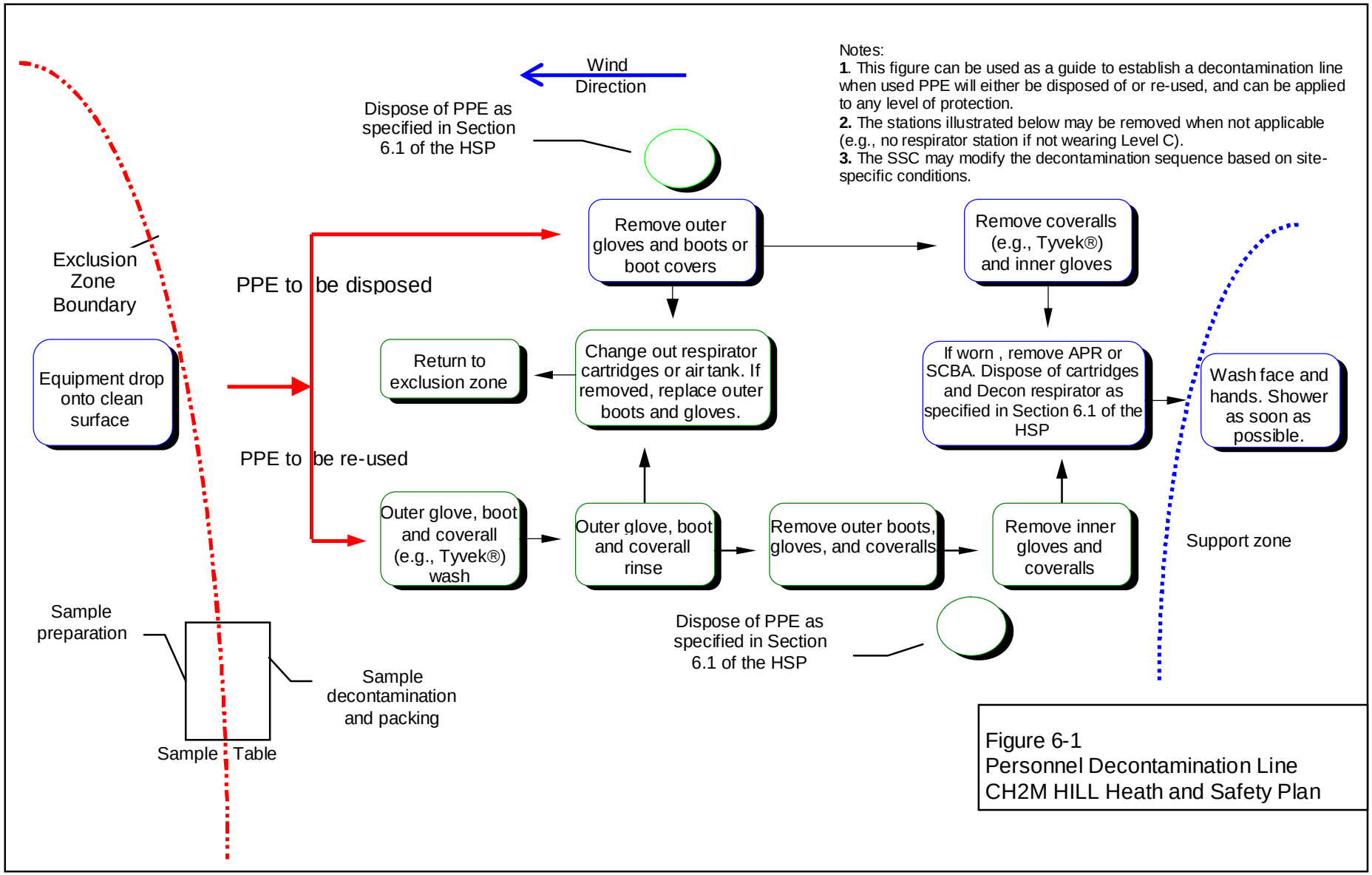


Figure 6-1
Personnel Decontamination Line
CH2M HILL Heath and Safety Plan

7 Spill-Containment Procedures

This Spill Prevention and Control Plan establishes minimum site requirements. Subcontractors are responsible for spill prevention and control related to their operations. Subcontractors written spill prevention and control procedures must be consistent with this plan. All spills must be reported to your supervisor, the site manager, and the Contract Manager.

7.1 Spill Prevention

All fuel and chemical storage areas will be properly protected from onsite and offsite vehicle traffic. Fuel storage tanks must be equipped with secondary containment. Fuel tanks must be inspected daily for signs of leaks. Accumulated water must be inspected for signs of product before discharge.

Incidental chemical products must be properly stored, transferred, and used in a safe manner. Should chemical product use occur outside areas equipped with spill control materials, adequate spill control materials must be maintained

7.2 Spill Containment and Control

Spill control materials will be maintained in the support zone and at fuel storage and dispensing locations. Incidental spills will be contained with sorbent and disposed of properly. Spilled materials must be contained and controlled immediately. Spill response procedures include:

- Immediately warn any nearby personnel and notify the work supervisor
- Assess the spill area to ensure that it is safe to approach
- Activate site evacuation signal if spill presents an emergency
- Ensure that any nearby ignition sources are immediately eliminated
- If it can be done safely, stop the source of the spill
- Establish site control for the spill area
- Use proper PPE in responding to the spill
- Contain and control spilled material through the use of sorbent booms, pads, or other materials

7.3 Spill Clean-up and Removal

All spilled material, contaminated sorbent, and contaminated media will be cleaned up and removed as soon as possible. Contaminated spill material will be drummed, labeled, and properly stored until material is disposed of. Contaminated material will be disposed of according to applicable federal, state, and local requirements. Contact the regulatory compliance person for the project or the program for assistance.

8 Site-Control Plan

8.1 Site-Control Procedures

(Reference CH2M HILL SOP HSE&Q-510, Site Control)

- The SSC will conduct a site safety briefing (see below) before starting field activities or as tasks and site conditions change.
- Topics for briefing on site safety: general discussion of Health and Safety Plan, site-specific hazards, locations of work zones, PPE requirements, equipment, special procedures, emergencies.
- The SSC records attendance at safety briefings in a logbook and documents the topics discussed.
- Post the OSHA job-site poster in a central and conspicuous location in accordance with CH2M HILL SOP HS-71, *OSHA Postings*.
- Establish support, decontamination, and exclusion zones. Delineate with flags or cones as appropriate. Support zone should be upwind of the site. Use access control at entry and exit from each work zone.
- Establish onsite communication consisting of the following:
  - Line-of-sight and hand signals
  - Air horn
  - Two-way radio or cellular telephone if available
- Establish offsite communication.
- Establish and maintain the "buddy system."
- Initial air monitoring is conducted by the SSC in appropriate level of protection.
- The SCC is to conduct periodic inspections of work practices to determine the effectiveness of this plan – refer to Sections 2 and 3. Deficiencies are to be noted, reported to the HSM, and corrected.

8.2 Hazwoper Compliance Plan

(Reference CH2M HILL SOP HSE&Q-220, Written Plans)

Certain parts of the site work are covered by state or federal Hazwoper standards and therefore require training and medical monitoring. Anticipated Hazwoper tasks (Section 1.1.1) might occur consecutively or concurrently with respect to non-Hazwoper tasks. This section outlines procedures to be followed when approved activities specified in Section 1.1.2 do not require 24- or 40-hour training. Non-Hazwoper-trained personnel also must be trained in accordance with all other state and federal OSHA requirements.

- In many cases, air sampling, in addition to real-time monitoring, must confirm that there is no exposure to gases or vapors before non-Hazwoper-trained personnel are allowed on the site, or while non-Hazwoper-trained staff are working in proximity to Hazwoper activities. Other data (e.g., soil) also must document that there is no potential for

exposure. The HSM must approve the interpretation of these data. Refer to subsections 2.5 and 5.3 for contaminant data and air sampling requirements, respectively.

- When non-Hazwoper-trained personnel are at risk of exposure, the SSC must post the exclusion zone and inform non-Hazwoper-trained personnel of the:
  - nature of the existing contamination and its locations
  - limitations of their access
  - emergency action plan for the site
- Periodic air monitoring with direct-reading instruments conducted during regulated tasks also should be used to ensure that non-Hazwoper-trained personnel (e.g., in an adjacent area) are not exposed to airborne contaminants.
- When exposure is possible, non-Hazwoper-trained personnel must be removed from the site until it can be demonstrated that there is no longer a potential for exposure to health and safety hazards.
- Remediation treatment system start-ups: Once a treatment system begins to pump and treat contaminated media, the site is (for the purposes of applying the Hazwoper standard) considered a treatment, storage, and disposal facility (TSDF). Therefore, once the system begins operation, only Hazwoper-trained personnel (minimum of 24 hours of training) will be permitted to enter the site. All non-Hazwoper-trained personnel must not enter the TSDF area of the site.

9 Emergency Response Plan

(Reference CH2M HILL, SOP HSE&Q-106, Emergency Planning)

9.1 Pre-Emergency Planning

The SSC performs the applicable pre-emergency planning tasks before starting field activities and coordinates emergency response with CH2M HILL onsite parties, the facility, and local emergency-service providers as appropriate. Refer to the Vieques Security Plan for additional instructions on emergency procedures.

- Review the facility emergency and contingency plans where applicable.
- Determine what onsite communication equipment is available (e.g., two-way radio, air horn).
- Determine what offsite communication equipment is needed (e.g., nearest telephone, cell phone).
- Confirm and post emergency telephone numbers, evacuation routes, assembly areas, and route to hospital; communicate the information to onsite personnel.
- Field Trailers: Post "Exit" signs above exit doors, and post "Fire Extinguisher" signs above locations of extinguishers. Keep areas near exits and extinguishers clear.
- Review changed site conditions, onsite operations, and personnel availability in relation to emergency response procedures.
- Where appropriate and acceptable to the client, inform emergency room and ambulance and emergency response teams of anticipated types of site emergencies.
- Designate one vehicle as the emergency vehicle; place hospital directions and map inside; keep keys in ignition during field activities.
- Inventory and check site emergency equipment, supplies, and potable water.
- Communicate emergency procedures for personnel injury, exposures, fires, explosions, and releases.
- Rehearse the emergency response plan before site activities begin, including driving route to hospital.
- Brief new workers on the emergency response plan.

The SSC will evaluate emergency response actions and initiate appropriate follow-up actions.

9.2 Emergency Equipment and Supplies

The SSC should mark the locations of emergency equipment on the site map and post the map.

Emergency Equipment and Supplies	Location
20 LB (or two 10-lb) fire extinguisher (A, B, and C classes)	Support Zone/Heavy Equipment
First aid kit	Support Zone/Field Vehicle
Eye wash	Support & Decon Zone/Field Vehicle
Potable water	Support & Decon Zone/Field Vehicle
Bloodborne-pathogen kit	Support Zone/Field Vehicle
Additional equipment (specify):	N/A

9.3 Incident Response

In fires, explosions, or chemical releases, actions to be taken include the following:

- Shut down CH2M HILL operations and evacuate the immediate work area.
- Notify appropriate response personnel.
- Account for personnel at the designated assembly area(s).
- Assess the need for site evacuation, and evacuate the site as warranted.

Instead of implementing a work-area evacuation, note that small fires or spills posing minimal safety or health hazards may be controlled.

9.4 Emergency Medical Treatment

The procedures listed below may also be applied to non-emergency incidents. Injuries and illnesses (including overexposure to contaminants) must be reported to Human Resources. If there is doubt about whether medical treatment is necessary, or if the injured person is reluctant to accept medical treatment, contact the CH2M HILL medical consultant. During non-emergencies, follow these procedures as appropriate.

- Notify appropriate emergency response authorities listed in Section 9.8 (e.g., 911).
- The SSC will assume charge during a medical emergency until the ambulance arrives or until the injured person is admitted to the emergency room.
- Prevent further injury.
- Initiate first aid and CPR where feasible.
- Get medical attention immediately.
- Perform decontamination where feasible; lifesaving and first aid or medical treatment take priority.
- Make certain that the injured person is accompanied to the emergency room.
- When contacting the medical consultant, state that the situation is a CH2M HILL matter, and give your name and telephone number, the name of the injured person, the extent of the injury or exposure, and the name and location of the medical facility where the injured person was taken.
- Report incident as outlined in Section 9.7.

9.5 Evacuation

- Evacuation routes and assembly areas (and alternative routes and assembly areas) are specified on the site map and in the Vieques Security Plan.
- Evacuation route(s) and assembly area(s) will be designated by the SSC before work begins.
- Personnel will assemble at the assembly area(s) upon hearing the emergency signal for evacuation.
- The SSC and a "buddy" will remain on the site after the site has been evacuated (if safe) to assist local responders and advise them of the nature and location of the incident.
- The SSC will account for all personnel in the onsite assembly area.
- A designated person will account for personnel at alternate assembly area(s).
- The SSC will write up the incident as soon as possible after it occurs and submit a report to the Corporate Director of Health and Safety.

9.6 Evacuation Signals

Signal	Meaning
Grasping throat with hand	Emergency-help me.
Thumbs up	OK; understood.
Grasping buddy's wrist	Leave area now.
Continuous sounding of horn	Emergency; leave site now.

9.7 Incident Notification and Reporting/Injury Management

- In the event of an emergency, immediately call….. **911.**
  - Severe Bleeding
  - Loss of consciousness
  - Chest Pain
  - Broken bones

- All other injuries or illness' (even those that are minor and may only require First Aid) which occur at work, while on business travel or commute must be reported to your supervisor and the Vieques ERP PM immediately.
- After informing their supervisor and the PM, the injured employee calls CH2M HILL's contracted Occupational Nurse.

24-hour CH2M HILL Emergency Nurse Assistance

800/756-1130

- The Occupational Injury Nurse listens to the injured employee to understand the injury/illness.
- Employee is provided guidance on appropriate treatment options (triage).
- If instructed to visit a medical facility by the Occupational Nurse, the Supervisor is responsible for instructing the injured employee to take a copy of the **CH2M HILL Initial**

Medical Treatment Form (Attachment # 12) with them to the physician, clinic or hospital.

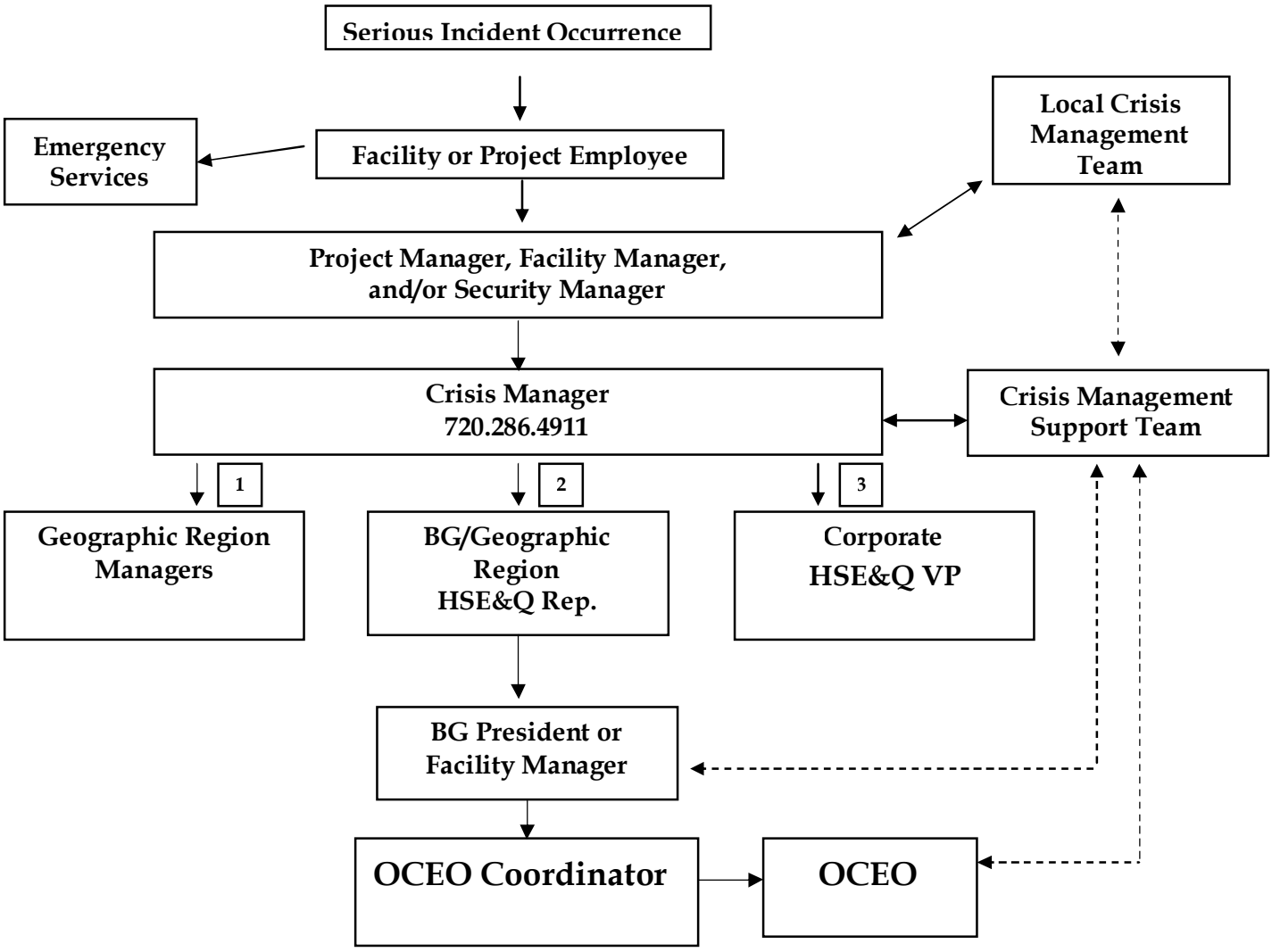
- Appropriate treatment details are handled by the Occupational Injury Nurse, and Workers Compensation Groups.
- Nurse communicates and troubleshoots with and for employee through full recovery.
- Upon any project incident (fire, spill, injury, near miss, death, etc.), immediately notify the PM and HSM. Call emergency pager number if HSM is unavailable.
- For CH2M HILL work-related injuries or illnesses, contact and help Human Resources administrator complete an Incident Report Form (IRF). IRF must be completed within 24 hours of incident.
- For CH2M HILL subcontractor incidents, complete the Subcontractor Accident/Illness Report Form and submit to the HSM.
- Notify and submit reports to NAVFAC as required in contract.

HSE&Q-111 Incident Reporting and Investigation, is incorporated in this plan as Attachment 10. HSE&Q-601 Serious Incident Reporting Process, is incorporated in this plan as Attachment 11. HSE&Q-124 Injury Management/Return-to-Work, is incorporated as Attachment 12.

9.8 Serious Incident Reporting

- Serious Incidents must be reported in accordance with CH2M HILL Standard of Practice HSE-601, *Serious Incident Reporting Process* (Attachment 11 to this plan), immediately. Serious incidents are those that involve any of the following:
  - Work related death, or life threatening injury or illness of a CH2M HILL employee, subcontractor, or member of the public
  - Kidnap/missing person
  - Acts or threats of terrorism
  - Event that involves a fire, explosion, or property damage that requires a site evacuation or is estimated to result in greater than $ 500,000 in damage.
  - Spill or release of hazardous materials or substances that involves a significant threat of imminent harm to site workers, neighboring facilities, the community or the environment

Serious Incident Notification Chart



Legend:

Direct line of communication

Indirect line of communication

9.9 Emergency Contacts

24-hour CH2M HILL Occupational Nurse: (800) 756-1130

Medical Emergency – 911
911 Operators on Vieques DO speak English
Local Ambulance #:911
Hospital (Non-Emergency) #(787)-741-2151
(In life threatening emergencies only, call (787) 765-3944 (air ambulance).

CH2M HILL Medical Consultant
Health Resources
Dr. Jerry H. Berke, M.D., M.P.H.
600 West Cummings Park, Suite 3400
Woburn, MA 01801-6350
1-781-938-4653 After hours: 1-800-350-4511
(After hours calls will be returned within 20 minutes)

Fire/Spill Emergency -- 911
Facility Fire Response #: 911
Local Fire Dept #: (787)-741-2111

Local Occupational Physician
NA Additional Ambulance No. 787-741-8261
This no. is for emergency services.

Security & Police – 911
Facility Security #: (787) 457-0082
Billy Wolfrum (FWS)
Local Police #: (787)-741-2020

Chief Health, Safety, Environment &Quality Officer and Senior VP:
Name: Keith Christopher/WDC
Phone: (703) 471-1441

Utilities Emergency
Water: NA
Gas: NA
Electric: NA

Health and Safety Managers (HSM)
Name: Michael Goldman
Phone: 770/604-9182 (office) ext 396; Cell (770) 331-3127; Home 404/872-6081
Name: Steve Beck
Phone: 414/272-1052, ext. 277

Site Safety Coordinator (SSC)
Name: TBD on task-by-task basis
Kenji Butler, Lisa Carter, or Jaydeep Saythe
Phone: (813) 874-0777 -

Regional Human Resources Department
Name: Mary Jo Jordan
Phone: 352/335-5877

Project Manager
Name: Brett Doerr
Phone: (757)348-8409 (cell)

Corporate Human Resources Department
Name: John Monark/COR
Phone: 303/771-0900

Federal Express Dangerous Goods Shipping
Phone: 800/238-5355
CH2M HILL Emergency Number for Shipping Dangerous Goods
Phone: 800/255-3924

Worker's Compensation and Auto Claims
Zurich Insurance Company: (800) 382-2150
Report fatalities AND report vehicular accidents involving pedestrians, motorcycles, or more than two cars.

Facility Alarms: None **Evacuation Assembly Area(s):** TBD at the site

Facility/Site Evacuation Route(s): See Vieques Security Plan

Hospital Name/Address: Vieques Hospital/Centro de Salud Familiar Susana Centeno
Address: Carr. 997 Kilometer 1 Ht. 0
Bo. Destino, Vieques, Puerto Rico

Hospital Phone #: (787) 741-2151

Directions to Hospital

Off Road 997, next to the Fire Department. North of Camp Garcia, and south grade school.

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10 Behavior Based Loss Prevention System

A Behavior Based Loss Prevention System (BBLPS) has been implemented on this project. BBLPS is a system to prevent or reduce losses using behavior-based tools and proven management techniques to focus on behaviors or acts that could lead to losses.

The four basic Loss Prevention tools that will be used to implement the BBLPS on this project include:

- Job Hazard Analysis (JHA)
- Pre-Task Safety Plans (PTSP)
- Safe Work Observations (SWO)
- Loss and Near Loss Investigations (NLI)

The ERP Site Manager serves as the Safety Coordinator (SC) and is responsible for implementing the BBLPS on the project site. When a separate individual is assigned as the SC, the SC is delegated authority from the ERP Site Manager to implement the BBLPS on the project site, but the ERP Site Manager remains accountable for it's implementation. The ERP Site Manager/Safety Coordinator shall only oversee the subcontractor's implementation of their AHAs and PTSPs processes on the project.

10.1 Job Hazard Analysis

A Job Hazard Analysis (JHA) defines the activity being performed, the hazards posed and control measures required to perform the work safely. Workers are briefed on the AHA before doing the work and their input is solicited prior, during and after the performance of work to further identify the hazards posed and control measures required.

Job Hazard Analysis will be prepared before beginning each project activity posing H&S hazards to project personnel using the JHA form provided in Attachment 8. The JHA shall identify the work tasks required to perform each activity, along with potential H&S hazards and recommended control measures for each work task. In addition, a listing of the equipment to be used to perform the activity, inspection requirements and training requirements for the safe operation of the equipment listed must be identified.

A JHA shall be prepared for all field activities performed by CH2M HILL and subcontractor during the course of the project by the MRP Site Manager/SSC. Hazard Controls (Section 2) of the HSP, the Hazard Analysis Table (Table B-1), and applicable CH2M HILL Standards of Practice (SOPs) should be used as a basis for preparing these JHAs.

CH2M HILL subcontractors will be required to provide JHA's specific to their scope of work on the project for acceptance by CH2M HILL. Each subcontractor shall submit JHAs for their field activities, as defined in their work plan/scope of work, along with their project-specific HSP. Additions or changes in CH2M HILL or subcontractor field activities, equipment, tools or material to perform work or additional/different hazard encountered

that require additional/different hazard control measures requires either a new JHA to be prepared or an existing JHA to be revised.

10.2 Pre-Task Safety Plans

Daily safety meetings are held with all project personnel in attendance to review the hazards posed and required H&S procedures/JHAs that apply for each day's project activities. The PTSPs serve the same purpose as these general assembly safety meetings, but the PTSPs are held between the crew supervisor and their work crews to focus on those hazards posed to individual work crews. At the start of each day's activities, the crew supervisor completes the **PTSP, provided in Attachment 8**, with input from the work crew, during their daily safety meeting. The day's tasks, personnel, tools and equipment that will be used to perform these tasks are listed, along with the hazards posed and required H&S procedures, as identified in the JHA. The use of PTSPs, better promotes worker participation in the hazard recognition and control process, while reinforcing the task-specific hazard and required H&S procedures with the crew each day. The use of PTSPs is a common safety practice in the construction industry.

10.3 Safe Work Observations

Safe Work Loss-Prevention Observations (SWOs) shall be conducted by ERP Site Managers/SCs for specific work tasks or operations comparing the actual work process against established safe work procedures identified in the project-specific HSP and AHAs. SWOs are a tool to be used by supervisors to provide positive reinforcement for work practices performed correctly, while also identifying and eliminating deviations from safe work procedures that could result in a loss. ERP Site Managers/SCs shall perform at least one SWO each week for tasks/operations addressed in the project-specific HSP or JHA. The ERP Site Managers/SCs shall complete the **SWO form in Attachment 8** for the task/operation being observed.

10.4 Loss/Near Loss Investigations

Loss/Near Loss Investigations shall be performed for the all CH2M HILL and subcontractor incidents involving:

- Person injuries/illnesses and near miss injuries
- Equipment/property damage
- Spills, leaks, regulatory violations
- Motor vehicle accidents

The cause of loss and near loss incidents are similar, so by identifying and correcting the causes of near loss causes, future loss incidents may be prevented. The following is the Loss/Near Loss Investigation Process:

- Gather all relevant facts, focusing on fact-finding, not faultfinding, while answering the who, what, when, where and how questions.
- Draw conclusions, pitting facts together into a probable scenario.
- Determine incident root cause(s), which are basic causes on why an unsafe act/condition existed.
- Develop and implement solutions, matching all identified root causes with solutions.

- Communicate incident as a Lesson Learned to all project personnel.
- Filed follow-up on implemented corrective active action to confirm solution is appropriate.

ERP Site Managers/SSCs shall perform an incident investigation, as soon as practical after incident occurrence during the day of the incident, for all Loss and Near Loss Incidents that occur on the project. Loss and Near Loss incident investigations shall be performed using the following **incident investigation forms provided in Attachment 10:**

- Incident Report Form (IRF)
- Incident Investigation Form
- Root Cause Analysis Form

All Loss and Near Loss incident involving personal injury, property damage in excess of $1,000 or near loss incidents that could have resulted in serious consequences shall be investigated by completing the incident investigation forms and submitting them to the PM and HSM within 24 hours of incident occurrence. A preliminary Incident Investigation and Root Cause Analysis shall be submitted to the Project Manager and HSM within 24 hours of incident occurs. The final Incident Investigation and Root Cause Analysis shall be submitted after completing a comprehensive investigation of the incident.

11 Approval

This Master Health and Safety Plan has been written for use by CH2M HILL only. CH2M HILL claims no responsibility for its use by others unless that use has been specified and defined in project or contract documents. The plan is written for the specific site conditions, purposes, dates, and personnel specified and must be amended if those conditions change.

11.1 Original Plan

Written By: **John Swenfurth, P.G.** Date: Feb. 15, 2001

Approved By: **Michael Goldman** Date: June 11, 2003

11.2 Revisions

Rev.1

Revisions Made By: **Michael Goldman** Date: July 11, 2005

Revisions to Plan: The plan was updated to include task specific information from both sides of the island and function as a master plan for future work.

Revisions Approved By: **Michael Goldman** Date: July 11, 2005

Rev. 2

Revisions Made By: **Michael Goldman** Date: September 5, 2005

Revisions to Plan: The plan was updated to include additional biological hazards that have been encountered by the field crew. In addition, Level B references were from the plan.

Revisions Approved By: **Michael Goldman** Date: September 5, 2005

Rev. 3

Revisions Made By: **John Swenfurth** Date: March 28, 2006

Revisions to Plan: The plan was updated to include descriptions of sites at both the former NASD and the former VNTR, as well as to update medical contact information. Procedure references were updated. BBLPS forms were added to the appendix.

Revisions Approved By: **Michael Goldman** Date: March 31, 2006

Rev. 4

Revisions Made By: **Stephen Brand** Date: November 15, 2006

Revisions to Plan: The plan was updated to include Incident Reporting and Investigation and Injury Management/Return to Work SOPs and Serious Incident Reporting SOP, as well as to update emergency and medical contact information. Procedure references were updated. A discussion of BBLPS was included.

Revisions Approved By: **Michael Goldman** Date: November 27, 2006

12 Attachments

Attachment 1:	Employee Signoff Form – Health and Safety Plan
Attachment 2:	Project-Specific Chemical Product Hazard Communication Form
Attachment 3:	Chemical-Specific Training Form
Attachment 4:	Subcontractor Safety Performance Questionnaire
Attachment 5:	Subcontractor Safety Procedure Criteria
Attachment 6:	Project Activity Self-Assessment Checklists
Attachment 7:	Applicable Material Safety Data Sheets
Attachment 8:	Project Forms and Permits
Attachment 9:	CH2M HILL HSE&Q-610, Explosives Usage and Munitions Response (MR)
Attachment 10	CH2M HILL HSE&Q-111 Incident Notification and Reporting
Attachment 11	CH2M HILL HSE&Q-601 Serious Incident Reporting Process
Attachment 12	CH2M HILL HSE&Q-124 Injury Management/Return-to-Work

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ATTACHMENT 1

CH2MHILL

EMPLOYEE SIGNOFF FORM

Health and Safety Plan

The CH2M HILL project employees and subcontractors listed below have been provided with a copy of this FSI, have read and understood it, and agree to abide by its provisions.

Project Name: **Project Number:**

EMPLOYEE NAME (Please print)	**EMPLOYEE SIGNATURE**	**COMPANY**	**DATE**

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ATTACHMENT 2

CH2MHILL

Project-Specific Chemical Product Hazard Communication Form

This form must be completed prior to performing activities that expose personnel to hazardous chemicals products. Upon completion of this form, the SSC shall verify that training is provided on the hazards associated with these chemicals and the control measures to be used to prevent exposure to CH2M HILL and subcontractor personnel. Labeling and MSDS systems will also be explained.

Project Name: **Project Number:**

MSDSs will be maintained at the following location(s):

Hazardous Chemical Products Inventory

Chemical	Quantity	Location	MSDS Available	Container labels	
				Identity	Hazard
Methane	1 liter, compressed	Support Zone			
Isobutylene	1 liter, compressed	Support Zone			
Pentane	1 liter, compressed	Support Zone			
Hydrochloric acid	< 500 ml	Support Zone / sample bottles			
Nitric acid	< 500 ml	Support Zone / sample bottles			
Sulfuric Acid	< 500 ml	Support Zone / sample bottles			
Sodium hydroxide	< 500 ml	Support Zone / sample bottles			
Methanol	< 1 Gallon	Support/Decon Zones			
Hexane	< 1 Gallon	Support/Decon Zones			
pH buffers	< 500 ml	Support Zone			
MSA Sanitizer	< 1 liter	Support/Decon Zones			
Alconox/Liquinox	< 1liter	Support/Decon Zones			

Refer to SOP HS-05 *Hazard Communication* for more detailed information.

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ATTACHMENT 3

CH2MHILL

CHEMICAL-SPECIFIC TRAINING FORM

Location:	Project # :
HCC:	Trainer:

TRAINING PARTICIPANTS:

NAME	SIGNATURE	NAME	SIGNATURE

REGULATED PRODUCTS/TASKS COVERED BY THIS TRAINING:

The HCC shall use the product MSDS to provide the following information concerning each of the products listed above.

☐ Physical and health hazards

☐ Control measures that can be used to provide protection (including appropriate work practices, emergency procedures, and personal protective equipment to be used)

☐ Methods and observations used to detect the presence or release of the regulated product in the workplace (including periodic monitoring, continuous monitoring devices, visual appearance or odor of regulated product when being released, etc.)

Training participants shall have the opportunity to ask questions concerning these products and, upon completion of this training, will understand the product hazards and appropriate control measures available for their protection.

Copies of MSDSs, chemical inventories, and CH2M HILL's written hazard communication program shall be made available for employee review in the facility/project hazard communication file.

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ATTACHMENT 4: SUBCONTRACTOR SAFETY PERFORMANCE QUESTIONNAIRE

Name of Subcontractor: _____

Address of Subcontractor: _____

Contact Name: _____

Phone Number: _____

Standard Industrial Classification (SIC) Code: _____

Date: _____

HEALTH AND SAFETY

Please use your OSHA No. 200 logs to record the number of injuries and illnesses for the last three (3) years. ***PLEASE NOTE: This form should be attached to CH2M HILL's request for bid/proposal. Subcontractors should return the completed form with their bid package to the CH2M Hill Contract Administrator (KA). The KA and others will review the information in this form as part of the selection criteria.***

1. **YEAR**	**20__**	**20__**	**20__**
a. Number of Fatalities	____	____	____
b. Lost Work Day Cases Incident Rate[1]	____	____	____
c. OSHA Recordable Incident Rate[2]	____	____	____
d. Number of Hours Worked	____	____	____
e. Total Number of Employees on Your Payroll	____	____	____

f. Attach a co of your OSHA No. 200 logs for the last three (3) years.

g. CH2M Hill requires all subcontractors to provide the above accident statistics, even though certain companies may not be statutorily required to keep OSHA 200 logs.

[1] The following formula is used for calculating the Lost Work Day Incident Rate: = Number of Lost Work Day Cases x 200,000 / Number of Hours Worked

[2] The following formula is used for calculating the OSHA Recordable Incident Rate: = Number of Recordable Cases x 200,000 / Number of Hours Worked

2. List your company's Worker's Compensation (WC) Experience Modification Rate **(EMR)** for the three (3) most recent years:

	Interstate	**Intrastate**
a. 199___	____	____
b. 199___	____	____
c. 199___	____	____

d. Provide a letter from your WC insurance carrier certifying the above EMRs.

e. If your WC carrier has not issued your company an EMR because you have not accrued enough WC costs, provide a copy of your WC Loss Run (available from your WC carrier).

f. If your current EMR is greater than 1.0, provide a written explanation of the safety methods that are being implemented by your company to reduce this rate.

3. List all activities your company will be performing on CH2M Hill Projects:

_____

_____

_____

4. Has your company received an OSHA (or State OSHA) citation within the last five (5) years?

Yes ____ No ____

If you answered yes above, provide the following information below or on additional sheet if necessary:

a. The number and type of violations?_____

b. The penalties assessed by OSHA? _____

c. Were the citations contested/vacated? _____

d. What specific corrective actions were taken to prevent further penalties/injuries?

_____

_____

5. Does your company have a written occupational safety and health program?

Yes ____ No ____ We reserve the right to request copies of your health & safety program.

6a. Does your company conduct field safety inspections to determine compliance with applicable regulations and procedures?

Yes ____ No ____

b. Who conducts these inspections? _____

c. How often are safety inspections conducted? _____

7. Does your company have the following on your staff or on retainer?

	Yes	How Many	Staff	Retainer	No
Occupational Physician*	___	____	____	____	____
Certified Industrial Hygienist	___	____	____	____	____
Certified Safety Professional	___	____	____	____	____
Certified Health Physicist	___	____	____	____	____

* Board Eligible or Board Certified

8. Does your company have an orientation program for new hires? Yes ____ No ____

9. Has your company implemented any of the following training programs?

Yes	No	N/A		Yes	No	N/A	
☐	☐	☐	Asbestos	☐	☐	☐	Hazardous Waste (40-hour)
☐	☐	☐	Blasting/Explosives	☐	☐	☐	Hearing Conservation
☐	☐	☐	Bloodborne Pathogens	☐	☐	☐	Heavy Equipment operation
☐	☐	☐	Confined Space Entry	☐	☐	☐	Laboratory Safety
☐	☐	☐	Construction (OSHA Certified 10 Hours)	☐	☐	☐	Ladder/Scaffolding
☐	☐	☐	Construction (OSHA Certified 30 Hours)	☐	☐	☐	Lead
☐	☐	☐	Cranes Operations	☐	☐	☐	Lockout/Tagout
☐	☐	☐	Electrical Safety	☐	☐	☐	Personal Protective Equipment
☐	☐	☐	Excavation Competent Person	☐	☐	☐	Powder-actuated Tools
☐	☐	☐	Fall Protection	☐	☐	☐	Process Safety Management
☐	☐	☐	Fire Extinguishers	☐	☐	☐	Radiation Protection
☐	☐	☐	First Aid/CPR	☐	☐	☐	Respiratory Protection
☐	☐	☐	Forklift Operations	☐	☐	☐	Welding/Cutting

10. Does your company have a program in place to discipline workers that perform unsafe work practices? Yes ____ No ____

11. Does your company have written Accident Investigation Procedures? Yes ____ No ____

12. Does your company currently maintain a program in compliance with applicable state "Right to Know" laws and the OSHA Hazard Communication Standard? Yes ____ No ____

13. Does your company currently maintain an Accident Prevention Program in compliance with applicable state OSHA regulations? (Required for Alaska, California, Minnesota, Nevada and North Carolina) Yes ____ No ____ N/A ____

14. Does your company implement a medical surveillance program for employees that work on hazardous waste sites or with hazardous chemicals (i.e., lead, asbestos, benzene, arsenic, formaldehyde, etc.)? Yes ____ No ____ N/A ____

15a. Does your company hold "tailgate/toolbox" safety meetings? Yes ____ No ____

b. If yes, how often? _____

16. Has your company worked for CH2M HILL in the past three years? Yes ____ No ____

If so, what year and what project manager were you working for?

Year: _____ Project Manager: _____

17. The undersigned warrants and represents the data provided in this document is accurate in all respects.

Name of Firm: _____

Completed by: _____

Title: _____

Date: _____

CH2M HILL use only

Reviewed by: _____ Date: _____

Acceptable: ☐ Yes ☐ No If no, please send to Regional HSM for review.

Entered into database by: _____ Date: _____

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ATTACHMENT 5

CH2M HILL Subcontractor Safety Procedure Criteria - Drilling

The following criteria are not intended to be all inclusive, but are provided as a tool to facilitate development and review of subcontractor safety procedures. Subcontractors are expected to address the following items, at a minimum, in their safety procedures.

Minimum Acceptable Criteria for Subcontractor Drilling Safety Procedures:

1 Provide name and qualifications of the drilling "competent person" responsible for drilling (years and type of experience, training background, etc.):

2 Describe drill rig and equipment inspection criteria or procedures (frequency of inspections, visual vs. written inspections, items that are inspected):

3 Describe methods of identifying underground utilities (contacting utility companies, detection equipment):

4 Describe methods of avoiding contact with overhead powerlines (deenergizing and grounding, insulating, safe clearance distances):

5 Describe methods to identify hazardous atmospheres and controls used to eliminate (detection equipment and controls):

6 Describe leveling and stabilizing methods of drill rig (drilling pad, jacks, cribbing, guy wires):

7 Verify that rig equipment is in good operational condition (including, "kill" switch, cathead, ropes, pressurized hoses and lines, operator controls, machine guards, and drilling tools):

8 Describe procedures for operating in inclement weather, including lightning, high winds, severe rain storms:

9 Describe other safe work practices for equipment operation (drill rig, equipment, tools, rig transportation, rig travel):

10 Describe on-the-job maintenance procedures, including lockout/tagout:

11 Describe safe work practices for other activities to be performed during this project (use of ladders, fall protection, use of electrical power tools, use of personal protective equipment, etc.):

12 If hazardous waste project, provide documentation of hazardous waste worker training and medical surveillance records for all project personnel (40-hour or 24-hour training, 8-hour refresher training):

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ATTACHMENT 6: CH2MHILL

H&S Self-Assessment Checklist - DRILLING

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's HSP/FSI.

This checklist is to be used at locations where: 1) CH2M HILL employees are potentially exposed to hazards associated with drilling operations (complete Sections 1 and 3), and/or 2) CH2M HILL oversight of a drilling subcontractor is required (complete entire checklist).

SSC/DSC may consult with drilling subcontractors when completing this checklist, but shall not direct the means and methods of drilling operations nor direct the details of corrective actions. Drilling subcontractors shall determine how to correct deficiencies and we must carefully rely on their expertise. Items considered to be imminently dangerous (possibility of serious injury or death) shall be corrected immediately or all exposed personnel shall be removed from the hazard until corrected.

Completed checklists shall be sent to the health and safety manager for review.

Project Name: _____ Project No.: _____

Location: _____ PM: _____

Auditor: _____ Title: _____
Date: _____

This specific checklist has been completed to:

☐ Evaluate CH2M HILL employee exposures to drilling hazards
☐ Evaluate a CH2M HILL subcontractor's compliance with drilling H&S requirements
Subcontractors Name: _____

- Check "Yes" if an assessment item is complete/correct.
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the drilling subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in Standard of Practice HS-35.

SECTION 1	Yes	No	N/A	N/O
PERSONNEL SAFE WORK PRACTICES (3.1)				
1. Only authorized personnel operating drill rig	☐	☐	☐	☐
2. Personnel cleared during rig startup	☐	☐	☐	☐
3. Personnel clear of rotating parts	☐	☐	☐	☐
4. Personnel not positioned under hoisted loads	☐	☐	☐	☐
5. Loose clothing and jewelry removed	☐	☐	☐	☐
6. Personnel instructed not to approach equipment that has become electrically energized	☐	☐	☐	☐
7. Smoking is prohibited around drilling operation	☐	☐	☐	☐
8. Personnel wearing appropriate PPE, per HSP/FSI	☐	☐	☐	☐

SECTION 2 N/O	Yes	No	N/A	
GENERAL (3.2.1)				
9. Daily safety briefing/meeting conducted with crew	☐	☐	☐	☐
10. Daily inspection of drill rig and equipment conducted before use	☐	☐	☐	☐
DRILL RIG PLACEMENT (3.2.2)				
11. Location of underground utilities identified	☐	☐	☐	☐
12. Safe clearance distance maintained from overhead powerlines	☐	☐	☐	☐
13. Drilling pad established, when necessary	☐	☐	☐	☐
14. Drill rig leveled and stabilized	☐	☐	☐	☐
DRILL RIG TRAVEL (3.2.3)				
15. Rig shut down and mast lowered and secured prior to rig movement	☐	☐	☐	☐
16. Tools and equipment secured prior to rig movement	☐	☐	☐	☐
17. Only personnel seated in cab are riding on rig during movement	☐	☐	☐	☐
18. Safe clearance distance maintained while traveling under overhead powerlines	☐	☐	☐	☐
19. Backup alarm or spotter used when backing rig	☐	☐	☐	☐
DRILL RIG OPERATION (3.2.4)				
20. Kill switch clearly identified and operational	☐	☐	☐	☐
21. All machine guards are in place	☐	☐	☐	☐
22. Rig ropes not wrapped around body parts	☐	☐	☐	☐
23. Pressurized lines and hoses secured from whipping hazards	☐	☐	☐	☐
24. Drill operation stopped during inclement weather	☐	☐	☐	☐
25. Air monitoring conducted per HSP/FSI for hazardous atmospheres	☐	☐	☐	☐
26. Rig placed in neutral when operator not at controls	☐	☐	☐	☐

DRILL RIG MAINTENANCE (3.2.5)

27. Defective components repaired immediately	☐	☐	☐	☐
28. Lockout/tagout procedures used prior to maintenance	☐	☐	☐	☐
29. Cathead in clean, sound condition	☐	☐	☐	☐
30. Drill rig ropes in clean, sound condition	☐	☐	☐	☐
31. Fall protection used for fall exposures of 6 feet or greater	☐	☐	☐	☐
32. Rig in neutral and augers stopped rotating before cleaning	☐	☐	☐	☐
33. Good housekeeping maintained on and around rig	☐	☐	☐	☐

DRILLING AT HAZARDOUS WASTE SITES (3.2.6)

34. Waste disposed of according to HSP	☐	☐	☐	☐
35. Appropriate decontamination procedures being followed, per HSP	☐	☐	☐	☐

SECTION 3

Complete this section for all items checked "No" in Sections 1 or 2. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

ATTACHMENT 7

Applicable Material Safety Data Sheets

MSDS Number: **H2381** * * * * * *Effective Date:* ***11/02/01*** * * * * * *Supercedes:* ***04/15/99***

HEXANE

1. Product Identification

Synonyms: Hexanes,Normal Hexane; Hexyl Hydride; Hexane 95%
CAS No.: 110-54-3 (n-hexane)
Molecular Weight: 86.18
Chemical Formula: CH3(CH2)4CH3 n-hexane
Product Codes: 9262, 9304, 9308, N168

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Hexane	110-54-3	85 - 100%	Yes
Methylcyclopentane	96-37-7	1 - 2%	Yes
Trace amount of Benzene (10 ppm)	071-43-2	*	No

3. Hazards Identification

Emergency Overview

DANGER! EXTREMELY FLAMMABLE LIQUID AND VAPOR. VAPOR MAY CAUSE FLASH FIRE. HARMFUL OR FATAL IF SWALLOWED. HARMFUL IF INHALED. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT. AFFECTS THE CENTRAL AND PERIPHERAL NERVOUS SYSTEMS.

J.T. Baker SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 2 - Moderate
Flammability Rating: 3 - Severe (Flammable)
Reactivity Rating: 0 - None
Contact Rating: 2 - Moderate
Lab Protective Equip: GOGGLES; LAB COAT; VENT HOOD; PROPER GLOVES; CLASS B EXTINGUISHER
Storage Color Code: Red (Flammable)

Potential Health Effects

The health hazards addressed are for the major component: n-hexane.

Inhalation:
Inhalation of vapors irritates the respiratory tract. Overexposure may cause lightheadedness, nausea, headache, and blurred vision. Greater exposure may cause muscle weakness, numbness of the extremities, unconsciousness and death.
Ingestion:
May produce abdominal pain, nausea. Aspiration into lungs can produce severe lung damage and is a medical emergency. Other symptoms expected to parallel inhalation.
Skin Contact:
May cause redness, irritation, with dryness, cracking.
Eye Contact:
Vapors may cause irritation. Splashes may cause redness and pain.
Chronic Exposure:
Repeated or prolonged skin contact may defat the skin and produce irritation and dermatitis. Chronic inhalation may cause peripheral nerve disorders and central nervous system effects.
Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems or impaired respiratory function may be more susceptible to the effects of the substance. May affect the developing fetus.

---

4. First Aid Measures

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.
Ingestion:
Aspiration hazard. If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. Get medical attention immediately.
Skin Contact:
Remove any contaminated clothing. Wipe off excess from skin. Wash skin with soap and water for at least 15 minutes. Get medical attention if irritation develops or persists.
Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

Note to Physician:
BEI=2,5-hexadione in urine, sample at end of shift at workweeks end, 5 mg/g creatine. Also, measure n-hexane in expired air. Analgesics may be necessary for pain management, there is no specific antidote. Monitor arterial blood gases in cases of severe aspiration.

---

5. Fire Fighting Measures

Fire:
Flash point: -23C (-9F) CC
Autoignition temperature: 224C (435F)
Flammable limits in air % by volume:
lel: 1.2; uel: 7.7
Extremely Flammable Liquid and Vapor! Vapor may cause flash fire. Dangerous fire hazard when exposed to heat or flame.
Explosion:
Above flash point, vapor-air mixtures are explosive within flammable limits noted above. Contact with oxidizing materials may cause extremely violent combustion.Explodes when mixed @ 28C with dinitrogen tetraoxide. Sensitive to static discharge.
Fire Extinguishing Media:
Dry chemical, foam or carbon dioxide. Water may be ineffective.
Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode. Water spray may be used to keep fire exposed containers cool. Vapors can flow along surfaces to distant ignition source and flash back. Vapor explosion hazard exists indoors, outdoors, or in sewers.

---

6. Accidental Release Measures

Ventilate area of leak or spill. Remove all sources of ignition. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Use non-sparking tools and equipment. Collect liquid in an appropriate container or absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer! If a leak or spill has not ignited, use water spray to disperse the vapors, to protect personnel attempting to stop leak, and to flush spills away from exposures. US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

J. T. Baker SOLUSORB® solvent adsorbent is recommended for spills of this product.

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7. Handling and Storage

Protect against physical damage. Store in a cool, dry well-ventilated location, away from direct sunlight and any area where the fire hazard may be acute. Store in tightly closed containers (preferably under nitrogen atmosphere). Outside or detached storage is preferred. Inside storage should be in a standard flammable liquids storage room or cabinet. Separate from oxidizing materials. Containers should be bonded and grounded for transfers to avoid static sparks. Storage and use areas should be No Smoking areas. Use non-sparking type

tools and equipment. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.

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8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
N-Hexane [110-54-3]:
-OSHA Permissible Exposure Limit (PEL): 500 ppm (TWA)
-ACGIH Threshold Limit Value (TLV): 50 ppm (TWA), Skin
other isomers of hexane
-ACGIH Threshold Limit Value (TLV): 500 ppm (TWA),1000ppm (STEL)

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded and engineering controls are not feasible, wear a supplied air, full-facepiece respirator, airlined hood, or full-facepiece self-contained breathing apparatus. Breathing air quality must meet the requirements of the OSHA respiratory protection standard (29CFR1910.134).

Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.

Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

---

9. Physical and Chemical Properties

Appearance:
Clear, colorless liquid.

Odor:
Light odor.

Solubility:
Insoluble in water.

Specific Gravity:
0.66

pH:
No information found.

% Volatiles by volume @ 21C (70F):
100

Boiling Point:
ca. 68C (ca. 154F)

Hexane

Melting Point:
ca. -95C (ca. -139F)
Vapor Density (Air=1):
3.0
Vapor Pressure (mm Hg):
130 @ 20C (68F)
Evaporation Rate (BuAc=1):
9

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10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage. Heat will contribute to instability.
Hazardous Decomposition Products:
May produce acrid smoke and irritating fumes when heated to decomposition.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Strong oxidizers.
Conditions to Avoid:
Heat, flames, ignition sources and incompatibles.

---

11. Toxicological Information

N-Hexane: Oral rat LD50: 28710 mg/kg. Irritation eye rabbit: 10 mg mild. Investigated as a tumorigen, mutagen and reproductive effector.

--------\Cancer Lists\----------

Ingredient	---NTP Carcinogen--- Known	Anticipated	IARC Category
Hexane (110-54-3)	No	No	None
Methylcyclopentane (96-37-7)	No	No	None
Trace amount of Benzene (10 ppm) (071-43-2)	Yes	No	1

---

12. Ecological Information

Environmental Fate:
When released into the soil, this material may biodegrade to a moderate extent. When released into the soil, this material is not expected to leach into groundwater. When released into the soil, this material is expected to quickly evaporate. When released into water, this material may biodegrade to a moderate extent. When released to water, this material is expected to quickly evaporate. When released into the water, this material is expected to have a half-life between 1 and 10 days. This material has an estimated bioconcentration factor (BCF) of less than 100. This material has a log octanol-water partition coefficient of greater

than 3.0. This material is not expected to significantly bioaccumulate. When released into the air, this material is expected to be readily degraded by reaction with photochemically produced hydroxyl radicals. When released into the air, this material is expected to have a half-life between 1 and 10 days.
Environmental Toxicity:
No information found.

---

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved incinerator or disposed in a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

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14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: HEXANES
Hazard Class: 3
UN/NA: UN1208
Packing Group: II
Information reported for product/size: 52L

International (Water, I.M.O.)

Proper Shipping Name: HEXANES
Hazard Class: 3
UN/NA: UN1208
Packing Group: II
Information reported for product/size: 52L

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15. Regulatory Information

--------\Chemical Inventory Status - Part 1\----------

Ingredient	TSCA	EC	Japan	Australia
Hexane (110-54-3)	Yes	Yes	Yes	Yes
Methylcyclopentane (96-37-7)	Yes	Yes	No	Yes
Trace amount of Benzene (10 ppm) (071-43-2)	Yes	Yes	Yes	Yes

Hexane

--------\Chemical Inventory Status - Part 2\----------

Ingredient	Korea	--Canada-- DSL	NDSL	Phil.
Hexane (110-54-3)	Yes	Yes	No	Yes
Methylcyclopentane (96-37-7)	Yes	Yes	No	Yes
Trace amount of Benzene (10 ppm) (071-43-2)	Yes	Yes	No	Yes

--------\Federal, State & International Regulations - Part 1\----------

Ingredient	RQ	-SARA 302- TPQ	List	------SARA 313- Chemical Catg.
Hexane (110-54-3)	No	No	Yes	No
Methylcyclopentane (96-37-7)	No	No	No	No
Trace amount of Benzene (10 ppm) (071-43-2)	No	No	Yes	No

--------\Federal, State & International Regulations - Part 2\----------

Ingredient	CERCLA	-RCRA- 261.33	-TSCA- 8(d)
Hexane (110-54-3)	5000	No	No
Methylcyclopentane (96-37-7)	No	No	No
Trace amount of Benzene (10 ppm) (071-43-2)	10	U019	No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
SARA 311/312: Acute: Yes Chronic: Yes Fire: Yes Pressure: No
Reactivity: No (Mixture / Liquid)

WARNING:
THIS PRODUCT CONTAINS A CHEMICAL(S) KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER.

Australian Hazchem Code: 3[Y]E
Poison Schedule: None allocated.
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

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16. Other Information

NFPA Ratings: Health: **1** Flammability: **3** Reactivity: **0**
Label Hazard Warning:
DANGER! EXTREMELY FLAMMABLE LIQUID AND VAPOR. VAPOR MAY CAUSE FLASH FIRE. HARMFUL OR FATAL IF SWALLOWED. HARMFUL IF INHALED. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT. AFFECTS THE CENTRAL AND PERIPHERAL NERVOUS SYSTEMS.
Label Precautions:
Keep away from heat, sparks and flame.
Keep container closed.
Use only with adequate ventilation.

Wash thoroughly after handling.
Avoid breathing vapor or mist.
Avoid contact with eyes, skin and clothing.

Label First Aid:

Aspiration hazard. If swallowed, vomiting may occur spontaneously, but DO NOT INDUCE. If vomiting occurs, keep head below hips to prevent aspiration into lungs. Never give anything by mouth to an unconscious person. Call a physician immediately. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. In all cases call a physician.

Product Use:

Laboratory Reagent.

Revision Information:

MSDS Section(s) changed since last revision of document include: 8.

Disclaimer:

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Prepared by: Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

HYDROGEN

INDIANA OXYGEN CO -- HYDROGEN, COMPRESSED, WATER GAS, NORMAL HYDROGEN -- 6830-00N085059

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MSDS Safety Information

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FSC: 6830
MSDS Date: 03/01/1991
MSDS Num: CGZWY
LIIN: 00N085059
Tech Review: 04/20/1998
Product ID: HYDROGEN, COMPRESSED, WATER GAS, NORMAL HYDROGEN
Responsible Party
Cage: 30470
Name: INDIANA OXYGEN CO
Address: 6099 W CORPORATE WAY
City: INDIANAPOLIS IN 46720 US
Info Phone Number: 317-632-4525
Emergency Phone Number: 317-632-4525
Review Ind: N

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Contractor Summary

==========

Cage: 30470
Name: INDIANA OXYGEN CO
Address: 6099 W CORPORATE WAY
Box: 78588
City: INDIANAPOLIS IN 46278 US
Phone: 317-632-4525

==========

Ingredients

==========

Cas: 1333-74-0
RTECS #: MW8900000
Name: HYDROGEN
OSHA PEL: N/K (FP N)
ACGIH TLV: N/K (FP N)
Ozone Depleting Chemical: N

Name: SUPDAT: RESPIRATION & SUPPLEMENTAL OXYGEN. FURTHER TREATMENT SHOULD BE SYMPTOMATIC & SUPPORTIVE.

Name: WASTE DISP METH: DISPOSAL ASSISTANCE, CONTACT YOUR CLOSEST SUPPLIER LOCATION OR CALL EMERGENCY TELEPHONE NUMBER LISTED.

Name: HNDLG/STOR PRECS: OR ROLL CYLS. USE SUITABLE HAND TRUCK FOR CYL MOVEMENT. USE PRESS REDUCING REGULATOR WHEN (ING 5)

Name: ING 4: CONNECTING CYL TO LOWER PRESS (<3,000 PSIG) PIPING OR SYS. DO NOT HEAT CYL BY ANY MEANS TO INCR DISCHARGE (ING 6)

Name: ING 5: RATE OF PROD FROM CYL. USE CHECK VALVE/TRAP IN DISCHARGE LINE TO PVNT HAZ BACK FLOW INTO CYL. PROTECT CYLS(ING 7)

Name: ING 6: FROM PHYSICAL DMG. STORE IN COOL, DRY, WELL-VENTD AREA OF NONCOMBUST CONSTRUCTION AWAY FROM HEAVILY (ING 8)

Name: ING 7: TRAFFICKED AREAS & EMER EXITS. DO NOT ALLOW TEMP WHERE CYLS

ARE STORED TO EXCEED 125F(52C). CYLS SHOULD (ING 9)

Name: ING 8: BE STORED UPRIGHT & FIRMLY SECURED TO PVNT FALLING/BEING KNOCKED OVER. FULL & EMPTY CYLS SHOULD BE (ING 10)

Name: ING 9: SEGREGATED. USE "FIRST IN-FIRST OUT" INVENTORY SYS TO PVNT FULL CYLS BEING STORED FOR EXCESS PERIODS OF (ING 11)

Name: ING 10: TIME. POSE "NO SMOKING OR OPEN FLAMES" SIGNS IN STORAGE/USE AREA. THERE SHOULD BE NO SOURCE OF IGNIT IN (ING 12)

Name: ING 11: STORAGE/USE AREA. FOR ADDNL HNDLG & STORAGE RECOMS, CONSULT COMPRSSED GAS ASSOC'S PAMPHLETS G-5, P-1, (ING 13)

Name: ING 12: P-14 & SAFETY BULLETIN SB-2.

Name: OTHER PRECS: PRODUCERS OF COMPRESSED GASES. SHIPMENT OF COMPRESSED GAS CYL WHICH HAS NOT BEEN FILLED BY OWNER (ING 15)

Name: ING 14: OR WITH HIS/HER (WRITTEN) CONSENT IS VIOLATION OF FED LAW (49CFR). ALWAYS SECURE CYLS IN UPRIGHT (ING 16)

Name: ING 15: POSITION BEFORE TRANSPORTING THEM. NEVER TRANSPORT CYLS IN TRUNKS OF VEHICLES, ENCLOSED VANS, TRUCK (ING 17)

Name: ING 16: CABS OR IN PASSENGER COMPARTMENTS. TRANSPORT CYLS SECURED IN OPEN FLATBED/IN OPEN PICK-UP TYPE VEHICLES.
==========
Health Hazards Data
==========
LD50 LC50 Mixture: NONE SPECIFIED BY MANUFACTURER.
Route Of Entry Inds - Inhalation: YES
Skin: NO
Ingestion: NO
Carcinogenicity Inds - NTP: NO
IARC: NO
OSHA: NO
Effects of Exposure: INHALATION: HIGH CONCENTRATIONS OF HYDROGEN SO AS TO EXCLUDE ADEQUATE SUPPLY OF OXYGEN TO LUNGS CAUSES DIZZINESS, DEEPER BREATHING DUE TO AIR HUNGER, POSSIBLE NAUSEA AND EVENTUAL UNCONSCIOUSNESS. TOXI COLOGICAL PROPERTIES: HYDROGEN IS INACTIVE BIOLOGICALLY AND ESSENTIALLY NONTOXIC; THEREFORE, THE (EFTS OF OVEREXP)
Explanation Of Carcinogenicity: NOT RELEVANT
Signs And Symptions Of Overexposure: HLTH HAZ: MAJOR PROPERTY IS THE EXCLUSION OF AN ADEQUATE SUPPLY OF OXYGEN TO THE LUNGS. HYDROGEN IS NOT LISTED IN IARC, NTP OR OSHA AS A CARCINOGEN OR POTENTIAL CARCINOGEN. PERSONS IN ILL HEALTH WHERE SUCH ILLNESS WOULD BE AGGRAVATED BY EXPOSURE TO HYDROGEN SHOULD NOT BE ALLOWED TO WORK WITH OR HANDLE THIS PRODUCT.
Medical Cond Aggravated By Exposure: NONE SPECIFIED BY MANUFACTURER.
First Aid: INGEST: CALL MD IMMED (FP N). EYES: IMMED FLUSH W/POTABLE WATER FOR AT LST 15 MIN, SEEK ASSISTANCE FROM MD (FP N). SKIN: FLUSH W/COPIOUS AMTS OF WATER. CALL MD (FP N). PROMPT MED ATTN MANDATORY IN ALL CASES OF OVEREXP TO HYDROGEN. RESCUE PERS SHOULD BE EQUIPPED W/NIOSH APPRVD SCBA & BE COGNIZANT OF EXTREME FIRE & EXPLO HAZ. INHAL: CONSCIOUS PERS SHOULD BE ASSISTED TO UNCONTAM AREA & INHALE(SUPDAT)
==========

HYDROGEN

Handling and Disposal
==========
Spill Release Procedures: EVACUATE ALL PERS FROM AFFECTED AREA. USE APPROP PROT EQUIP. IF LEAK IS IN USER'S EQUIP, BE CERTAIN TO PURGE PIPING W/INERT GAS PRIOR TO ATTEMPTING REPAIRS. IF LEAK IS IN CNTNR/CNTNR VALVE, CNTCT CLOS EST SUPPLIER LOCATION/CALL EMER NUMBER LISTED.
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.
Waste Disposal Methods: DISP MUST BE I/A/W FED, STATE & LOCAL REGS (FP N). DO NOT ATTEMPT TO DISPOSE OF WASTE OR UNUSED QTYS. RETURN IN SHIPPING CNTNR PROPERLY LABELED W/ANY VALVE OUTLET PLUGS/CAPS SECURED & VALVE PROT CAP I N PLACE TO YOUR SUPPLIER. FOR EMER (ING3)
Handling And Storage Precautions: USE ONLY IN WELL-VENTD AREAS. VALVE PROT CAPS MUST REMAIN IN PLACE UNLESS CNTNR SECURED W/VALVE OUTLET PIPED TO USE POINT. DO NOT DRAG, SLIDE (ING 4)
Other Precautions: HYDROGEN IS NONCORR & MAY BE USED W/ANY COMMON STRUCTURAL MATL. EARTH-GROUND & BOND ALL LINES & EQUIP ASSOC W/HYDROGEN SYS. ELEC EQUIP SHOULD BE NON-SPKG OR EXPLO PROOF. COMPRESSED GAS CYLS SHUOLD NOT BE REFILLED EXCEPT BY QUALIFIED(ING 14)
==========
Fire and Explosion Hazard Information
==========
Flash Point Text: GAS
Lower Limits: 4%
Upper Limits: 74.5%
Extinguishing Media: WATER, CARBON DIOXIDE, DRY CHEMICAL.
Fire Fighting Procedures: USE NIOSH APPRVD SCBA & FULL PROT EQUIP (FP N). IF POSS, STOP FLOW OF HYDROGEN. COOL SURROUNDING CNTNRS W/WATER SPRAY. HYDROGEN BURNS W/ALMOST INVISIBLE(SUPDAT)
Unusual Fire/Explosion Hazard: HYDROGEN IS VERY LIGHT & RISES VERY RAPIDLY IN AIR. SHOULD HYDROGEN FIRE BE EXTING & FLOW OF GAS CONTINUE, INCR VENT TO PVNT EXPLO HAZ, PARTICULARLY IN (SUPDAT)
==========
Control Measures
==========
Respiratory Protection: NIOSH APPROVED POSITIVE PRESSURE AIR LINE WITH MASK OR SELF-CONTAINED BREATHING APPARATUS SHOULD BE AVAILABLE FOR EMERGENCY USE.
Ventilation: HOOD WITH FORCED VENT. LOCAL EXHAUST: TO PREVENT ACCUMULATION ABOVE LEL. MECHANICAL (GENERAL): I/A/W ELECTRICAL CODES.
Protective Gloves: PLASTIC OR RUBBER GLOVES.
Eye Protection: ANSI APPRVD CHEM WORKERS GOGGLES (FP N).
Other Protective Equipment: ANSI APPROVED EYE WASH & DELUGE SHOWER (FP N). SAFETY SHOES.
Work Hygienic Practices: NONE SPECIFIED BY MANUFACTURER.
Supplemental Safety and Health: VP: ABOVE CRITICAL TEMP OF -398.8F(-239.9D). FIRE FIGHT PROC: FLAME OF RELATIVELY LOW THERMAL RADIA. EXPLO HAZ: UPPER PORTIONS OF BLDGS/SHEDS WHERE GAS MIGHT "COLLECT." FIRST AID PROC: FRESH AIR. QUIC K REMOVAL FROM CONTAM AREA IS MOST IMPORTANT. UNCON PERS SHOULD BE MOVED TO UNCONTAM AREA, GIVEN ASSISTED (ING 2)
==========
Physical/Chemical Properties
==========
B.P. Text: -423F,-253C
M.P/F.P Text: -435F,-259C
Vapor Pres: SUPDAT
Vapor Density: 0.0052

Spec Gravity: 0.069
Solubility in Water: VERY SLIGHTLY
Appearance and Odor: COLORLESS, ODORLESS GAS.
==========
Reactivity Data
==========
Stability Indicator: YES
Stability Condition To Avoid: NOT APPLICABLE.
Materials To Avoid: OXIDIZERS.
Hazardous Decomposition Products: NONE.
Hazardous Polymerization Indicator: NO
Conditions To Avoid Polymerization: NOT RELEVANT
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Toxicological Information
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Ecological Information
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MSDS Transport Information
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Regulatory Information
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Other Information
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==========
HAZCOM Label
==========
Product ID: HYDROGEN, COMPRESSED, WATER GAS, NORMAL HYDROGEN
Cage: 30470
Company Name: INDIANA OXYGEN CO
Street: 6099 W CORPORATE WAY
PO Box: 78588
City: INDIANAPOLIS IN
Zipcode: 46278 US
Health Emergency Phone: 317-632-4525
Date Of Label Review: 04/20/1998
Label Date: 04/20/1998
Chronic Hazard IND: N
Eye Protection IND: YES
Skin Protection IND: YES
Signal Word: DANGER
Respiratory Protection IND: YES
Health Hazard: Slight
Contact Hazard: None
Fire Hazard: Severe
Reactivity Hazard: None
Hazard And Precautions: FLAMMABLE GAS. ACUTE: INHALATION: HIGH
CONCENTRATIONS OF HYDROGEN SO AS TO EXCLUDE ADEQUATE SUPPLY OF OXYGEN TO
LUNGS CAUSES DIZZINESS, DEEPER BREATHING DUE TO AIR HUNGER, POSSIBLE
NAUSEA AND EVENTUAL UNCONSCIOUSNESS. CHRONIC: NONE LISTED BY
MANUFACTURER.
==========
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ISOBUTYLENE

SCOTT SPECIALTY GASES -- ISOBUTYLENE IN AIR, (SEE SUPPL.)
==========
MSDS Safety Information
==========
FSC: 6665
NIIN: 01-449-8454
MSDS Date: 11/20/1997
MSDS Num: CLFCR
Product ID: ISOBUTYLENE IN AIR, (SEE SUPPL.)
MFN: 01
Kit Part: Y
Responsible Party
Cage: 54262
Name: SCOTT SPECIALTY GASES
Address: 2330 HAMILTON BLVD
City: SOUTH PLAINFIELD NJ 07080
Info Phone Number: 908-754-7700
Emergency Phone Number: 908-754-7700
Resp. Party Other MSDS No.: M-704/E-1
Review Ind: Y
Published: Y
==========
Contractor Summary
==========
Cage: 70123
Name: PHOTOVAC INTL INC/DBA PHOTOVAC MONITORING INSTRUMENTS
Address: UNK
Box: UNK
City: DEER PARK NY 11729
Phone: 000-000-0000
Cage: 1JSC4
Name: PINE ENVIRONMENTAL SERVICES INC
Address: 379 PRINCETON-HIGHTSTOWN RD
City: CRANBURY NJ 08512
Phone: 609-371-9663
Contract Number: SP0200-99-M-T071
Cage: 54262
Name: SCOTT SPECIALTY GASES
Address: 2330 HAMILTON BLVD
City: SOUTH PLAINFIELD NJ 07080
Phone: 908-754-7700
==========
Item Description Information
==========
Item Manager: S9M
Item Name: ACCESSORY KIT, PHOTOIONIZATION MONITOR, 2020 MINIATURE
Unit of Issue: EA
==========
Ingredients
==========
Cas: 115-11-7
RTECS #: UD0890000
Name: ISOBUTYLENE
% Wt: 1-1500 PPM

Cas: 132259-10-0
Name: AIR

% Wt: BALANCE
==========
Health Hazards Data
==========
Route Of Entry Inds - Inhalation: YES
Carcinogenicity Inds - NTP: NO
IARC: NO
OSHA: NO
Effects of Exposure: ACUTE EFFECTS: NONE. CHRONIC EFFECTS: NONE KNOWN.
Explanation Of Carcinogenicity: CARCINOGENICITY (U.S. ONLY): NTP - NO; IARC
MONOGRAPHS - NO; OSHA REGULATED - NO.
Signs And Symptions Of Overexposure: NONE.
Medical Cond Aggravated By Exposure: NONE KNOWN.
First Aid: IN EVENT OF EXPOSURE, CONSULT A PHYSICIAN. INHALATION: IMMEDIATELY
REMOVE VICTIM TO FRESH AIR. IF BREATHING HAS STOPPED, GIVE ARTIFICIAL
RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN. EYE CONTAC T: NONE. SKIN
CONTACT: NONE. INGESTION: NONE.
==========
Handling and Disposal
==========
Spill Release Procedures: EVACUATE AND VENTILATE AREA. REMOVE LEAKING CYLINDER
TO EXHAUST HOOD OR SAFE OUTDOOR AREA. SHUT OFF SOURCE IF POSSIBLE AND REMOVE
SOURCE OF HEAT.
Waste Disposal Methods: DISPOSE OF NON-REFILLABLE CYLINDERS IN ACCORDANCE WITH
FEDERAL, STATE, AND LOCAL REGULATIONS. ALLOW GAS TO VENT SLOWLY TO ATMOSPHERE
IN AN UNCONFINED AREA OR EXHAUST HOOD. IF THE CYLINDERS ARE THE REF ILLABLE
TYPE, RETURN CYLINDERS TO SUPPLIER WITH ANY VALVE OUTLET PLUGS OR CAPS
SECURED AND VALVE PRO TECTION CAPS IN PLACE.
Handling And Storage Precautions: HANDLING: SECURE CYLINDER WHEN USING TO
PROTECT FROM FALLING. USE SUITABLE HAND TRUCK TO MOVE CYLINDERS. STORAGE:
STORE IN WELL VENTILATED AREAS. KEEP VALVE PROTECTION CAP ON CYLINDERS WHEN
NOT IN USE .
Other Precautions: PROTECT CONTAINERS FROM PHYSICAL DAMAGE. DO NOT DEFACE
CYLINDERS OR LABELS. CYLINDERS SHOULD BE REFILLED BY QUALIFIED PRODUCERS OF
COMPRESSED GAS. SHIPMENT OF A COMPRESSED GAS CYLINDER WHICH HAS NOT B EEN
FILLED BY THE OWNER OR WITH HIS WRITTEN CONSENT IS A VIOLATION OF FEDERAL LAW
(49 CFR)
==========
Fire and Explosion Hazard Information
==========
Flash Point Text: NONFLAMMABLE
Extinguishing Media: USE WHAT IS APPROPRIATE FOR SURROUNDING FIRE.
Fire Fighting Procedures: WEAR SELF-CONTAINED BREATHING APPARATUS AND FULL

PROTECIVE CLOTHING. KEEP FIRE EXPOSED CYLINDERS COOL WITH WATER SPRAY. IF
POSSIBLE, STOP THE PRODUCT FLOW.
Unusual Fire/Explosion Hazard: CYLINDER RUPTURE MAY OCCUR UNDER FIRE
CONDITIONS. COMPRESSED AIR AT HIGH PRESSURE WILL ACCELERATE THE COMBUSTION OF
FLAMMABLE MATERIALS.
==========
Control Measures
==========
Respiratory Protection: IN CASE OF LEAKAGE, USE SELF-CONTAINED BREATHING
APPARATUS.
Ventilation: PROVIDE ADEQUATE GENERAL AND LOCAL EXHAUST VENTILATION.
Protective Gloves: NONE
Eye Protection: SAFETY GLASSES.
Other Protective Equipment: SAFETY SHOES WHEN HANDLING CYLINDERS.
Supplemental Safety and Health: VENDOR (CAGE 70123) PART NUMBER: 350005. THIS
ENTRY DESCRIBES ONE PART, SERIAL NUMBER XXXXX, ISOBUTYLENE IN AIR, OF A FIELD
KIT. SEE THIS SAME NSN, SERIAL NUMBER XXXXX, A 10 HOUR RECHARGEABLE BATTERY
PACK, FOR DATA ON SECOND PART OF KIT.
==========
Physical/Chemical Properties
==========
HCC: G3
Vapor Density: .991(AIR=1
Spec Gravity: GAS
Evaporation Rate & Reference: GAS
Solubility in Water: 18.68CM3/1@20C
Appearance and Odor: COLORLESS, ODORLESS GAS
==========
Reactivity Data
==========
Stability Indicator: YES
Stability Condition To Avoid: STABLE UNDER NORMAL STORAGE CONDITIONS. AVOID
STORAGE IN POORLY VENTILATED AREAS AND STORAGE NEAR A HEAT SOURCE.
Materials To Avoid: OXIDIZING AGENTS.
Hazardous Decomposition Products: NONE.
Hazardous Polymerization Indicator: NO
Conditions To Avoid Polymerization: WILL NOT OCCUR.
==========
Toxicological Information
==========
==========
Ecological Information
==========
Ecological: NO ADVERSE ECOLOGICAL EFFECTS ARE EXPECTED.
==========
MSDS Transport Information
==========
Transport Information: CONCENTRATION: 1 - 1500 PPM. DOT DESCRIPTION (US ONLY):
PROPER SHIPPING NAME: COMPRESSED GASSES, N.O.S.; HAZARD CLASS: 2.2

(NONFLAMMABLE); UN 1956; REPORTABLE QUANTITIES: NONE. LABELING: NONFLAMMABLE
GAS. ADR/RID (EU ONLY): CLASS 2, 1A. SPECIAL PRECAUTIONS: CYLINDERS SHOULD BE
TRANSPORTATED IN A SECURE UPRIGHT POSITION IN A WELL VENTILATED TRUCK.

==========
Regulatory Information
==========

Sara Title III Information: THE THRESHOLD PLANNING QUANTIRY FOR THES MIXTURE IS
10,000 LBS.
Federal Regulatory Information: OSHA: PROCESS SAFETY MANAGEMENT: MINOR
COMPONENT IS NOT LISTED IN APPENDIX A OF 29 CFR 1910.119 AS A HIGHLY
HAZARDOUS CHEMICAL. TSCA: MIXTURE IS NOT LISTED IN TSCA INVENTORY. EU NUMBER:
N/A. NUMBER IN ANNES 1 OF DIR 67/548: MIXTURE IS NOT LISTED IN ANNES 1. EU
CLASSIFICATION: N/AP. R: 20; S: 9.

==========
Transportation Information
==========

Responsible Party Cage: 54262
Trans ID NO: 157469
Product ID: ISOBUTYLENE IN AIR, (SEE SUPPL.)
MSDS Prepared Date: 11/20/1997
Review Date: 06/14/2001
MFN: 1
Tech Entry NOS Shipping Nm: (ISOBUTYLENE, AIR)
Net Unit Weight: 22 GRAMS
Multiple KIT Number: 0
Kit Part IND: Y
Unit Of Issue: EA
Additional Data: TRANSPORTATION DATA PER MANUFACTURER'S MSDS.

==========
Detail DOT Information
==========

DOT PSN Code: DQQ
Symbols: G
DOT Proper Shipping Name: COMPRESSED GASES, N.O.S.
Hazard Class: 2.2
UN ID Num: UN1956
Label: NONFLAMMABLE GAS
Special Provision: B13
Non Bulk Pack: 302,305
Bulk Pack: 314,315
Max Qty Pass: 75 KG
Max Qty Cargo: 150 KG
Vessel Stow Req: A

==========
Detail IMO Information
==========

IMO PSN Code: EQH
IMO Proper Shipping Name: COMPRESSED GAS, N.O.S. o
IMDG Page Number: 2124
UN Number: 1956
UN Hazard Class: 2(2.2)
IMO Packaging Group: -

Subsidiary Risk Label: -
EMS Number: 2-04
MED First Aid Guide NUM: 620
==========
Detail IATA Information
==========
IATA PSN Code: HDO
IATA UN ID Num: 1956
IATA Proper Shipping Name: COMPRESSED GAS, N.O.S. *
IATA UN Class: 2.2
IATA Label: NON-FLAMMABLE GAS
Packing Note Passenger: 200
Max Quant Pass: 75KG
Max Quant Cargo: 150KG
Packaging Note Cargo: 200
==========
Detail AFI Information
==========
AFI PSN Code: HDO
AFI Symbols: *
AFI Proper Shipping Name: COMPRESSED GAS, N.O.S.
AFI Hazard Class: 2.2
AFI UN ID NUM: UN1956
Special Provisions: P5
Back Pack Reference: A6.3, A6.5,A6.6
==========
HAZCOM Label
==========
Product ID: ISOBUTYLENE IN AIR, (SEE SUPPL.)
Cage: 54262
Company Name: SCOTT SPECIALTY GASES
Street: 2330 HAMILTON BLVD
City: SOUTH PLAINFIELD NJ
Zipcode: 07080
Health Emergency Phone: 908-754-7700
Label Required IND: Y
Date Of Label Review: 06/14/2001
Status Code: A
Label Date: 06/14/2001
Origination Code: F
Eye Protection IND: YES
Skin Protection IND: NO
Signal Word: NONE
Respiratory Protection IND: YES
Health Hazard: None
Contact Hazard: None
Fire Hazard: None
Reactivity Hazard: None
Hazard And Precautions: COMPRESSED, NONFLAMMABLE GAS. ACUTE EFFECTS: NONE.
CHRONIC EFFECTS: NONE KNOWN. LABELING: NONFLAMMABLE GAS.
==========
Disclaimer (provided with this information by the compiling agencies): This
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METHANE

LIQUID AIR CORP -- 10 PPM-2.5% METHANE IN AIR

==========

MSDS Safety Information

==========

FSC: 6830
MSDS Date: 01/01/1992
MSDS Num: BXSMS
LIIN: 00N032858
Product ID: 10 PPM-2.5% METHANE IN AIR
MFN: 02
Responsible Party
Cage: 18260
Name: LIQUID AIR CORP
Address: 2121 N CALIFORNIA BLVD
City: WALNUT CREEK CA 94596
Info Phone Number: 510-977-6500
Emergency Phone Number: 510-977-6500
Published: Y

==========

Contractor Summary

==========

Cage: 18260
Name: LIQUID AIR CORP ONE CALIFORNIA PLAZA
Address: 2121 N. CALIFORNIA BLVD
City: WALNUT CREEK CA 94596
Phone: 415-977-6500

==========

Ingredients

==========

Name: ING 5:IN AIR. DOT 39 CYLS MAY NOT BE REUSED/REFILLED (49CFR). NEVER
TRANSPORT THESE CYLS IN TRUNKS OF VEHICLES,

Name: ING 6:ENCLOSED VANS, TRUCK CABS/IN PASSENGER COMPARTMENTS. TRANSPORT
THEM
"CONTAINED" IN OPEN FLATBED/OPEN

Name: ING 7:PICK-UP TYPE VEHICLES.

Cas: 74-82-8
RTECS #: PA1490000
Name: METHANE. BP:-259F,-161C. MP:-297F,-183C. PCT:10PPM-2.5%
% Wt: <2.5
OSHA PEL: N/K (FP N)
ACGIH TLV: ASPHYXIANT

Name: AIR. BP:-318F,-194C. MP:AIR IS MIXTURE
OSHA PEL: N/K (FP N)
ACGIH TLV: N/K (FP N)

Name: SUPDAT:STORED FOR EXCESS PERIODS OF TIME. THESE MIX ARE NONCORR &
MAY
BE USED W/ALL MATLS OF CONSTRUCTION.

Name: ING 3:MOISTURE CAUSES METAL OXIDES WHICH ARE FORMED W/AIR TO BE
HYDRATED
SO THAT THEY INCREASE IN VOL & LOSE

Name: ING 4:THEIR PROT ROLE (RUST FORMATION). CONC OF SO*2, CL*2, SALT, ETC IN
MOISTURE ENHANCES RUSTING OF METALS
==========
Health Hazards Data
==========
LD50 LC50 Mixture: NONE SPECIFIED BY MANUFACTURER.
Route Of Entry Inds - Inhalation: YES
Skin: YES
Ingestion: YES
Carcinogenicity Inds - NTP: NO
IARC: NO
OSHA: NO
Effects of Exposure: THESE MIXTURES SHOULD BE CONSIDERED SIMILAR TO AIR AND
WOULD THEREFORE CAUSE NO SYMPTOMS OF EXPOSURE.
Explanation Of Carcinogenicity: NOT RELEVANT.
Signs And Symptions Of Overexposure: SEE HEALTH HAZARDS.
Medical Cond Aggravated By Exposure: NONE SPECIFIED BY MANUFACTURER.
First Aid: INGEST:CALL MD IMMEDIATELY (FP N). INHAL:REMOVE TO FRESH AIR.
SUPPORT BREATHING (GIVE O*2/ARTF RESP) (FP N). EYES:IMMEDIATELY FLUSH
W/POTABLE WATER FOR MINIMUM OF 15 MINUTES, SEEK ASSISTANCE FROM MD (FP N).
SKIN:FLUSH W/COPIOUS AMOUNTS OF WATER. CALL MD (FP N).
==========
Handling and Disposal
==========
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.
Handling And Storage Precautions: USE PRESS REDUCING REGULATOR WHEN CONNECTING
CYL TO LOWER PRESS (<500 PSIG) PIPING/SYS. CLOSE VALVE AFTER EACH USE AND
WHEN EMPTY.
Other Precautions: DO NOT HEAT CYL BY ANY MEANS TO INCREASE DISCHARGE RATE OF
PROD FROM CYL. USE CHECK VALVE/TRAP IN DISCHARGE LINE TO PVNT HAZ BACK FLOW
INTO CYL. PROT CYLS FROM PHYSICAL DMG. STORE IN COOL, DRY, WELL V ENTILATED
AREA AWAY FROM HEAVILY(SUPDAT)
==========
Fire and Explosion Hazard Information
==========
Extinguishing Media: NONFLAMMABLE GAS MIXTURES.
Fire Fighting Procedures: USE NIOSH/MSHA APPROVED SCBA & FULL PROTECTIVE
EQUIPMENT (FP N). IF CYLINDERS ARE INVOLVED IN FIRE, SAFELY RELOCATE OR KEEP
COOL W/WATER SPRAY.
Unusual Fire/Explosion Hazard: THESE MIX @ HIGH PRESS WILL ACCELERATE BURNING
OF MATLS TO GREATER RATE THAN THEY BURN @ ATMOS PRESSURE.
==========
Control Measures
==========
Protective Gloves: IMPERVIOUS GLOVES (FP N).
Eye Protection: ANSI APPRVD CHEM WORKERS GOGGLES (FP N).
Other Protective Equipment: SAFETY SHOES. ANSI APPRVD EMERGENCY EYE WASH &

DELUGE SHOWER (FP N).
Work Hygienic Practices: NONE SPECIFIED BY MANUFACTURER.
Supplemental Safety and Health: VP:ABOVE CRITICAL TEMP OF METHANE. AIR IS MIXTURE. VAP DENS:0.0741-0.0749 LB/FT3(1.187-1.200 KG/M3). OTHER PRECAUT:TRAFFICKED AREAS & EMER EXITS. DO NOT ALLOW TEMP WHERE CYLS ARE STORED TO EXCEED 125F (52C). FULL & EMPTY CYLS SHOULD BE SEGREGATED. USE "FIRST IN-FIRST OUT"INVENTORY SYS TO PVNT FULL CYLS BEING

==========
Physical/Chemical Properties
==========
B.P. Text: SEE INGS
M.P/F.P Text: SEE INGS
Vapor Pres: SUPDAT
Vapor Density: SUPDAT
Spec Gravity: 0.99-1.0(AIR=1)
Evaporation Rate & Reference: NOT KNOWN
Solubility in Water: VERY SLIGHTLY
Appearance and Odor: COLORLESS, ODORLESS GAS.
==========
Reactivity Data
==========
Stability Indicator: YES
Materials To Avoid: NONE
Hazardous Decomposition Products: NONE
Hazardous Polymerization Indicator: NO
Conditions To Avoid Polymerization: NOT RELEVANT.
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Toxicological Information
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Ecological Information
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MSDS Transport Information
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Regulatory Information
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==========
Other Information
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==========
HAZCOM Label
==========
Product ID: 10 PPM-2.5% METHANE IN AIR
Cage: 18260
Company Name: LIQUID AIR CORP ONE CALIFORNIA PLAZA
Street: 2121 N. CALIFORNIA BLVD
City: WALNUT CREEK CA
Zipcode: 94596
Health Emergency Phone: 510-977-6500
Label Required IND: Y
Date Of Label Review: 05/20/1995
Status Code: C
Label Date: 05/20/1995
Origination Code: G
Eye Protection IND: YES

Skin Protection IND: YES
Signal Word: NONE
Respiratory Protection IND: YES
Health Hazard: None
Contact Hazard: None
Fire Hazard: None
Reactivity Hazard: None
Hazard And Precautions: PROTECT FROM PHYSICAL DAMAGE. ACUTE:THESE MIXTURES SHOULD BE CONSIDERED SIMILAR TO AIR AND WOULD THEREFORE CAUSE NO SYMPTOMS OF EXPOSURE. CHRONIC:NONE LISTED BY MANUFACTURER.
==========
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MSDS Number: **M2015** * * * * * *Effective Date:* ***11/12/01*** * * * * * *Supercedes:* ***12/14/00***

METHYL ALCOHOL

1. Product Identification

Synonyms: Wood alcohol; methanol; carbinol
CAS No.: 67-56-1
Molecular Weight: 32.04
Chemical Formula: CH3OH
Product Codes:
J.T. Baker: 5217, 5370, 5794, 5807, 5811, 5842, 5869, 9049, 9063, 9065, 9066, 9067, 9069, 9070, 9071, 9073, 9075, 9076, 9077, 9091, 9093, 9096, 9097, 9098, 9263, 9822, 9893, V654
Mallinckrodt: 3004, 3006, 3016, 3017, 3018, 3024, 3041, 3701, 4295, 5160, 8814, H080, H488, H603, H985, V079, V571

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Methyl Alcohol	67-56-1	100%	Yes

3. Hazards Identification

Emergency Overview

POISON! DANGER! VAPOR HARMFUL. MAY BE FATAL OR CAUSE BLINDNESS IF SWALLOWED. HARMFUL IF INHALED OR ABSORBED THROUGH SKIN. CANNOT BE MADE NONPOISONOUS. FLAMMABLE LIQUID AND VAPOR. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT. AFFECTS CENTRAL NERVOUS SYSTEM AND LIVER.

SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 3 - Severe (Poison)
Flammability Rating: 3 - Severe (Flammable)
Reactivity Rating: 1 - Slight
Contact Rating: 3 - Severe (Life)
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES; CLASS B EXTINGUISHER
Storage Color Code: Red (Flammable)

Potential Health Effects

Inhalation:
A slight irritant to the mucous membranes. Toxic effects exerted upon nervous system, particularly the optic nerve. Once absorbed into the body, it is very slowly eliminated. Symptoms of overexposure may include headache, drowsiness, nausea, vomiting, blurred vision, blindness, coma, and death. A person may get better but then worse again up to 30 hours later.
Ingestion:
Toxic. Symptoms parallel inhalation. Can intoxicate and cause blindness. Usual fatal dose: 100-125 milliliters.
Skin Contact:
Methyl alcohol is a defatting agent and may cause skin to become dry and cracked. Skin absorption can occur; symptoms may parallel inhalation exposure.
Eye Contact:
Irritant. Continued exposure may cause eye lesions.
Chronic Exposure:
Marked impairment of vision has been reported. Repeated or prolonged exposure may cause skin irritation.
Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems or impaired liver or kidney function may be more susceptible to the effects of the substance.

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4. First Aid Measures

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.
Ingestion:
Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention immediately.
Skin Contact:
Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention. Wash clothing before reuse. Thoroughly clean shoes before reuse.
Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

---

5. Fire Fighting Measures

Fire:
Flash point: 12C (54F) CC
Autoignition temperature: 464C (867F)

Flammable limits in air % by volume:
lel: 6.0; uel: 36
Flammable Liquid and Vapor!

Explosion:

Above flash point, vapor-air mixtures are explosive within flammable limits noted above. Moderate explosion hazard and dangerous fire hazard when exposed to heat, sparks or flames. Sensitive to static discharge.

Fire Extinguishing Media:

Use alcohol foam, dry chemical or carbon dioxide. (Water may be ineffective.)

Special Information:

In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode. Use water spray to blanket fire, cool fire exposed containers, and to flush non-ignited spills or vapors away from fire. Vapors can flow along surfaces to distant ignition source and flash back.

---

6. Accidental Release Measures

Ventilate area of leak or spill. Remove all sources of ignition. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Use non-sparking tools and equipment. Collect liquid in an appropriate container or absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer! If a leak or spill has not ignited, use water spray to disperse the vapors, to protect personnel attempting to stop leak, and to flush spills away from exposures. US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

J. T. Baker SOLUSORB® solvent adsorbent is recommended for spills of this product.

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7. Handling and Storage

Protect against physical damage. Store in a cool, dry well-ventilated location, away from any area where the fire hazard may be acute. Outside or detached storage is preferred. Separate from incompatibles. Containers should be bonded and grounded for transfers to avoid static sparks. Storage and use areas should be No Smoking areas. Use non-sparking type tools and equipment, including explosion proof ventilation. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product. Do Not attempt to clean empty containers since residue is difficult to remove. Do not pressurize, cut, weld, braze, solder, drill, grind or expose such containers to heat, sparks, flame, static electricity or other sources of ignition: they may explode and cause injury or death.

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8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
For Methyl Alcohol:
- OSHA Permissible Exposure Limit (PEL):
200 ppm (TWA)
- ACGIH Threshold Limit Value (TLV):
200 ppm (TWA), 250 ppm (STEL) skin

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details. Use explosion-proof equipment.

Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded and engineering controls are not feasible, wear a supplied air, full-facepiece respirator, airlined hood, or full-facepiece self-contained breathing apparatus. Breathing air quality must meet the requirements of the OSHA respiratory protection standard (29CFR1910.134). This substance has poor warning properties.

Skin Protection:
Rubber or neoprene gloves and additional protection including impervious boots, apron, or coveralls, as needed in areas of unusual exposure.

Eye Protection:
Use chemical safety goggles. Maintain eye wash fountain and quick-drench facilities in work area.

---

9. Physical and Chemical Properties

Appearance:
Clear, colorless liquid.

Odor:
Characteristic odor.

Solubility:
Miscible in water.

Specific Gravity:
0.8

pH:
No information found.

% Volatiles by volume @ 21C (70F):
100

Boiling Point:
64.5C (147F)

Melting Point:
-98C (-144F)

Vapor Density (Air=1):
1.1

Vapor Pressure (mm Hg):
97 @ 20C (68F)
Evaporation Rate (BuAc=1):
5.9

---

10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage.
Hazardous Decomposition Products:
May form carbon dioxide, carbon monoxide, and formaldehyde when heated to decomposition.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Strong oxidizing agents such as nitrates, perchlorates or sulfuric acid. Will attack some forms of plastics, rubber, and coatings. May react with metallic aluminum and generate hydrogen gas.
Conditions to Avoid:
Heat, flames, ignition sources and incompatibles.

---

11. Toxicological Information

Methyl Alcohol (Methanol) Oral rat LD50: 5628 mg/kg; inhalation rat LC50: 64000 ppm/4H; skin rabbit LD50: 15800 mg/kg; Irritation data-standard Draize test: skin, rabbit: 20mg/24 hr. Moderate; eye, rabbit: 100 mg/24 hr. Moderate. Investigated as a mutagen, reproductive effector.

--------\Cancer Lists\----------

	---NTP Carcinogen---		
Ingredient	Known	Anticipated	IARC Category
Methyl Alcohol (67-56-1)	No	No	None

---

12. Ecological Information

Environmental Fate:
When released into the soil, this material is expected to readily biodegrade. When released into the soil, this material is expected to leach into groundwater. When released into the soil, this material is expected to quickly evaporate. When released into the water, this material is expected to have a half-life between 1 and 10 days. When released into water, this material is expected to readily biodegrade. When released into the air, this material is expected to exist in the aerosol phase with a short half-life. When released into the air, this material is expected to be readily degraded by reaction with photochemically produced hydroxyl radicals. When released into air, this material is expected to have a half-life between 10 and 30 days. When released into the air, this material is expected to be readily removed from the

atmosphere by wet deposition.
Environmental Toxicity:
This material is expected to be slightly toxic to aquatic life.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved incinerator or disposed in a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: METHANOL
Hazard Class: 3
UN/NA: UN1230
Packing Group: II
Information reported for product/size: 350LB

International (Water, I.M.O.)

Proper Shipping Name: METHANOL
Hazard Class: 3, 6.1
UN/NA: UN1230
Packing Group: II
Information reported for product/size: 350LB

15. Regulatory Information

--------\Chemical Inventory Status - Part 1\----------

Ingredient	TSCA	EC	Japan	Australia
Methyl Alcohol (67-56-1)	Yes	Yes	Yes	Yes

--------\Chemical Inventory Status - Part 2\----------

			--Canada--	
Ingredient	Korea	DSL	NDSL	Phil.
Methyl Alcohol (67-56-1)	Yes	Yes	No	Yes

--------\Federal, State & International Regulations - Part 1\----------

		-SARA 302-		------SARA 313-
Ingredient	RQ	TPQ	List	Chemical Catg.
Methyl Alcohol (67-56-1)	No	No	Yes	No

--------\Federal, State & International Regulations - Part 2\----------

Ingredient	CERCLA	-RCRA- 261.33	-TSCA- 8(d)
Methyl Alcohol (67-56-1)	5000	U154	No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
SARA 311/312: Acute: Yes Chronic: Yes Fire: Yes Pressure: No
Reactivity: No (Pure / Liquid)

Australian Hazchem Code: 2PE
Poison Schedule: S6
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

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16. Other Information

NFPA Ratings: Health: **1** Flammability: **3** Reactivity: **0**
Label Hazard Warning:
POISON! DANGER! VAPOR HARMFUL. MAY BE FATAL OR CAUSE BLINDNESS IF SWALLOWED. HARMFUL IF INHALED OR ABSORBED THROUGH SKIN. CANNOT BE MADE NONPOISONOUS. FLAMMABLE LIQUID AND VAPOR. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT. AFFECTS CENTRAL NERVOUS SYSTEM AND LIVER.
Label Precautions:
Avoid breathing vapor.
Avoid contact with eyes, skin and clothing.
Wash thoroughly after handling.
Keep container closed.
Use only with adequate ventilation.
Keep away from heat, sparks and flame.
Label First Aid:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. If swallowed, induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. In all cases get medical attention immediately.
Product Use:
Laboratory Reagent.
Revision Information:
MSDS Section(s) changed since last revision of document include: 3, 8.

METHYL ALCOHOL

Disclaimer:

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Prepared by: Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

MSDS Number: **N3660** * * * * * *Effective Date:* ***07/02/02*** * * * * * *Supercedes:* ***07/13/00***

NITRIC ACID, 50-70%

1. Product Identification

Synonyms: Aqua Fortis; Azotic Acid; Nitric Acid 50%; Nitric Acid 65%; nitric acid 69-70%
CAS No.: 7697-37-2
Molecular Weight: 63.01
Chemical Formula: HNO3
Product Codes:
J.T. Baker: 411D, 412D, 5371, 5555, 5801, 5826, 5876, 5896, 9597, 9598, 9600, 9601, 9602, 9603, 9604, 9606, 9607, 9608, 9616, 9617
Mallinckrodt: 1409, 2704, 6623, V077, V336, V561, V633, V650

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Nitric Acid	7697-37-2	50 - 70%	Yes
Water	7732-18-5	30 - 50%	No

3. Hazards Identification

Emergency Overview

POISON! DANGER! STRONG OXIDIZER. CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE. CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED OR INHALED. INHALATION MAY CAUSE LUNG AND TOOTH DAMAGE.

SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 4 - Extreme (Poison)
Flammability Rating: 0 - None
Reactivity Rating: 3 - Severe (Oxidizer)
Contact Rating: 4 - Extreme (Corrosive)
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES
Storage Color Code: White (Corrosive)

Potential Health Effects

Nitric acid is extremely hazardous; it is corrosive, reactive, an oxidizer, and a poison.

Inhalation:
Corrosive! Inhalation of vapors can cause breathing difficulties and lead to pneumonia and pulmonary edema, which may be fatal. Other symptoms may include coughing, choking, and irritation of the nose, throat, and respiratory tract.
Ingestion:
Corrosive! Swallowing nitric acid can cause immediate pain and burns of the mouth, throat, esophagus and gastrointestinal tract.
Skin Contact:
Corrosive! Can cause redness, pain, and severe skin burns. Concentrated solutions cause deep ulcers and stain skin a yellow or yellow-brown color.
Eye Contact:
Corrosive! Vapors are irritating and may cause damage to the eyes. Contact may cause severe burns and permanent eye damage.
Chronic Exposure:
Long-term exposure to concentrated vapors may cause erosion of teeth and lung damage. Long-term exposures seldom occur due to the corrosive properties of the acid.
Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders, eye disease, or cardiopulmonary diseases may be more susceptible to the effects of this substance.

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4. First Aid Measures

Immediate first aid treatment reduces the health effects of this substance.
Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.
Ingestion:
DO NOT INDUCE VOMITING! Give large quantities of water or milk if available. Never give anything by mouth to an unconscious person. Get medical attention immediately.
Skin Contact:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.
Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

---

5. Fire Fighting Measures

Fire:
Not combustible, but substance is a strong oxidizer and its heat of reaction with reducing agents or combustibles may cause ignition. Can react with metals to release flammable hydrogen gas.
Explosion:
Reacts explosively with combustible organic or readily oxidizable materials such as: alcohols, turpentine, charcoal, organic refuse, metal powder, hydrogen sulfide, etc. Reacts with most metals to release hydrogen gas which can form explosive mixtures with air.
Fire Extinguishing Media:
Water spray may be used to keep fire exposed containers cool. Do not get water inside container.
Special Information:
Increases the flammability of combustible, organic and readily oxidizable materials. In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

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6. Accidental Release Measures

Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Neutralize with alkaline material (soda ash, lime), then absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer! US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

J. T. Baker NEUTRASORB® or TEAM® 'Low Na+' acid neutralizers are recommended for spills of this product.

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7. Handling and Storage

Store in a cool, dry, ventilated storage area with acid resistant floors and good drainage. Protect from physical damage. Keep out of direct sunlight and away from heat, water, and incompatible materials. Do not wash out container and use it for other purposes. When diluting, the acid should always be added slowly to water and in small amounts. Never use hot water and never add water to the acid. Water added to acid can cause uncontrolled boiling and splashing. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.

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8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
-OSHA Permissible Exposure Limit (PEL):
2 ppm (TWA), 4 ppm (STEL)
-ACGIH Threshold Limit Value (TLV):
2 ppm (TWA); 4 ppm (STEL)

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.
Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded, wear a supplied air, full-facepiece respirator, airlined hood, or full-facepiece self-contained breathing apparatus. Nitric acid is an oxidizer and should not come in contact with cartridges and canisters that contain oxidizable materials, such as activated charcoal. Canister-type respirators using sorbents are ineffective.
Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.
Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

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9. Physical and Chemical Properties

Appearance:
Colorless to yellowish liquid.
Odor:
Suffocating, acrid.
Solubility:
Infinitely soluble.
Specific Gravity:
1.41
pH:
1.0 (0.1M solution)
% Volatiles by volume @ 21C (70F):
100 (as water and acid)
Boiling Point:
122C (252F)
Melting Point:
-42C (-44F)
Vapor Density (Air=1):
2-3

Vapor Pressure (mm Hg):
48 @ 20C (68F)
Evaporation Rate (BuAc=1):
No information found.

10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage. Containers may burst when heated.
Hazardous Decomposition Products:
When heated to decomposition, emits toxic nitrogen oxides fumes and hydrogen nitrate. Will react with water or steam to produce heat and toxic and corrosive fumes.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
A dangerously powerful oxidizing agent, concentrated nitric acid is incompatible with most substances, especially strong bases, metallic powders, carbides, hydrogen sulfide, turpentine, and combustible organics.
Conditions to Avoid:
Light and heat.

11. Toxicological Information

Nitric acid: Inhalation rat LC50: 244 ppm (NO2)/30M; Investigated as a mutagen, reproductive effector. Oral (human) LDLo: 430 mg/kg.

--------\Cancer Lists\----------

Ingredient	---NTP Carcinogen--- Known	Anticipated	IARC Category
Nitric Acid (7697-37-2)	No	No	None
Water (7732-18-5)	No	No	None

12. Ecological Information

Environmental Fate:
No information found.
Environmental Toxicity:
No information found.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste facility. Although not a listed RCRA hazardous waste, this material may exhibit one or more characteristics of a hazardous waste and require appropriate analysis to determine specific disposal requirements. Processing, use or contamination of this product

may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: NITRIC ACID (WITH NOT MORE THAN 70% NITRIC ACID)
Hazard Class: 8
UN/NA: UN2031
Packing Group: II
Information reported for product/size: 150LB

International (Water, I.M.O.)

Proper Shipping Name: NITRIC ACID (WITH NOT MORE THAN 70% NITRIC ACID)
Hazard Class: 8
UN/NA: UN2031
Packing Group: II
Information reported for product/size: 150LB

International (Air, I.C.A.O.)

Proper Shipping Name: NITRIC ACID (WITH NOT MORE THAN 70% NITRIC ACID)
Hazard Class: 8
UN/NA: UN2031
Packing Group: II
Information reported for product/size: 150LB

15. Regulatory Information

--------\Chemical Inventory Status - Part 1\----------

Ingredient	TSCA	EC	Japan	Australia
Nitric Acid (7697-37-2)	Yes	Yes	Yes	Yes
Water (7732-18-5)	Yes	Yes	Yes	Yes

--------\Chemical Inventory Status - Part 2\----------

		--Canada--		
Ingredient	Korea	DSL	NDSL	Phil.
Nitric Acid (7697-37-2)	Yes	Yes	No	Yes
Water (7732-18-5)	Yes	Yes	No	Yes

Ingredient	RQ	-SARA 302- TPQ	List	------SARA 313- Chemical Catg.
Nitric Acid (7697-37-2)	1000	1000	Yes	No
Water (7732-18-5)	No	No	No	No

Ingredient	CERCLA	-RCRA- 261.33	-TSCA- 8(d)
Nitric Acid (7697-37-2)	1000	No	No
Water (7732-18-5)	No	No	No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
SARA 311/312: Acute: Yes Chronic: Yes Fire: Yes Pressure: No
Reactivity: No (Mixture / Liquid)

Australian Hazchem Code: 2PE
Poison Schedule: S6
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

16. Other Information

NFPA Ratings: Health: **3** Flammability: **0** Reactivity: **0** Other: **Oxidizer**
Label Hazard Warning:
POISON! DANGER! STRONG OXIDIZER. CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE. CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED OR INHALED. INHALATION MAY CAUSE LUNG AND TOOTH DAMAGE.
Label Precautions:
Do not get in eyes, on skin, or on clothing.
Do not breathe vapor or mist.
Use only with adequate ventilation.
Wash thoroughly after handling.
Keep from contact with clothing and other combustible materials.
Do not store near combustible materials.
Store in a tightly closed container.
Remove and wash contaminated clothing promptly.
Label First Aid:
In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In all cases get medical attention

immediately.

Product Use:

Laboratory Reagent.

Revision Information:

MSDS Section(s) changed since last revision of document include: 3.

Disclaimer:

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Prepared by: Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

PENTANE

LIQUID AIR CORP -- 10-7000 PPM PENTANE IN AIR

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MSDS Safety Information

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FSC: 6830
MSDS Date: 01/01/1992
MSDS Num: BWGGR
LIIN: 00N056643
Product ID: 10-7000 PPM PENTANE IN AIR
MFN: 01
Responsible Party
Cage: 18260
Name: LIQUID AIR CORP
Address: 2121 N CALIFORNIA BLVD
City: WALNUT CREEK CA 94596
Country: -U
Info Phone Number: 412-788-4353
Emergency Phone Number: 510-977-6500
Published: Y

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Contractor Summary

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Cage: 18260
Name: LIQUID AIR CORP ONE CALIFORNIA PLAZA
Address: 2121 N. CALIFORNIA BLVD
City: WALNUT CREEK CA 94596
Phone: 415-977-6500

==========

Ingredients

==========

Cas: 109-66-0
RTECS #: RZ9450000
Name: PENTANE. BOILING PT: 97F(36C). VP: 15 PSIA (103 KPA)@ 100F(37.8C).
%:
10-7000 PPM.
OSHA PEL: 1000 PPM
ACGIH TLV: 600 PPM; 750 STEL

RTECS #: AX5271000
Name: AIR, REFRIGERATED LIQUID; AIR COMPRESSED (UN1002, DOT); AIR
REFRIGERATED
LIQUID (CRYOGENIC LIQUID) (UN1003) (DOT)
OSHA PEL: N/K (FP N)
ACGIH TLV: N/K (FP N)

Name: SUPP DATA: FOR EXCESSIVE PERIOD OF TIME. THESE MIXTURES ARE NONCORR
&
MAY BE USED W/ALL MATLS OF CONSTRUCTION.

Name: ING 3: MOISTURE CAUSES METAL OXIDES WHICH ARE FORMED W/AIR TO BE
HYDRATED
SO THAT THEY INCREASE IN VOLUME & LOSE

Name: ING 4: THEIR PROT ROLE(RUST FORMATION). CONCS OF SO*2, CL*2, SALT,
ETC,
IN MOISTURE ENHANCES RUSTING OF METALS IN AIR.

==========

Health Hazards Data
==========
LD50 LC50 Mixture: NONE SPECIFIED BY MANUFACTURER.
Route Of Entry Inds - Inhalation: NO
Skin: NO
Ingestion: NO
Carcinogenicity Inds - NTP: NO
IARC: NO
OSHA: NO
Effects of Exposure: THESE MIXTURES SHOULD BE CONSIDERED SIMILAR TO AIR & WOULD THEREFORE CAUSE NO SYMPTOMS OF EXPOSURE.
Explanation Of Carcinogenicity: NOT RELEVANT.
Signs And Symptions Of Overexposure: SEE HEALTH HAZARDS.
Medical Cond Aggravated By Exposure: NONE SPECIFIED BY MANUFACTURER.
First Aid: NONE NEEDED(MFR). INHAL: REMOVE TO FRESH AIR. SUPPORT BREATHING(GIVE O*2/ARTF RESP)(FP N). INGEST: CALL MD IMMEDIATELY (FP N). EYE: FLUSH W/POTABLE AMOUNTS OF WATER FOR AT LEAST 15 MINUTES. CALL MD(FP N). SKIN: FLUSH W/COPIOUS AMOUNTS OF WATER. CALL MD(FP N).
==========
Handling and Disposal
==========
Spill Release Procedures: NONE SPECIFIED BY MANUFACTURER.
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.
Waste Disposal Methods: DISPOSE OF IN ACCORDANCE WITH LOCAL, STATE & FEDERAL REGULATIONS (FP N).
Handling And Storage Precautions: USE PRESS REDUCING REGULATOR WHEN CONNECTING CYLINDER TO LOWER PRESS (<500 PSIG) PIPING/SYSTEMS. DO NOT HEAT CYLINDER BY ANY MEANS TO INCREASE(SUPDAT)
Other Precautions: PROT CYLINDERS FROM PHYSICAL DMG. STORE IN COOL, DRY WELL-VENT AREA AWAY FROM HEAVILY TRAFFICKED AREAS & EMER EXITS. DO NOT ALLOW THE TEMP WHERE CYLINDERS ARE STORED TO EXCEED 125F(52C). FULL & EMPTY CYLINDERS CHOULD BE SEGREGATED.(SUPDAT)
==========
Fire and Explosion Hazard Information
==========
Extinguishing Media: NONFLAMMABLE GAS MIXTURES. USE MEDIA SUITABLE FOR SURROUNDING FIRE(FP N).
Fire Fighting Procedures: WEAR NIOSH/MSHA APPROVED SCBA & FULL PROTECTIVE EQUIPMENT(FP N). IF CYLINDERS ARE INVOLVED IN A FIRE, SAFELY RELOCATE OR KEEP COOL W/WATER SPRAY.
Unusual Fire/Explosion Hazard: THESE MIXTURES AT HIGH PERSSURES WILL ACCELERATE THE BURNING OF MATERIALS TO A GREATER RATE THAN THEY BURN AT ATMOSPHERIC PRESSURE.
==========
Control Measures
==========
Respiratory Protection: USE NIOSH/MSHA APPROVED RESPIRATOR APPROPRIATE FOR EXPOSURE OF CONCERN (FP N).
Ventilation: NONE SPECIFIED BY MANUFACTURER.
Protective Gloves: IMPERVIOUS GLOVES (FP N).
Eye Protection: SAFETY GOGGLES OR GLASSES.
Other Protective Equipment: SAFETY SHOES.

Work Hygienic Practices: NONE SPECIFIED BY MANUFACTURER.
Supplemental Safety and Health: SPEC GRAVITY: 1.00-1.01 @ 70F(21.1C)(AIR=1).
HNDLG/STOR: THE DISCHARGE RATE OF PROD FROM CYLINDER. USE CHECK VALVE/TRAP IN
DISCHARGE LINE TO PVNT HAZ BACK FLOW INTO CYLINDER. CLOSE VALVE AFTER EACH US
E & WHEN EMPTY. OTHER PROT: USE A "FIRST IN"- "FIRST OUT" INVENTORY
SYSTEM TO PVNT FULL CYLINDERS BEING STORED

==========

Physical/Chemical Properties

==========

HCC: G3
B.P. Text: -318F,-194C
Vapor Pres: SEE INGS
Spec Gravity: SUPP DATA
Solubility in Water: VERY SLIGHTLY
Appearance and Odor: COLORLESS GAS WITH VERY SLIGHT PARAFFINIC ODOR.

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Reactivity Data

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Stability Indicator: YES
Stability Condition To Avoid: NONE SPECIFIED BY MANUFACTURER.
Materials To Avoid: NONE.
Hazardous Decomposition Products: NONE.
Hazardous Polymerization Indicator: NO
Conditions To Avoid Polymerization: NOT RELEVANT.

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Toxicological Information

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Ecological Information

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MSDS Transport Information

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Regulatory Information

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Other Information

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HAZCOM Label

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Product ID: 10-7000 PPM PENTANE IN AIR
Cage: 18260
Company Name: LIQUID AIR CORP ONE CALIFORNIA PLAZA
Street: 2121 N. CALIFORNIA BLVD
City: WALNUT CREEK CA
Zipcode: 94596
Health Emergency Phone: 510-977-6500
Label Required IND: Y
Date Of Label Review: 01/04/1995
Status Code: C
Label Date: 01/04/1995
Origination Code: G

Eye Protection IND: YES
Skin Protection IND: YES
Signal Word: NONE
Respiratory Protection IND: YES
Health Hazard: None
Contact Hazard: None
Fire Hazard: None
Reactivity Hazard: None
Hazard And Precautions: ACUTE: THESE MIXTURES SHOULD BE CONSIDERED SIMILAR TO
AIR & WOULD THEREFORE CAUSE NO SYMPTOMS OF EXPOSURE. CHRONIC: NONE
SPECIFIED BY MANUFACTURER.
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of Defense or other government situation.

MSDS Number: **S4040** * * * * * *Effective Date:* ***08/02/01*** * * * * * *Supercedes:* ***08/20/98***

SODIUM HYDROXIDE SOLUTIONS AND CONCENTRATES

1. Product Identification

Synonyms: Sodium hydroxide, 0.2 to 2.0 normal volumetric solutions; DILUT-IT® analytical concentrates; Sodium Hydroxide Concentrate Solution StandARd®
CAS No.: 1310-73-2
Molecular Weight: 40.00
Chemical Formula: NaOH in water
Product Codes:
J.T. Baker: 0328, 0329, 4687, 4691, 4715, 5633, 5634, 5635, 5636, 5638, 5665, 5667
Mallinckrodt: 4693, H361, H364, H377, H380, H635

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Sodium Hydroxide	1310-73-2	0.8 - 8%	Yes
Water	7732-18-5	92 - 99%	No

3. Hazards Identification

Emergency Overview

DANGER! CORROSIVE. HARMFUL IF SWALLOWED OR INHALED. CAUSES BURNS TO ANY AREA OF CONTACT. REACTS WITH WATER, ACIDS AND OTHER MATERIALS.

J.T. Baker SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 2 - Moderate
Flammability Rating: 0 - None
Reactivity Rating: 1 - Slight
Contact Rating: 3 - Severe (Corrosive)
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES
Storage Color Code: White Stripe (Store Separately)

Potential Health Effects

The health effects from exposure to diluted forms of this chemical are not well documented. They are expected to be less severe than those for concentrated forms which are referenced in the descriptions below.

Inhalation:
Severe irritant. Effects from inhalation of mist vary from mild irritation to serious damage of the upper respiratory tract, depending on severity of exposure. Symptoms may include sneezing, sore throat or runny nose. Severe pneumonitis may occur.
Ingestion:
Corrosive! Swallowing may cause severe burns of mouth, throat, and stomach. Severe scarring of tissue and death may result. Symptoms may include bleeding, vomiting, diarrhea, fall in blood pressure. Damage may appears days after exposure.
Skin Contact:
Corrosive! Contact with skin can cause irritation or severe burns and scarring with greater exposures.
Eye Contact:
Corrosive! Causes irritation of eyes, and with greater exposures it can cause burns that may result in permanent impairment of vision, even blindness.
Chronic Exposure:
Prolonged contact with dilute solutions or dust has a destructive effect upon tissue.
Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems or impaired respiratory function may be more susceptible to the effects of the substance.

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4. First Aid Measures

Inhalation:
Remove to fresh air. Get medical attention for any breathing difficulty.
Ingestion:
If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. Get medical attention immediately.
Skin Contact:
Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician, immediately. Wash clothing before reuse.
Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

Note to Physician:
Perform endoscopy in all cases of suspected sodium hydroxide ingestion. In cases of severe esophageal corrosion, the use of therapeutic doses of steroids should be considered. General

supportive measures with continual monitoring of gas exchange, acid-base balance, electrolytes, and fluid intake are also required.

5. Fire Fighting Measures

Fire:
Not considered to be a fire hazard.
Explosion:
Not considered to be an explosion hazard.
Fire Extinguishing Media:
Use any means suitable for extinguishing surrounding fire. Adding water to caustic solution generates large amounts of heat.
Special Information:
Use protective clothing and breathing equipment appropriate for the surrounding fire.

6. Accidental Release Measures

Ventilate area of leak or spill. Keep unnecessary and unprotected people away from area of spill. Wear appropriate personal protective equipment as specified in Section 8. Contain and recover liquid when possible.
Do not flush caustic residues to the sewer. Residues from spills can be diluted with water, neutralized with dilute acid such as acetic, hydrochloric or sulfuric. Absorb neutralized caustic residue on clay, vermiculite or other inert substance and package in a suitable container for disposal.
US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

J. T. Baker NEUTRACIT®-2 or BuCAIM® caustic neutralizers are recommended for spills of this product.

7. Handling and Storage

Keep in a tightly closed container. Protect from physical damage. Store in a cool, dry, ventilated area away from sources of heat, moisture and incompatibilities. Protect from freezing. Always add the caustic to water while stirring; never the reverse. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product. Do not store with aluminum or magnesium. Do not mix with acids or organic materials.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
Sodium hydroxide:
-OSHA Permissible Exposure Limit (PEL):

2 mg/m3 Ceiling
-ACGIH Threshold Limit Value (TLV):
2 mg/m3 Ceiling

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices,* most recent edition, for details.
Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded and engineering controls are not feasible, a half facepiece particulate respirator (NIOSH type N95 or better filters) may be worn for up to ten times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest.. A full-face piece particulate respirator (NIOSH type N100 filters) may be worn up to 50 times the exposure limit, or the maximum use concentration specified by the appropriate regulatory agency, or respirator supplier, whichever is lowest. If oil particles (e.g. lubricants, cutting fluids, glycerine, etc.) are present, use a NIOSH type R or P filter. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.
Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.
Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

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9. Physical and Chemical Properties

Physical data is displayed for a 5% solution of sodium hydroxide.
Appearance:
Clear, colorless solution.
Odor:
Odorless.
Solubility:
Miscible in water.
Density:
5% solution: 1.05
pH:
14.0
% Volatiles by volume @ 21C (70F):
No information found.
Boiling Point:
102C (216F) (5% solution)
Melting Point:

-4C (25F) (5% solution)
Vapor Density (Air=1):
No information found.
Vapor Pressure (mm Hg):
No information found.
Evaporation Rate (BuAc=1):
No information found.

10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage.
Hazardous Decomposition Products:
No hazardous decomposition products.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Sodium hydroxide in contact with acids and organic halogen compounds, especially trichloroethylene, may causes violent reactions. Contact with nitromethane and other similar nitro compounds causes formation of shock-sensitive salts. Contact with metals such as aluminum, magnesium, tin, and zinc cause formation of flammable hydrogen gas. Sodium hydroxide, even in fairly dilute solution, reacts readily with various sugars to produce carbon monoxide. Precautions should be taken including monitoring the tank atmosphere for carbon monoxide to ensure safety of personnel before vessel entry.
Conditions to Avoid:
Heat, moisture, incompatibles.

11. Toxicological Information

Sodium hydroxide: irritation data: skin, rabbit: 500 mg/24H severe; eye rabbit: 50 ug/24H severe. Investigated as a mutagen.

--------\Cancer Lists\----------

Ingredient	---NTP Carcinogen--- Known	Anticipated	IARC Category
Sodium Hydroxide (1310-73-2)	No	No	None
Water (7732-18-5)	No	No	None

12. Ecological Information

Environmental Fate:
No information found.
Environmental Toxicity:
No information found.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste facility. Although not a listed RCRA hazardous waste, this material may exhibit one or more characteristics of a hazardous waste and require appropriate analysis to determine specific disposal requirements. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

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14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: SODIUM HYDROXIDE SOLUTION
Hazard Class: 8
UN/NA: UN1824
Packing Group: II
Information reported for product/size: 208L

International (Water, I.M.O.)

Proper Shipping Name: SODIUM HYDROXIDE SOLUTION
Hazard Class: 8
UN/NA: UN1824
Packing Group: II
Information reported for product/size: 208L

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15. Regulatory Information

--------\Chemical Inventory Status - Part 1\----------

Ingredient	TSCA	EC	Japan	Australia
Sodium Hydroxide (1310-73-2)	Yes	Yes	Yes	Yes
Water (7732-18-5)	Yes	Yes	Yes	Yes

--------\Chemical Inventory Status - Part 2\----------

		--Canada--		
Ingredient	Korea	DSL	NDSL	Phil.
Sodium Hydroxide (1310-73-2)	Yes	Yes	No	Yes
Water (7732-18-5)	Yes	Yes	No	Yes

--------\Federal, State & International Regulations - Part 1\----------

	-SARA 302-		------SARA 313---	
Ingredient	RQ	TPQ	List	Chemical Catg.
Sodium Hydroxide (1310-73-2)	No	No	No	No
Water (7732-18-5)	No	No	No	No

SODIUM HYDROXIDE

--------\Federal, State & International Regulations - Part 2\----------

Ingredient	CERCLA	-RCRA- 261.33	-TSCA- 8(d)
Sodium Hydroxide (1310-73-2)	1000	No	No
Water (7732-18-5)	No	No	No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
SARA 311/312: Acute: Yes Chronic: No Fire: No Pressure: No
Reactivity: No (Pure / Liquid)

Australian Hazchem Code: 2R
Poison Schedule: S5
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

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16. Other Information

NFPA Ratings: Health: **3** Flammability: **0** Reactivity: **0**
Label Hazard Warning:
DANGER! CORROSIVE. HARMFUL IF SWALLOWED OR INHALED. CAUSES BURNS TO ANY AREA OF CONTACT. REACTS WITH WATER, ACIDS AND OTHER MATERIALS.
Label Precautions:
Do not get in eyes, on skin, or on clothing.
Do not breathe mist.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.
Label First Aid:
If swallowed, give several glasses of water or milk to drink. Vomiting may occur spontaneously, but DO NOT INDUCE! Never give anything by mouth to an unconscious person. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. If inhaled, remove to fresh air. If not breathing give artificial respiration. If breathing is difficult, give oxygen. In all cases get medical attention immediately.
Product Use:
Laboratory Reagent.
Revision Information:
MSDS Section(s) changed since last revision of document include: 8.
Disclaimer:
****
Mallinckrodt Baker, Inc. provides the information contained herein in good faith but makes no representation as to its comprehensiveness or accuracy. This document is intended only as a guide to the appropriate precautionary handling of the material by a

properly trained person using this product. Individuals receiving the information must exercise their independent judgment in determining its appropriateness for a particular purpose. MALLINCKRODT BAKER, INC. MAKES NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE INFORMATION SET FORTH HEREIN OR THE PRODUCT TO WHICH THE INFORMATION REFERS. ACCORDINGLY, MALLINCKRODT BAKER, INC. WILL NOT BE RESPONSIBLE FOR DAMAGES RESULTING FROM USE OF OR RELIANCE UPON THIS INFORMATION.

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Prepared by: Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

MSDS Number: **S8231** * * * * * *Effective Date:* ***05/08/03*** * * * * * *Supercedes:* ***09/14/00***

Sulfuric Acid 57%

1. Product Identification

Synonyms: Oil of Vitriol,57%; Hydrogen Sulfate,57%
CAS No.: 7664-93-9
Molecular Weight: 98.08
Chemical Formula: H2SO4 in H2O
Product Codes: 9695, 9706

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Sulfuric Acid	7664-93-9	43 - 57%	Yes
Water	7732-18-5	43 - 57%	No

3. Hazards Identification

Emergency Overview

POISON! DANGER! CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED OR CONTACTED WITH SKIN. HARMFUL IF INHALED. AFFECTS TEETH. WATER REACTIVE. CANCER HAZARD. STRONG INORGANIC ACID MISTS CONTAINING SULFURIC ACID CAN CAUSE CANCER. Risk of cancer depends on duration and level of exposure.

J.T. Baker SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 3 - Severe (Poison)
Flammability Rating: 0 - None
Reactivity Rating: 3 - Severe (Water Reactive)
Contact Rating: 4 - Extreme (Corrosive)
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES
Storage Color Code: White (Corrosive)

Potential Health Effects

Inhalation:
Inhalation produces damaging effects on the mucous membranes and upper respiratory tract. Symptoms may include irritation of the nose and throat, and labored breathing. May cause lung edema, a medical emergency.
Ingestion:
Corrosive. Swallowing can cause severe burns of the mouth, throat, and stomach, leading to death. Can cause sore throat, vomiting, diarrhea. Circulatory collapse with clammy skin, weak and rapid pulse, shallow respirations, and scanty urine may follow ingestion or skin contact. Circulatory shock is often the immediate cause of death.
Skin Contact:
Corrosive. Symptoms of redness, pain, and severe burn can occur. Circulatory collapse with clammy skin, weak and rapid pulse, shallow respirations, and scanty urine may follow skin contact or ingestion. Circulatory shock is often the immediate cause of death.
Eye Contact:
Corrosive. Contact can cause blurred vision, redness, pain and severe tissue burns. Can cause blindness.
Chronic Exposure:
Long-term exposure to mist or vapors may cause damage to teeth. Chronic exposure to mists containing sulfuric acid is a cancer hazard.
Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems or impaired respiratory function may be more susceptible to the effects of the substance.

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4. First Aid Measures

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.
Ingestion:
If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. Get medical attention immediately.
Skin Contact:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Excess acid on skin can be neutralized with a 2% solution of bicarbonate of soda. Get medical attention immediately.
Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

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5. Fire Fighting Measures

Fire:
Concentrated material is a strong dehydrating agent. Reacts with organic materials and may cause ignition of finely divided materials on contact.
Explosion:
Contact with most metals causes formation of flammable and explosive hydrogen gas. A violent exothermic reaction occurs with water. Sufficient heat may be produced to ignite combustible materials.
Fire Extinguishing Media:
Dry chemical, foam or carbon dioxide. Do not use water on material. However, water spray may be used to keep fire exposed containers cool.
Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode. Structural firefighter's protective clothing is ineffective for fires involving this material. Stay away from sealed containers.

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6. Accidental Release Measures

Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Neutralize with alkaline material (soda ash, lime), then absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer! US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

J. T. Baker NEUTRASORB® or TEAM® 'Low Na+' acid neutralizers are recommended for spills of this product.

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7. Handling and Storage

Store in a cool, dry, ventilated storage area with acid resistant floors and good drainage. Protect from physical damage. Keep out of direct sunlight and away from heat, water, and incompatible materials. Do not wash out container and use it for other purposes. When diluting, always add the acid to water; never add water to the acid. When opening metal containers, use non-sparking tools because of the possibility of hydrogen gas being present. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.

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8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
For Sulfuric Acid:
- OSHA Permissible Exposure Limit (PEL) -
1 mg/m3 (TWA)
- ACGIH Threshold Limit Value (TLV) -
1 mg/m3(TWA), 3 mg/m3 (STEL), A2 - suspected human carcinogen for sulfuric acid contained in strong inorganic acid mists.

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded and engineering controls are not feasible, a full facepiece respirator with an acid gas cartridge and particulate filter (NIOSH type N100 filter) may be worn up to 50 times the exposure limit, or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. If oil particles (e.g. lubricants, cutting fluids, glycerine, etc.) are present, use a NIOSH type R or P particulate filter. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. WARNING: Air purifying respirators do not protect workers in oxygen-deficient atmospheres. Where respirators are required, you must have a written program covering the basic requirements in the OSHA respirator standard. These include training, fit testing, medical approval, cleaning, maintenance, cartridge change schedules, etc. See 29CFR1910.134 for details.

Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.

Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

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9. Physical and Chemical Properties

Appearance:
Colorless to yellow liquid.

Odor:
Odorless.

Solubility:
Complete (100%)

Specific Gravity:
1.4508 @ 25C (for 57% solution)

pH:
1 N solution (ca. 5% w/w) = 0.3; 0.1 N solution (ca. 0.5% w/w) = 1.2; 0.01 N solution (ca.

0.05% w/w) = 2.1.
% Volatiles by volume @ 21C (70F):
100
Boiling Point:
No information found.
Melting Point:
-64C (-83F) (65%)
Vapor Density (Air=1):
3.4
Vapor Pressure (mm Hg):
1 @ 145.8C (295F)
Evaporation Rate (BuAc=1):
No information found.

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10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage. Concentrated solutions react violently with water, spattering and liberating heat.
Hazardous Decomposition Products:
Toxic fumes of oxides of sulfur when heated to decomposition. Will react with water or steam to produce toxic and corrosive fumes. Reacts with carbonates to generate carbon dioxide gas, and with cyanides and sulfides to form poisonous hydrogen cyanide and hydrogen sulfide respectively.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Water, potassium chlorate, potassium perchlorate, potassium permanganate, sodium, lithium, bases, organic material, halogens, metal acetylides, oxides and hydrides, metals (yields hydrogen gas), strong oxidizing and reducing agents and many other reactive substances.
Conditions to Avoid:
Heat, moisture, incompatibles.

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11. Toxicological Information

Toxicological Data:
Oral rat LD50: 2140 mg/kg; inhalation rat LC50: 510 mg/m3/2H; standard Draize, eye rabbit, 250 ug (severe); investigated as a tumorigen, mutagen, reproductive effector.
Carcinogenicity:
Cancer Status: The International Agency for Research on Cancer (IARC) has classified "strong inorganic acid mists containing sulfuric acid" as a known human carcinogen, (IARC category 1). This classification applies only to mists containing sulfuric acid and not to sulfuric acid or sulfuric acid solutions.

--------\Cancer Lists\----------

Ingredient	---NTP Carcinogen--- Known	Anticipated	IARC Category
Sulfuric Acid (7664-93-9)	No	No	None
Water (7732-18-5)	No	No	None

12. Ecological Information

Environmental Fate:
When released into the soil, this material may leach into groundwater. When released into the air, this material may be removed from the atmosphere to a moderate extent by wet deposition. When released into the air, this material may be removed from the atmosphere to a moderate extent by dry deposition.
Environmental Toxicity:
LC50 Flounder 100 to 330 mg/l/48 hr aerated water/Conditions of bioassay not specified; LC50 Shrimp 80 to 90 mg/l/48 hr aerated water /Conditions of bioassay not specified; LC50 Prawn 42.5 ppm/48 hr salt water /Conditions of bioassay not specified.
This material may be toxic to aquatic life.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: SULFURIC ACID (WITH MORE THAN 51% ACID)
Hazard Class: 8
UN/NA: UN1830
Packing Group: II
Information reported for product/size: 12.5LB

International (Water, I.M.O.)

Proper Shipping Name: SULFURIC ACID (WITH MORE THAN 51% ACID)
Hazard Class: 8
UN/NA: UN1830
Packing Group: II
Information reported for product/size: 12.5LB

International (Air, I.C.A.O.)

Proper Shipping Name: SULFURIC ACID (WITH MORE THAN 51% ACID)
Hazard Class: 8
UN/NA: UN1830
Packing Group: II
Information reported for product/size: 12.5LB

15. Regulatory Information

--------\Chemical Inventory Status - Part 1\----------

Ingredient	TSCA	EC	Japan	Australia
Sulfuric Acid (7664-93-9)	Yes	Yes	Yes	Yes
Water (7732-18-5)	Yes	Yes	Yes	Yes

--------\Chemical Inventory Status - Part 2\----------

Ingredient	Korea	DSL	--Canada-- NDSL	Phil.
Sulfuric Acid (7664-93-9)	Yes	Yes	No	Yes
Water (7732-18-5)	Yes	Yes	No	Yes

--------\Federal, State & International Regulations - Part 1\----------

Ingredient	RQ	-SARA 302- TPQ	List	------SARA 313- Chemical	Catg.
Sulfuric Acid (7664-93-9)	1000	1000	Yes	No	
Water (7732-18-5)	No	No	No	No	

--------\Federal, State & International Regulations - Part 2\----------

Ingredient	-RCRA- CERCLA	-TSCA- 261.33	8(d)
Sulfuric Acid (7664-93-9)	1000	No	No
Water (7732-18-5)	No	No	No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: Yes
SARA 311/312: Acute: Yes Chronic: Yes Fire: No Pressure: No
Reactivity: Yes (Mixture / Liquid)

Australian Hazchem Code: 2P
Poison Schedule: None allocated.
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

16. Other Information

NFPA Ratings: Health: **3** Flammability: **0** Reactivity: **2** Other: **Water reactive**
Label Hazard Warning:
POISON! DANGER! CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED OR CONTACTED WITH SKIN. HARMFUL IF INHALED. AFFECTS TEETH. WATER REACTIVE. CANCER HAZARD. STRONG INORGANIC ACID MISTS CONTAINING SULFURIC ACID CAN CAUSE CANCER. Risk of cancer depends on duration and level of exposure.
Label Precautions:
Do not get in eyes, on skin, or on clothing.
Do not breathe vapor or mist.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.
Do not contact with water.
Label First Aid:
In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. Excess acid on skin can be neutralized with a 2% bicarbonate of soda solution. If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In all cases get medical attention immediately.
Product Use:
Laboratory Reagent.
Revision Information:
No Changes.
Disclaimer:
************Mallinckrodt Baker, Inc. provides the information contained herein in good faith but makes no representation as to its comprehensiveness or accuracy. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person using this product. Individuals receiving the information must exercise their independent judgment in determining its appropriateness for a particular purpose. MALLINCKRODT BAKER, INC. MAKES NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE INFORMATION SET FORTH HEREIN OR THE PRODUCT TO WHICH THE INFORMATION REFERS. ACCORDINGLY, MALLINCKRODT BAKER, INC. WILL NOT BE RESPONSIBLE FOR DAMAGES RESULTING FROM USE OF OR RELIANCE UPON THIS INFORMATION.**
****
Phone Number: (314) 654-1600 (U.S.A.)

ATTACHMENT 8

Project Forms and Permits

Project HS&E Change Management Form

*This evaluation form should be reviewed on a **continual basis** to determine if the current site-specific HASP adequately addresses ongoing project work, and it should be modified whenever new tasks are contemplated or changed conditions are encountered.*

Project Task:	Activity Manager:
Project Number:	Project Name:

Evaluation Checklist		**Yes**	**No**
1.	Has CH2M HILL staff changed?		
2.	Has a new subcontractor been added to the project?		
3.	Is any chemical or product to be used that is not listed in **Attachment 2** of the plan?		
4.	Are all tasks addressed in Section 1.1 of the site-specific HASP?		
5.	Have new contaminants or higher than anticipated levels of original contaminants been encountered?		
6.	Has other safety, equipment, activity, or environmental hazards been encountered that are not addressed in Section 2.1 of the plan?		

If the answer is "YES" to Questions 1-3, a HASP revision is NOT needed. Please take the following actions:
Confirm that the staff's medical and training status is current—check training records at:

http://www.int.ch2m.com/hands (or contact your regional SPA) and confirm subcontractor qualifications.
- Confirm with the project KA that subcontractor safety performance has been reviewed and is acceptable.
- Confirm with H&S that subcontractor safety procedures have been reviewed and are acceptable.

If the answer is "YES" to Questions 4-6, a HASP revision MAY BE NEEDED. To determine if a revision is needed, please contact HS&E directly or complete the field project start-up form at:
http://www.int.ch2m.com/hsdocgen/fppricing.asp**.**

Incident & Near-Loss
Root Cause Analysis Form

Root Cause Analysis (RCA)

Root Cause Categories (RCC): Select the RCC numbered below that applies for the root cause (RC) and/or contributing factor (CF) in the first column, then describe the specific root cause and corrective actions in each column.

1. **Lack of skill or knowledge**
2. **Absence of, inadequate, or lack of current operational procedures or work standards**
3. **Inadequate communication of expectations regarding procedures or work standards**
4. **Absence of or inadequate tools or equipment**
5. **Correct way takes more time and/or requires more effort**
6. **Short cutting standard procedures and safe practices is positively reinforced or tolerated**
7. **Person thinks there is no personal benefit to always doing the job according to standards**

RCC #	Root Cause(s)	Corrective Actions	RC[1]	CF[2]	Due Date	Completion Date	Date Verified

[1] RC = Root Cause; [2] CF = Contributing Factors (check which applies)

Investigation Team Members

Name	Job Title	Date

Results of Solution Verification and Validation

Reviewed By

Name	Job Title	Date

Determination of Root Cause(s)

For minor losses or near losses the information may be gathered by the supervisor or other personnel immediately following the loss. Based on the complexity of the situation, this information may be all that is necessary to enable the investigation team to analyze the loss, to determine the root cause, and to develop recommendations. More complex situations may require the investigation team to revisit the loss site or re-interview key witnesses to obtain answers to questions that may arise during the investigation process.

Photographs or videotapes of the scene and damaged equipment should be taken from all sides and from various distances. This point is especially important when the investigation team will not be able to review the loss scene.

The investigation team must use the Root Cause Analysis Flow Chart to assist in identifying the root cause(s) of a loss. Any loss may have one or more "root causes" and "contributing factors". The "root cause" is the primary or immediate cause of the incident, while a "contributing factor" is a condition or event that contributes to the incident happening, but is not the primary cause of the incident. Root causes and contributing factors that relate to the *person* involved in the loss, his or her peers, or the supervisor should be referred to as "personal factors". Causes that pertain to the *system* within which the loss or injury occurred should be referred to as "job factors".

<u>Personal Factors</u>

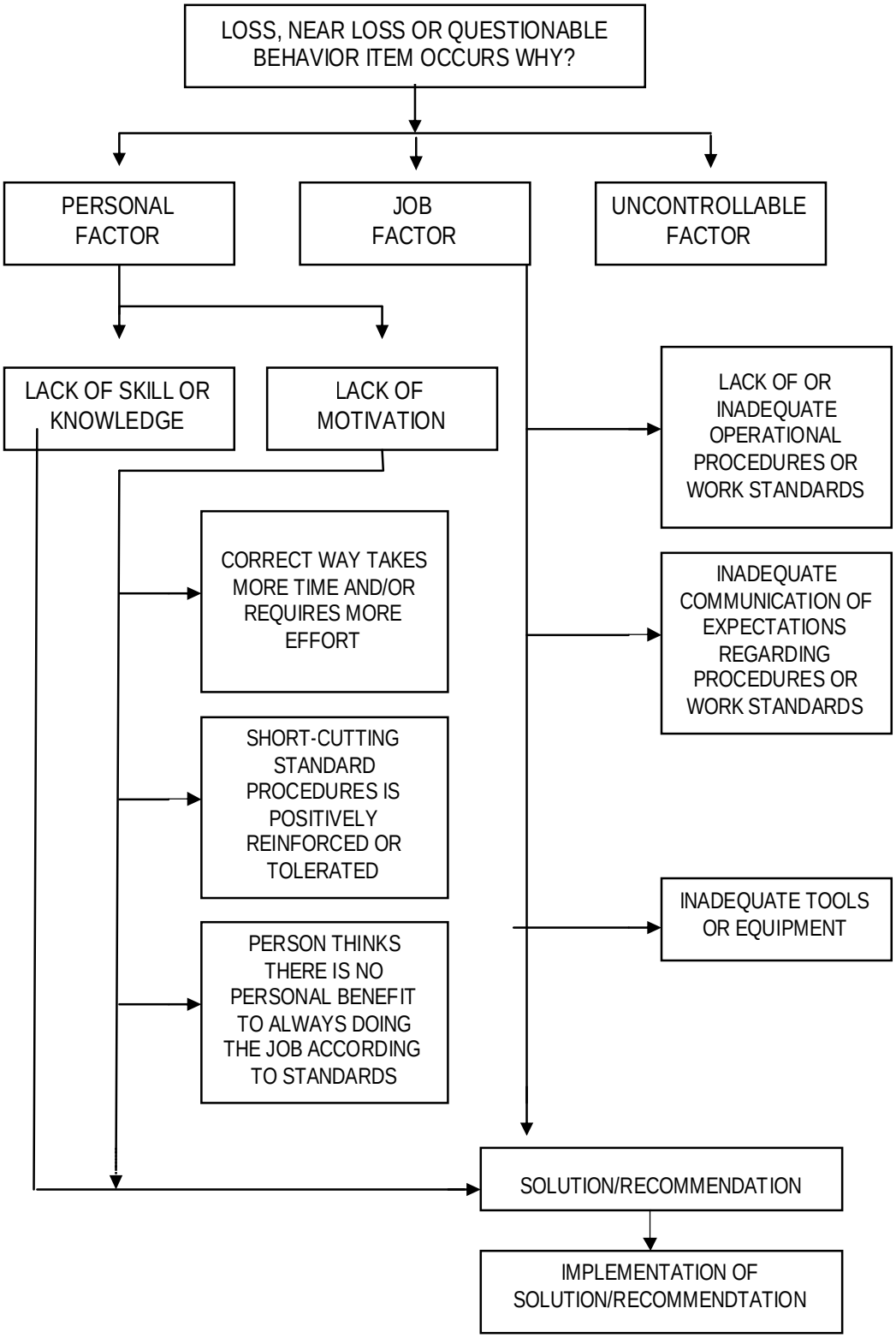
- Lack of skill of knowledge
- Correct way takes more time and/or requires more effort
- Short-cutting standard procedures is positively reinforced or tolerated
- Person thinks that there is no personal benefit to always doing the job according to standards

<u>Job Factors</u>

- Lack of or inadequate operational procedures or work standards.
- Inadequate communication of expectations regarding procedures or standards
- Inadequate tools or equipment

The root cause(s) could be any one or a combination of these seven possibilities or some other "uncontrollable factor." In the vast majority of losses, the root cause is very much related to one or more of these seven factors. Uncontrollable factors should be used rarely and only after a thorough review eliminates "all" seven other factors.

ROOT CAUSE ANALYSIS
Flow Chart



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SAFETY HAZARD ANALYSIS CARD

Name/Company: _____

Date/Time: _____

Job Description: _____

Daily Safety Goal: _____

PRE-TASK CHECKLIST

SAFETY EQUIPMENT (Check all that apply)

- ❑ PPE
- ❑ Equipment in HSP/FSI available

List: _____

_____

_____

- ❑ Inspected/in good condition
- ❑ Trained in use
- ❑ Fall protection
- ❑ Inspect before use
- ❑ Trained in use
- ❑ Monitoring Equipment
- ❑ Equipment in HSP/FSI available
- ❑ Inspected/maintained
- ❑ Within calibration range

PERMITS

- ❑ Confined space
- ❑ Lock-out/Tagout
- ❑ Hot work/welding
- ❑ Electrical
- ❑ Excavation/Drilling

EXAMPLE HAZARD AND CONTROL MEASURES

(Use to help you complete the reverse side)

OVERHEAD WORK (People/equipment above workers)

- ❑ Barricades
- ❑ Signage
- ❑ Flaggers

WORKING FROM HEIGHTS

- ❑ Personnel trained
- ❑ Fall protection equipment available
- ❑ Guardrails and/or railings
- ❑ Safety net
- ❑ Ladder
- ❑ Inspect before use
- ❑ Proper placement

SPILLS

- ❑ Spill Prevention Plan
- ❑ Secondary containment available
- ❑ Spill kit available

HEAVY EQUIPMENT (Drill rigs, backhoes, excavators, etc)

- ❑ Personnel trained
- ❑ Site-specific plan in place
- ❑ Maintenance/inspection checklist available
- ❑ Equipment on firm, level surface
- ❑ Competent person onsite (excavation)
- ❑ Dig permit obtained
- ❑ Underground utilities identified
- ❑ Overhead utilities identified
- ❑ Safety equipment identified in HSP/FSI available
- ❑ Able to work outside of operating radius (People/equipment above workers)

TOOLS

- ❑ Correct tool for job
- ❑ Inspected and maintained
- ❑ Proper explosion rating
- ❑ Guards in place

ELECTRICAL

- ❑ Power tools & extension cord inspection
- ❑ Qualified personnel work on/near energized equipment
- ❑ Lockout/tagout equipment available
- ❑ Equipment grounded
- ❑ GCIFs in use
- ❑ Safe clearances maintained

LIFTING

- ❑ Assistance required
- ❑ Mechanical lift (dolley, crane, chain fall, etc)**CHEMICAL**
- ❑ Trained
- ❑ MSDS available and reviewed
- ❑ Medically monitored
- ❑ PPE available per the HSP/FSI
- ❑ Air sampling/equipment available per the HSP/FSI

GENERAL

- ❑ Heat stress management planned (rest-work schedules, liquid available, work hours shifted to cooler hours, etc)
- ❑ Aisle-ways clear
- ❑ Fire extinguishers available
- ❑ Good housekeeping maintained
- ❑ Trash containers used and emptied
- ❑ Containers labeled
- ❑ Safety glasses/goggles used when flying objects/particulars present

OFFICE/ERGONOMICS

- ❑ Neutral position when working on a computer
- ❑ Slip, trip, and fall hazards removed
- ❑ Drawers closed when not in use
- ❑ Top drawers closed before bottom drawers opened

DRIVING

- ❑ Seat belt fastened
- ❑ Mirrors and headsets adjusted
- ❑ Valid drivers license for vehicle type

OTHER

- ❑ _____
- ❑ _____
- ❑ _____

WHAT AM I DOING? (List Tasks)

WHAT ARE THE POSSIBLE HAZARDS OF THE TASK I'M DOING? (List Potential Hazards)

WHAT WILL I DO TO REDUCE THE LIKELIHOOD OR SEVERITY OF THE HAZARD? (List Control Measures)

HS&E CH2MHILL

CH2MHILL **DAILY PRE-TASK SAFETY PLAN (PTSP)**

Project: _____ Location: _____Date:_____

Safety Coor./Supervisor: _____ Job Activity:_____

_____

Task Personnel:

_____
_____
_____

List Tasks:

_____
_____
_____

Tools/Equipment/Materials required (ladders, scaffolds, fall protection, cranes/rigging, heavy equipment, power tools, cords, generators, compressed gases, regulated chemical products, etc.):

_____
_____
_____

Potential H&S Hazards, including chemical, physical, safety, biological and environmental (Check all that apply):

__ Chemical burns/contact	__ Trench, excavations, cave-ins	__Ergonomics
__ Pressurized lines/equipment	__ Overexertion	__ Chemical splash
__ Thermal burns	__ Pinch points	__ Poisonous plants/insects
__ Electrical	__ Cuts/abrasions	___Eye hazards/flying projectile
__ Weather conditions	__ Spills	__ Inhalation hazard
__Heights/fall> 6’	__ Overhead Electrical hazards	__ Heat/cold stress
__ Noise	__ Elevated loads	__ Water/drowning hazard
__ Explosion/fire	__ Slips, trip and falls	__ Heavy equipment
__Radiation	__ Manual lifting	__ Aerial lifts/platforms
__ Confined space entry	__Welding/cutting	__ Demolition

Other Potential Hazards (Describe):

_____
_____
_____

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DAILY PRE-TASK SAFETY PLAN (PTSP)

Hazard Control Measures (Check all that apply):

PPE	**Protective Systems**	**Fire Protection**	**Electrical**
__ Thermal/lined	__ Locate buried utilities	__ Fire extinguishers	__ Lockout/tagout
__ Eye	__ Competent person	__ Fire watch	__ Grounded
__ Dermal/hand	__ Daily inspections	__ Non-spark tools	__ Panels covered
__ Hearing	__ Sloping	__ Grounding/bonding	__ GFCI/extension cords
__ Respiratory	__ Shoring	__ Intrinsically safe equipment	__ Power tools/cord inspected
__ Reflective vests	__ Trench box	__Combustible materials storage	__Insulated tools/gloves
__ Flotation device	__ Barricades	__Chemical Storage	
Fall Protection	**Air Monitoring**	**Proper Equipment**	**Welding & Cutting**
__ Harness/lanyards	__ PID/FID	__ Aerial lift/ladders/scaffolds	__ Cylinders secured/capped
__ Adequate anchorage	__ Detector tubes	__ Forklift/ Heavy equipment	__ Cylinders separated/upright
__ Guardrail system	__ Radiation	__ Backup alarms	__ Flash-back arrestors
__ Covered opening	__ Personnel sampling	__ Hand/power tools	__ No cylinders in CSE
__ Fixed barricades	__ LEL/O2	__ Crane w/current inspection	__ Flame retardant clothing
__ Warning system	__ Other	__ Proper rigging	__ Appropriate goggles
		__ Operator qualified	
Confined Space Entry	**Medical/Emerg. Response**	**Heat/Cold Stress**	**Vehicle/Traffic**
__ Isolation	__ First-aid & BBP kit	__ Work/rest regime	__ Traffic Awareness
__ Air monitoring	__ Eye wash	__ Rest area	__Traffic control
__ Trained personnel	__ FA-CPR training	__ Liquids available	__ Barricades
__ Permit completed	__ Route to hospital	__ Monitoring	__ Flags
__ Rescue provisions		__ Training	__ Signs
Permits	**Demolition**	**Inspections**	**Training**
__ Hot work	__ Pre-demolition survey	__ Ladders/aerial lifts	__ Hazwaste
__ Confined space	__ Structure condition	__ Lanyards/harness	__ Construction
__ Lockout/tagout	__ Isolate area/utilities	__ Scaffolds	__Equipment
__ Excavation	__ Competent person	__ Heavy equipment	__ Competent person
__ Demolition	__ Hazmat present	__Cranes and rigging	__ Task-specific (AHA)
__ Energized work		__Other per Field Safety Plan	__ Hazcom
__Local/Environmental			

FieldNotes:_____
_____
_____

Supervisor signature:_____ Date:_____

Activity:	**Date:**
	Project:
Description of the work:	**Site Supervisor:**
	Site Safety Officer:
	Review for latest use: Before the job is performed.

Work Activity Sequence (Identify the principal steps involved and the sequence of work activities)	**Potential Health and Safety Hazards** (Analyze each principal step for potential hazards)	**Hazard Controls** (Develop specific controls for each potential hazard)

Equipment to be used (List equipment to be used in the work activity)	**Inspection Requirements** (List inspection requirements for the work activity)	**Training Requirements** (List training requirements including hazard communication)

	PRINT NAME	SIGNATURE	
Supervisor Name:	_____	_____	**Date/Time:** _____
Safety Officer Name:	_____	_____	**Date/Time:** _____
Employee Name(s):	_____	_____	**Date/Time:** _____
	_____	_____	**Date/Time:** _____
	_____	_____	**Date/Time:** _____
	_____	_____	**Date/Time:** _____
	_____	_____	**Date/Time:** _____
	_____	_____	**Date/Time:** _____
	_____	_____	**Date/Time:** _____
	_____	_____	**Date/Time:** _____
	_____	_____	**Date/Time:** _____
	_____	_____	**Date/Time:** _____

Observation Form & Instructions

CH2MHILL

Top Section of the Form:

Complete the project information in the first section of the form. All that is required to be included is the general position or role of the individual whose work is being observed – individual names are not necessary.

Body of the Table:

In this section, indicate "Actions and Behaviors" as either "Safe" or "At-Risk" as applicable. If an action is not observed, then leave that area blank or put "N/O" for not observed. The first six rows under "Actions & Behaviors" include HS&E controls that most of us are familiar with – plans, training, tools, site control, and housekeeping. The remaining actions and behaviors focus on how we are performing our work – the safe (or unsafe) choices that we are making, whether intentionally or merely out of habit, in doing our job.

The large spaces on the right side of the table are available for noting observations and comments by both the person completing the form, and the individual being observed. Use these spaces to provide more detailed information on observations and improvements.

> Example: A section of pipe was rested on a tripod and was held by one worker while another used a hand-held pipe cutting saw to make a cut. Three things were observed: the cord to the tool was damaged, the operator was on his toes bearing down on the work, and the operator's vest was open and dangling near the work. A more traditional safety inspection would have only noted the damaged equipment (compliance). However, the bigger risks here were the work approach (bearing down on the work) and loose clothing. The crew immediately changed out the tool and adjusted the workstation and vest so that the cut could be made safely. "Work Approach/Habits", "Uncomfortable/Unsafe Position", and "Apparel" were checked as "At-Risk", and a brief note was added to document the changes made by the crew.

Do not forget to review your observations with the individual that you have observed and give the completed form to the Safety Coordinator.

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Safe Work Observation Form			
Project:	Observer:		Date:
Position/Title of worker observed:	Background Information/comments:		
Number of People Observed:			
Task/Observation Observed:			

- ❖ Identify and reinforce safe work practices/behaviors
- ❖ Identify and improve on at-risk practices/acts
- ❖ Identify and improve on practices, conditions, controls, and compliance that eliminate or reduce hazards
- ❖ Proactive PM support facilitates eliminating/reducing hazards (do you have what you need?)
- ❖ Positive, corrective, cooperative, collaborative feedback/recommendations

Actions & Behaviors	Safe	At-Risk	Observations/Comments
Current & accurate Pre-Task Planning/Briefing (Project safety plan, STAC, AHA, PTSP, tailgate briefing, etc., as needed)			**Positive Observations/Safe Work Practices:**
Properly trained/qualified/experienced			
Tools/equipment available and adequate			
Proper use of tools			**Questionable Activity/Unsafe Condition Observed:**
Barricades/work zone control			
Housekeeping			
Communication			
Work Approach/Habits			
Attitude			
Focus/attentiveness			**Observer's Corrective Actions/Comments:**
Pace			
Uncomfortable/unsafe position			
Inconvenient/unsafe location			
Position/Line of fire			
Apparel (hair, loose clothing, jewelry)			
Repetitive motion			**Observed Worker's Corrective Actions/Comments:**
Other…			

ATTACHMENT 9

CH2MHILL

HSE&Q-610 Explosives Usage and Munitions Response (MR)

CLICK HERE TO GET TO ATTACHMENTS

CH2MHILL

Explosives Usage and Munitions Response (MR) Standard of Practice HSE&Q-610

1.0 Applicability and Scope

1.1 Applicability

This Standard of Practice (SOP) applies to:

(1) CH2M HILL employees who enter areas known or suspected of having munitions,

(2) Areas where explosives are used for construction or demolition purposes, and

(3) Managers who may be responsible for oversight of a subcontractor's explosives usage, MR operations, or Controlled Detonation Chamber (CDC) operations.

Explosives usage or MR operations may be conducted on active, inactive, closed, transferring, or transferred ranges; former battlefields; disposal sites; munitions manufacturing and storage sites; and construction sites.

1.2 Scope

This SOP provides information regarding the spectrum of hazards and issues to be addressed during each phase of a project associated with operations involving the use of explosives. Hazardous situations addressed in this SOP include exposure to explosives used for construction or demolition work; munitions and explosives of concern (MEC), which include unexploded ordnance (UXO), discarded military munitions (DMM), and material that presents a potential explosive hazard (MPPEH); chemical warfare materiel (CWM), or munitions constituents (MC) contaminated soil and groundwater; munitions demilitarization operations; Controlled Detonation Chamber (CDC) operations; and operations to locate, identify, remove, and dispose of munitions.

CH2M HILL employees who enter areas where explosives may be encountered or used must take precautions to avoid these hazards and be aware of associated safe work practices.

As described in SOP HSE&Q-215, Contracts, Subcontracts, & HSE&Q Management Practices, responsibilities for health, safety, and environmental (HS&E) protection are expressly defined through subcontract terms and conditions. CH2M HILL's HS&E practices in the field are determined on the basis of these defined responsibilities. Consistent with HSE&Q-215, the subcontractor must determine how to operate safely, comply with applicable HS&E regulations and industry standards, and correct any deficiencies.

1.3 Regulatory Review

Projects involving the use of explosives are often complex (may require the acquisition, receipt, storage, and use of explosives to include insurance, permits/license, public safety, etc.) and have a myriad of regulatory requirements to ensure safety. A brief description of the major requirements follows:

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U.S. Department of Defense (DOD) Ammunition and Explosives Safety Standards, DOD 6055.9-STD, establishes uniform safety standards that apply to ammunition and explosives, to associated personnel and property, and to unrelated personnel and property exposed to the potential damaging effects of an accident involving ammunition and explosives during their development, manufacturing, testing, transportation, handling, storage, maintenance, demilitarization, and disposal. Additional regulatory requirements are: Title 18 U. S. Code, 842, Safe Explosives Act, 27 CFR Part 555.1 Explosives, 29 CFR 1910.109 Explosives and Blasting Agents, National Fire Protection Association 495 Explosive Materials Code, 49 CFR Parts 100–199, Hazardous Materials Transportation.

The U.S. Environmental Protection Agency (EPA) regulates the disposal of military munitions, and of waste that contains military munitions, through the Military Munitions Rule (MMR) (62 Federal Register [Fed. Reg.] 6621, February 12, 1997; 40 Code of Federal Regulations [CFR] Part 260 et seq.) under authority of the Resource Conservation and Recovery Act (RCRA). The rule has two functions: (1) it identifies when conventional and chemical military munitions become a solid waste, and (2) it provides criteria for storing and transporting such waste, including a conditional exemption if the munitions are managed under DOD rules.

This SOP incorporates by reference the guidelines and requirements for MR operations that are published by the U.S. Army Corps of Engineers (USACE) Engineering Support Center, Huntsville, Alabama. These are generally accepted industry standards, similar to voluntary consensus standards published by such organizations as the National Fire Protection Association (NFPA) and the American National Standards Institute (ANSI).

2.0 Project Planning

2.1 Planning Requirements

Compliance with the applicable governing laws and regulations is the responsibility of the Project Manager. The Project Manager will contact the MR Operations Manager, or in his absence the MR Safety Officer or the Munitions Response Market Segment Director, prior to and post MR ORE approval and subsequent GO/NO GO decision for determination of applicable governing laws and regulations and to assist with planning and executing support for such activities as blasting operations, hazardous toxic radiological waste (HTRW) support, construction support, MR actions, handling of CWM or explosive-contaminated soils, and munitions demilitarization. The following types of support may be needed for MR operations:

- For on-site visits with known or suspected MEC, an Abbreviated Site Safety and Health Plan (ASSHP) (See **Attachment 1**) must be prepared. This ASSHP is to be used only for non-intrusive site visits, and it must be approved by the MR Safety Officer, or in his absence either the MR Operations Manager or MR Market Segment Director, before the field visit starts. All team members must read and comply with the ASSHSP and attend the safety briefings. The UXO Safety Officer (UXOSO) shall ensure that the Safety Briefing Checklist and the Plan Acceptance forms are filled out before the site visit begins.
- On an HTRW site with known or suspected MEC, MEC support involves implementing anomaly avoidance techniques to avoid any potential surface MEC and any subsurface

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anomalies. A Site Safety & Health Plan (SSHP) must be prepared. This SSHP is to be used only for non-intrusive anomaly avoidance activities, and it must be approved by the MR Safety Officer, or in his absence the MR Operations Manager or the MR Market Segment Director prior to the start of fieldwork. All team members must read and comply with the SSHP and attend the safety briefings. The UXOSO shall ensure that the Safety Briefing Checklist and Plan Acceptance Form are filled out prior to the start of the site work.

- On a construction site with known or suspected MEC, support must be provided by qualified UXO personnel during construction activities. The level of MEC support required depends on the probability of encountering MEC, determined on a project-by-project basis. This will be identified during the MR ORE.
- MR actions in which the intent is to locate, identify, excavate, remove, and dispose of MEC may require a Senior UXO Supervisor, UXO Safety Officer, and UXO Quality Control Specialist, to oversee UXO Teams performing operations.
- On an MR site that has MC contamination of soil or groundwater, MEC support may include both anomaly avoidance techniques and MEC construction support for excavating and/or treating MC-contaminated soil and groundwater.
- On ordnance demilitarization projects, MEC support is required to identify, handle, disassemble, process, certify, transport, and treat or dispose of munitions components.
- On projects where explosives waste is transported or disposed of off range, the MR Operations Manager and the BG Environmental Compliance Coordinator (ECC) may assist in identifying the applicable regulations and permits required.
- On projects where munitions debris (MD), material presenting a potential explosive hazard (MPPEH), or inert ordnance is recovered and processed for disposal as scrap, the MR Operations Manager and the BG ECC may determine whether treatment and certification is required, along with any permitting requirements.
- For drilling activities at project sites suspected of MEC contamination, the UXO team shall conduct a reconnaissance and MEC avoidance to provide clear access routes to each site before drilling crews enter the area. The procedures listed in HSE&Q-204, *Drilling*, apply and shall be implemented.
- For excavation activities at project sites suspected of MEC contamination, the UXO team shall conduct a reconnaissance and MEC avoidance to provide clear access routes to each site before excavation crews enter the area. The procedures listed in HSE&Q-307, *Excavations*, apply and shall be implemented.
- Safety and quality control (QC) audits shall be included in developing cost estimates for any MR or explosives usage project that will last more then two weeks.
- On projects that include intrusive activities to investigate MEC or use of explosives (blasting), an Explosive Safety Submission (ESS), an Explosive Siting Plan (ESP), and an Explosive Management Plan (EMP) may be required. The MR Operations Manager, or in his absence the MR Safety Officer or MR Market Segment Director, shall assist in evaluating project requirements and coordinate with others as appropriate.

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The MR Operations Manager, or in his absence the MR Quality Control Manager, shall verify subcontractor training, personnel qualifications, and current medical examinations prior to the start of field operations. Any identified shortfalls in qualifications should be reported to the MR Operations Manager or in his absence to the MR Safety Officer or the Market Segment Director for resolution.

2.2 Opportunity and Risk Evaluation (ORE)

Every project or task involving the usage of explosives or a Munitions Response (MR) requires completion of paragraph 17 of the ORE form in **Attachment 2**. The most current form and assistance in filling out the form can be obtained from the MR Safety Officer, MR Operations Manager, or MR Market Segment Director. This document is a living form and should be updated as a project is developed and executed or upon change of scope of work (SOW), identification of previously unknown hazards, etc. Final acceptance of the MR portion (paragraph 17) of the ORE is done by the MR Safety Officer.

2.3 Alcohol, Tobacco, Firearms, and Explosives (ATF&E) Background Investigation

The "Safe Explosives Act of 2002" requires the employer (CH2M HILL) to submit to ATF&E identifying information, fingerprints, and photographs for all "Responsible Persons" and "Possessors of Explosives."

All personnel designated as Responsible Persons or Possessors of Explosives involved in explosives usage and MR projects must provide a 2-inch by 2-inch color picture and an ATF Form 5400.28 filled out for submission by the ATF&E License Holder (contact MR Operations for assistance) who will forward them to ATF&E so that a background investigation can be conducted to establish eligibility to work with explosives.

Under the "Safe Explosives Act," a "Responsible Person" and a "Possessor of Explosives" are defined as follows:

Responsible Person: An individual who has the power to direct the management and policies of the applicant pertaining to explosive materials. Generally the term includes partners, sole proprietors, project managers, site managers, corporate officers and directors, and majority shareholders.

Possessor of Explosives: An individual who has actual physical possession or constructive possession, which means the person has dominion or control over explosives. For example, persons who are physically handling explosive materials would be considered to be possessors of explosives. This would include employees who handle explosive materials in order to ship, transport, or sell them; and employees, such as blasters, who actually use explosive materials. Other examples of possessors include a supervisor at a construction site who keeps keys for magazines in which explosives are stored, or who directs the use of explosive materials by other employees; and an employee of a licensee or permittee transporting explosive materials from a licensed distributor to a purchaser.

Assistance in filling out required forms can be obtained from the MR Operations Manager, or in his absence the MR Safety Officer or the MR Market Segment Director. Submission of completed forms to ATF&E is the responsibility of the ATF&E License Holder. Upon

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submission of the required forms "responsible persons and possessors of explosives" may execute their duties pending completion of the background investigation.

ATF&E will notify employers in writing or electronically of the result of each background check and will supply the "responsible person" or "possessor of explosives" with a "Letter of Clearance" where appropriate.

2.4 Training Requirements

2.4.1 MR Projects

CH2M HILL employees and subcontractors who work on projects that involve MR must complete the following training:

- A one-time, 40-hour Hazardous Waste Operations and Emergency Response course, and a minimum of three days' actual field experience under the direct supervision of a trained supervisor as specified in 29 CFR §1910.120(e).
- An annual 8-hour hazardous waste refresher course, as specified in 29 CFR §1910.120(e)(8).
- Hazardous waste supervisory training (required for managers and supervisors only) as specified in 29 CFR §1910.120(e)(4).

All UXO technicians must be graduates of one of the following:

- U.S. Army Bomb Disposal School, Aberdeen Proving Ground, MD;
- U.S. Naval Explosive Ordnance Disposal (EOD) School, Indian Head, MD;
- U.S. Naval EOD School, Eglin Air Force Base (AFB), FL;
- EOD Assistants Course, Redstone Arsenal, AL;
- EOD Assistant Course, Eglin AFB; or
- An equivalent course as identified in Department of Defense Explosives Safety Board (DDESB) Technical Publication (TP) 18

The MR Operations Manager, or in his absence the MR Safety Officer or the MR Market Segment Director, must review subcontractor personnel qualifications.

2.4.2 Commercial Blaster Requirements

Commercial blasting is most often done in support of construction projects to remove or reduce obstacles that interfere with the construction of new roads, bridges, tunnels, harbors, or other facilities.

In order to be qualified as a "Blaster," the individual shall be able to understand and give written and oral orders; be in good physical condition and not be addicted to narcotics, intoxicants, or similar types of drugs; and be qualified by reason of training, knowledge, or experience in the field of transporting, storing, handling, and use of explosives, and have a working knowledge of state and local laws and regulations that pertain to explosives. A "Blaster" will be required to furnish satisfactory evidence of competency in handling explosives and performing in a safe manner the type of blasting that will be required. A

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Blaster must also be knowledgeable and competent in the use of each type of blasting method used.

Depending on the type and location of work performed, personnel that transport explosives may need to have a commercial driver's license (CDL) with a hazardous material endorsement in accordance with Department of Transportation Requirements specified in 49 CFR.

The following definitions provide an overview the types of explosives which may be used in commercial blasting:

Explosives -- any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion, i.e., with substantially instantaneous release of gas and heat, unless such compound, mixture, or device is otherwise specifically classified by the U.S. Department of Transportation; see 49 CFR Chapter I. The term "explosives" shall include all material which is classified as Class A, Class B, and Class C explosives by the U.S. Department of Transportation, and includes, but is not limited to dynamite, black powder, pellet powders, initiating explosives, blasting caps, electric blasting caps, safety fuse, fuse lighters, fuse igniters, squibs, cordeau detonant fuse, instantaneous fuse, igniter cord, igniters, small arms ammunition, small arms ammunition primers, smokeless propellant, cartridges for propellant-actuated power devices, and cartridges for industrial guns. Commercial explosives are those explosives which are intended to be used in commercial or industrial operations.

(i) ***Class A explosives***. Possessing, detonating, or otherwise having maximum hazard, such as dynamite, nitroglycerin, picric acid, lead azide, fulminate of mercury, black powder, blasting caps, and detonating primers.

(ii) ***Class B explosives***. Possessing flammable hazard, such as propellant explosives (including some smokeless propellants), photographic flash powders, and some special fireworks.

(iii) ***Class C explosives***. Includes certain types of manufactured articles which contain Class A or Class B explosives, or both, as components but in restricted quantities.

2.5 Medical Surveillance Requirements

All CH2M HILL employees who perform field work on MR sites must participate in a medical monitoring program in accordance with 29 CFR 1910.120 and HSE&Q 113, *Medical Monitoring*.

Employees who terminate employment and who have performed field work at MR project sites may be required to undergo an exit examination.

Subcontractors are responsible for ensuring that their employees are enrolled in a medical surveillance or monitoring program that meets the requirements of 29 CFR 1910.120.

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2.6 Drug Free Workplace Requirements

CH2M HILL employees who perform or oversee MR operations are subject to the provisions of HSE&Q-105, *Drug-Free Workplace*.

Subcontractors are responsible for ensuring that their employees who perform MR operations on CH2M HILL projects are on a drug abuse surveillance program that meets the requirements of HSE&Q-105.

2.7 Competent Person Requirements

2.7.1 Munitions Response

MR subcontractors are responsible for providing a competent person to oversee MR operations. A competent person may be a Senior UXO Supervisor, UXO Safety Officer, UXO Quality Control Specialist, or UXO Technician III. The competent person must meet the following minimum qualifications:

- Be a graduate of one of the schools and courses listed for all UXO technicians in Section 2.4.1 above,
- Have at least 8 years of combined active-duty military EOD experience and contractor UXO experience, and
- Have experience in MR operations and supervision of personnel.

CH2M HILL-competent person requirements are the same as for a subcontractor.

The MR Operations Manager, the MR Market Segment Director, and the MR Safety Officer will compose the Ammunition & Explosive Personnel Qualification and Certification Board for employees of CH2M HILL. This Board will review individual qualifications and experiences for determining who will be allowed to perform those duties and assignments associated with SUXOS, UXOQC, UXOSO, and CDC Chamber Operator.

2.7.2 Blasting

Blasting subcontractors are responsible for providing a competent person to oversee blasting operations. A competent person may be a state licensed blaster. The competent person must be qualified through a license or permit issued by a state or local jurisdiction based on testing, extensive knowledge, training, and experience with an ability to solve or resolve problems related to blasting, and must meet the following requirements:

- Able to understand and give written and oral orders.
- In good physical condition and not be addicted to narcotics, intoxicants, or similar types of drugs.
- Required to furnish satisfactory evidence of competency in handling explosives and performing in a safe manner the type of blasting that will be required.
- Knowledgeable and competent in the use of each type of blasting method used.

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2.8 Safety Equipment

Subcontractors are responsible for providing all necessary personal protective equipment (PPE) for their employees. CH2M HILL will provide PPE only for its own employees. Other safety equipment will be provided as delineated in the subcontract and documents referenced by the subcontract. The MR Safety Officer, or in his absence the MR Operations Manager or the MR Market Segment Director, must review subcontractor work plans and site-specific HS&E plans to ensure that appropriate safety equipment has been included to meet the requirements of the scope of work (SOW).

Personnel who will be handling explosives will not wear outer or inner garments having static electricity-generating characteristics. These include clothing made of 100 percent polyester, nylon, silk, and wool, which are all highly static producing.

Protective shoes worn by personnel performing explosives operations should be constructed of nonferrous materials (e.g., fiberglass) to prevent interference with sensitive geophysical instruments.

UXO Technicians are required to wear hard hats when an overhead hazard exists or when specified in the site-specific HS&E plan. Hard hats should *not* be worn, however, when investigating suspect MEC. A hard hat can create an unsafe condition by falling off the technician's head at a critical moment. Also, if a MEC is accidentally detonated (the worst-case accident scenario), the hard hat will not protect the technician from fragments and may worsen the injury by reflecting fragments into the head of the technician. This is consistent with safety guidance from the Corps of Engineers, Huntsville Center, Military Munitions Center of Expertise (MM-CX).

2.9 Subcontractor Selection

Subcontractors are selected based on their past performance in working for CH2M HILL, safety record, experience, and compliance with federal, state, and local jurisdiction licensing and permitting.

Additional criteria may be developed, depending upon the specific SOW requirements for the subcontractor. When oversight is required by HSE&Q-215, the CH2M HILL MR Safety Officer, or in his absence the MR Operations Manager or MR Market Segment Director, shall use these developed criteria to review the explosives procedures submitted by the sub-contractor.

3.0 Definitions

Please see **Attachment 3** for definitions.

4.0 Project Execution

4.1 Safe Work Practices

Management is responsible to control and eliminate unsafe work conditions through training and engineering out the hazard. The requirements of this section are to be followed by all personnel where explosives are used, regardless of the company performing the operations. These requirements also pertain to subcontractor personnel.

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4.2 MR Operations

On MR project sites, the MR Operations Manager will be contacted to establish requirements.

4.3 Regulations and Industry Standards

As described in HSE&Q-215, the MR Safety Officer or MR Quality Control Manager may be required to oversee a subcontractor's field activities. Subcontractors retain control over their practices, and CH2M HILL's oversight does not relieve them of their own responsibility for effective implementation and enforcement of HS&E requirements. The following subsections provide the minimum regulatory and industry standards for operations.

The Military Munitions Response Program (MMRP) is a maturing program with different levels of regulatory oversight within each service component. Unless a service component has issued written regulations/guidance for execution of MR actions, then the default regulations/guidance followed will be those issued by the Department of Defense Explosive Safety Board (DDESB) and the U.S. Army Corps of Engineers. For commercial blasting operations, the following guidelines shall apply: ATF&E federal explosive laws and regulations (ATF P5400.7); ANSI A10.7, Safety Requirements for Transportation, Storage, Handling and Use of Explosives; and NFPA 495, Explosive Material Code.

4.3.1 General Safety Concerns and Procedures

Operations, including site visits, shall not be conducted until a complete plan for the site is prepared and approval for use is given by the CH2M HILL MR Safety Officer, MR Operations Manager, or MR Market Segment Director. These plans will be based upon the cardinal rule of explosive safety which is to limit exposure to the minimum number of personnel, for the minimum amount of time, to the least amount of explosives hazards consistent with safe and efficient operations.

Only UXO-qualified personnel shall perform MEC procedures. Non-UXO personnel may be used to perform MEC-related procedures when supervised by a UXO Technician III. All personnel engaged in field operations shall be thoroughly trained and capable of recognizing the specific hazards of the procedures being performed. To ensure that these procedures are performed to standards, all field personnel shall be under the direct supervision of a UXO Technician III or a Senior UXO Supervisor (SUXOS).

4.3.2 Explosives Safety Precautions

Comply with the cardinal rule for explosives safety: expose the minimum number of people to the minimum amount of explosives for the minimum amount of time. Project-specific explosives safety precautions shall be developed prior to field activities and included in Work Plans and Health & Safety Plans that must be reviewed and approved by the MR Safety Officer, or in his absence the MR Operations Manager or MR Market Segment Director.

4.3.3 Recognize, Retreat, and Report MEC

Any CH2M HILL project located on a present or former Department of Defense (DOD) facility, even if it is now under the control of a city, state, or private owner, should plan on the potential to encounter MEC/MPPEH. A contingency plan developed during pre-mobilization that addresses the three Rs of MEC/MPPEH (recognize the potential hazard, retreat upwind a safe distance, and report in accordance with approved plans) will lesson

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the impact to the project and enhance employee safety if MEC/MPPEH is encountered. Assistance in developing this contingency plan should be obtained from the MR Safety Officer, or in his absence the MR Operations Manager or the MR Market Segment Director.

4.3.4 Explosives Management

Management of explosives material under the "Safe Explosives Act of 2002" implements stringent requirements that must be followed. Management of explosives is a process that, if in compliance with federal, state, and local jurisdiction, will reduce, control, or eliminate civil and criminal penalties, disciplinary actions, and potential risk to personnel, the public, and the environment. Details of explosives management are developed on a site-specific basis and included in a site-specific explosives management plan. These details are based on federal, state, and local jurisdiction requirements and on contractual specifications by the client.

4.3.5 Explosives Security

Security of explosives will conform to the requirements set forth by federal, state, and local jurisdictions. Provisions for explosives security during interstate or intrastate shipment will be performed by transportation vendors. Project site and overnight explosives security will conform to 49 CFR 171-173, transportation security requirements. Details of explosives security requirements are included in the explosives management plan for each project.

4.3.6 Controlled Detonation Chamber Operations

A Controlled Detonation Chamber (CDC) is capable of repeated controlled detonations of a suite of energetic materials that are currently demilitarized by open burn/open detonation (OB/OD). On CDC projects, the MR Operations Manager will be contacted to establish requirements.

4.3.7 Explosive Waste Disposal

When used or fired munitions are managed off range (i.e., transported off range and stored, reclaimed, treated, or disposed) or disposed of on range (i.e., buried without treatment), it is subject to regulation as a solid waste under RCRA. This means it may also be subject to regulation as a hazardous waste. Also, munitions that land off range and are not promptly retrieved are solid wastes. Table 4-1 describes how solid wastes may be characterized as hazardous in these situations. All characterization must be based on field observations by qualified MR personnel who are trained to properly identify waste munitions items and meet the requirements for an emergency response expert under RCRA. In the event that the explosive waste is regulated as hazardous waste, refer to SOP HSE&Q-409, Waste Handling: Hazardous Waste for RCRA hazardous waste management requirements.

TABLE 4-1
Waste Characterization

Item	Characterization	Waste Code
Uncontaminated metal debris	If visual inspection determines that the item does not contain waste residue, then waste is non-hazardous scrap metal excluded from RCRA regulation under 40 CFR §261.6(a)(3). Waste may be subject to further incineration and certification requirements.	None

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TABLE 4-1
Waste Characterization

Item	Characterization	Waste Code
Contaminated metal debris	If visual inspection determines that the item contains hazardous waste residue, then manage it as potential hazardous waste.	Potential D003 and/or D008
Ordnance items less than 0.50 caliber	Small-arms ammunition is not considered reactive hazardous waste in accordance with EPA policy (November 30, 1984 Memorandum, John Skinner, OSWER Director).	None
Ordnance items greater than 0.50 caliber	Untreated MEC is presumed to be reactive hazardous waste using generator knowledge under 40 CFR §261.23.	D003

4.3.8 Forms and Permits

(1) **Type-20 Manufacturer of High Explosives License/Permit** issued by the ATF&E is required to purchase, store, and use high explosives including on-site use of binary explosives in support of MR operations, construction projects, and demolition and deactivation (D&D) projects. The following must be done prior to execution of field activities:

- Explosives will not be ordered, shipped, stored, or used without the review and approval of the ATF&E License Holder.
- The ATF&E License Holder must review and approve all Explosive Siting Plans (ESPs) and Explosives Management Plans (EMPs) to ensure compliance with ATF&E regulations.
- Following compliance with the above, the ATF&E License Holder will provide procurement/contracting with a certified copy of our Type 20 license and the authorization letter (responsible persons & possessors of explosives) to procure explosives.
- Written authorization designating the "Responsible Persons" and "Possessors of Explosives" who can order, receive, store, and use explosives must be provided by the ATF&E License Holder to explosives supplier.
- A copy of the CH2M HILL ATF&E Type 20 Manufacturer of High Explosives license must be posted on the project site.
- A copy of the ESP must be provided through the ATF&E License Holder to the ATF&E Office that inspects the CH2M HILL records and to the nearest ATF&E Office to the project site.

Additional details are provided in **Attachment 4**, Explosives Management Check List, including required records that must be forwarded to the CH2M HILL ATF&E Type 20 License Holder upon completion of work.

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(2) State and local explosives permits may be required for CH2M HILL and individuals to purchase, store, and use explosives in support of MR operations, CDC operations, construction projects, and D&D projects. In addition there may be local requirements to notify law enforcement or fire department agencies when establishing explosives storage.

5.0 Attachments

The following attachments are included with this SOP:

Attachment 1 Abbreviated Site Safety and Health Plan (ASSHP)

Attachment 2 Opportunity Risk Evaluation (ORE)

Attachment 3 Glossary, Acronyms, and Abbreviations

Attachment 4 Explosives Management Check List

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CH2MHILL

Explosives Usage and Munitions Response (MR)
Standard of Practice HSE&Q-610

Attachment 1: Abbreviated Site Health, Safety, and Environmental Protection Plan (ASSHP)

For

Site name _____

Site location _____

Purpose of visit _____

ASSHP prepared by _____

Office _____

Address _____

Telephone _____

Date prepared _____

Signature and date _____

ASSHP reviewed and approved by:

Safety office: _____ Date: _____

Date: _____

NOTE: This ASSHP is to be used only for non-intrusive site visits and must be approved by the MR Safety Office, or in his absence the MR Operations Manager or the MR Market Segment Director, prior to the start of the field visit. All team members must read and comply with the ASSHP and attend the safety briefings. The UXOSO shall ensure that the Safety Briefing Checklist and Plan Acceptance Form are filled out prior to the start of the site visit.

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I. Site Description and Previous Investigation

A. Site Description

. Size ____+ acres

. Present usage

( ) Military	( ) Recreational	( ) Other (wildlife refuge)
( ) Residential	( ) Commercial	( ) _____
( ) Natural area	( ) Industrial	( ) _____
( ) Agricultural	( ) Landfill	( ) _____
( ) Secured	( ) Active	( ) Unknown
( ) Unsecured	( ) Inactive	

B. Past Uses

All members of the site visit team have been provided with a copy of the ASR.

Yes No

C. Surrounding Population

( ) Rural	( ) Residential	( ) Other (specify)
( ) Urban	( ) Industrial	( ) _____
	( ) Commercial	( ) _____

D. Previous Sampling and Investigation Results

1. MEC Encountered

Location	Description

2. Samples (air, water, soil, and/or vegetation)

Chemical	Concentration	Medium	Location

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II. Description of On-Site Activities

( ) Walk-through	( ) Drive-through	( ) Other
( ) On-road	( ) Off-road	( ) _____
( ) On-path	( ) Off-path	( ) _____
( ) Other	( ) Other	( ) _____

Activities and/or tasks to be performed: _____

III. Site Personnel and Responsibilities

Project Manager

Office _____

Address _____

Phone _____

Responsibilities _____

MEC Safety

Office _____

Address _____

Phone _____

Responsibility _____

Safety Office

Address _____

Phone _____

Responsibility _____

Team Leader

Office _____

Address _____

Phone _____

Responsibilities _____

UXOSO

Office _____

Address _____

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Phone _____

Responsibilities _____

First Aid and CPR

Certified _____

Office _____

Address _____

Phone _____

Responsibilities _____

IV. Hazard Analysis

A. Safety and Health Hazards Anticipated

( ) Chemical (be specific and include warning signs and symptoms of overexposure)

( ) Ordnance (specify)

( ) Heat stress	( ) Cold stress	( ) Tripping hazard
( ) Noise	( ) Electrical	( ) Falling objects
( ) Foot hazard	( ) Biological	( ) Overhead hazard
( ) Radiological	( ) Confined space	( ) Water hazard
( ) Explosive	( ) Climbing hazard	( ) Sunburn
( ) Flammable	( ) Other	

B. Overall Hazard Evaluation

( ) High ( ) Moderate ( ) Low ( ) Unknown

Justification

_____

V. Accident Prevention

A. General Precautions

Before the on-site visit, all team members are required to read this ASSHP and sign the form acknowledging that they have read and will comply with it. In addition, the UXOSO shall hold a brief tailgate meeting in which site-specific topics regarding the day's activities are discussed. The buddy system shall be enforced at all times. If unanticipated hazardous conditions arise, team members are to stop work, leave the immediate area, and notify the SSHO.

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VI. Standard Operation Safety Procedures, Engineering Controls, and Work Practices

A. Site Rules and Prohibitions

At any sign of unanticipated hazardous conditions, stop tasks, leave the immediate area, and notify the UXOSO. Smoking, eating, and drinking are allowed in designated areas only.

B. Material-Handling Procedures

Do not handle.

C. Drum-Handling Procedures

Do not handle.

D. Confined Space Entry

Do not enter.

E. Ignition Source and Electrical Protection

Smoke in designated areas only.

F. Spill Containment

N/A

G. Excavation Safety

Do not enter trenches and excavations.

H. Illumination

Work during daylight hours only.

I. Sanitation

Use existing sanitary facilities.

J. Buddy System

Two persons shall be on-site maintaining constant contact with each other; this shall be adhered to at all times.

K. Engineering Controls

N/A

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L. Heat Stress and Cold Stress

Dress appropriately, take sufficient breaks, and drink plenty of fluids. Watch for signs and symptoms of cold or heat stress. Monitoring may be applicable depending on site weather conditions and type of PPE worn.

M. Ordnance

1. General Information

a. The cardinal principle to be observed involving explosives, ammunition, severe fire hazards, or toxic materials is to limit the exposure to a minimum number of personnel, for the minimum amount of time, to a minimum amount of hazardous material, consistent with a safe and efficient operation.

b. The age or condition of an ordnance item does not decrease its effectiveness. Ordnance that has been exposed to the elements for extended periods of time becomes more sensitive to shock, movement, and friction because the stabilizing agent in the explosive may be degraded.

c. When chemical agents may be present, further precautions are necessary. If the munitions item has green markings, leave the area immediately, since it may contain a chemical filler.

d. Consider ordnance that has been exposed to fire as extremely hazardous. Chemical and physical changes may have occurred to the contents which render it more sensitive than it was in its original state.

2. On-Site Instructions

a. DO NOT touch or move any ordnance item regardless of the marking or apparent condition.

b. DO NOT visit an ordnance site if an electrical storm is occurring or approaching. If a storm approaches during a site visit, leave the site immediately and seek shelter.

c. DO NOT use radio or cellular phones in the vicinity of suspected ordnance items.

d. DO NOT walk across an area where the ground cannot be seen. If dead vegetation or animals are observed, leave the area immediately due to the potential of contamination by a chemical agent.

e. DO NOT drive a vehicle into a suspected MR area; use clearly marked lanes.

f. DO NOT carry matches, cigarettes, lighters, or other flame-producing devices into an MR site.

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g. DO NOT rely on color code for positive identification of ordnance items or their contents.

h. Approach ordnance items from the side. Avoid approaching the front and rear areas.

i. Always assume that an ordnance item contains a live charge until it can be determined otherwise.

3. Specific Actions upon Locating MEC

a. DO NOT touch, move, or jar any ordnance item regardless of its apparent condition.

b. Approach the item cautiously; take photographs and a full description. Take notes of the markings or any other identifiers.

c. DO NOT be misled by markings on the ordnance item stating "practice bomb," "dummy," or "inert." Even practice bombs have explosive charges that are used to mark or spot the point of impact; or the item could be mismarked.

d. DO NOT roll the item over or scrape the item to identify the markings.

e. The location of any ordnance items found during site investigation should be clearly marked so they can be easily located and avoided.

f. Notify CEHND upon location of any ordnance. See Section VIII for phone number.

N. Other

Specify: _____

VII. Site Control and Communications

A. Site Map

Attach copy

B. Site Work Zones

N/A

C. Buddy System

To be adhered to at all times.

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D. Communications

1. On Site

Use verbal communications among team members to communicate to each other on-site. If this communication is not possible, develop and use hand signals. Here are some examples:

Hand gripping throat:	"Breathing problems, can't breathe."
Thumbs up:	"OK, I'm all right, I understand."
Thumbs down:	"No, negative."
Hand(s) on top of head:	"Need assistance."
Grab buddy's wrist:	"Evacuate site now, no questions."
One long airhorn blast:	"Evacuate site to assembly point."
Two short airhorn blasts:	"Condition under control, return to site."

2. Off Site

Off-site communications shall be established on every site. Communications may be established by using an on-site cellular phone or by locating the nearest public or private phone that may be readily accessed. Mark the appropriate box:

( ) Cellular phone

( ) Public or private phone

( ) Other: _____

3. Emergency Signals

In the case of small groups, a verbal signal for emergencies shall suffice. The emergency signal for large groups (i.e., airhorn) should be incorporated at the discretion of the UXOSO. Mark the appropriate box:

( ) Verbal

( ) Nonverbal (specify) _____

VIII. Emergency Response

A. Alert Procedures

Team members are to be alert to the dangers associated with the site at all times. If an unanticipated hazardous condition arises, stop work, evacuate the immediate area, and notify the UXOSO. Practice MEC avoidance. If a suspected MEC is encountered during field activities, the appropriate person will contact local authorities and government Project Manager. The local authorities will

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contact military EOD. The suspected item will be marked with colored tape by on-site UXO specialist as applicable.

B. First Aid

A first aid kit and emergency eyewash (as applicable) will be located in the UXOSO's field car. If qualified persons (i.e., a fire department, medical facility, or physician) are not accessible within five minutes of the site, at least one team member shall be qualified to administer first aid and cardiopulmonary resuscitation (CPR).

C. Emergency Telephone Numbers

1. Medical Facility

   _____

2. Fire Department

   _____

3. Police Department

   _____

4. Poison Control Center (NJ): (800) 962-1253

   _____

5. Government Safety Office:

   For emergencies involving the discovery of MEC, contact the appropriate government Safety Office. If there is no answer at the appropriate government Safety Office, contact the local law enforcement office.

   _____

6. Local EOD

   _____

7. Project Manager

   _____

8. Others (list)

   _____

D. Hospital and Medical Facility Information

Route to hospital: Attach a map with the route to the hospital marked; if a map is not available, then provide clear, written instructions.

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IX. Monitoring Equipment and Procedures

A. Exposure Monitoring

For non-intrusive on-site activities such as site visits, air monitoring is typically not required. However, if the site situation dictates the need for monitoring, then complete the following information on a separate page and attach the page to the ASSHP.

- Monitoring equipment to be utilized
- Documentation of equipment calibration and results
- Action levels

B. Heat and Cold Stress Monitoring

If heat stress monitoring is necessary, the monitoring criteria published in Chapter 8 of *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities* (NIOSH/OSHA/USCG/EPA, October 1985) shall be followed. If cold stress monitoring is necessary, it shall be conducted in accordance with the most current American Conference of Governmental Industrial Hygienists (ACGIH) cold stress standard.

X. Personal Protective Equipment

A. General

Typically, for non-intrusive site visits, Level D PPE is required. Hard hats shall be worn if an overhead hazard exists, safety shoes if a foot hazard exists, and safety glasses if an eye hazard exists. If a higher level of protection is to be used initially or as a contingency, attach a brief discussion.

B. Non-intrusive Site Visit

Level of Protection

Initial:	( ) C	( ) D	( ) Modified (specify)
Contingency:	( ) C	( ) D	( ) Modified (specify)
	( ) Evacuate site if higher level of protection is needed.		

XI. Decontamination Procedures

If decontamination is required, attach an additional sheet with the requirements.

Decontamination procedures are not anticipated for this site investigation. Team members are cautioned not to walk, kneel, or sit on any surface with potential leaks, spills, or contamination.

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XII. Training

All site personnel shall have completed the training required by EM 385-1-1 and 29 CFR §1910.120 (e). The Project Manager shall ensure, and the UXOSO shall verify, that all on-site persons have completed appropriate training prior to submitting the plan to the safety office for review. Additionally, the UXOSO shall inform personnel, before they enter the site, of any potential site-specific hazards and procedures.

XIII. Medical Surveillance Program

The Project Manager shall ensure, and the UXOSO shall verify, that all on-site personnel are in the Medical Surveillance Program meeting the requirements of 29 CFR §1910.120 (NAVMED P-117 or equivalent) and ANSI Z-88.2, as appropriate, depending on the PPE and site-specific tasks.

Provide the following information on training and medical surveillance:

Name:

Course Date:

Medical Exam:

40-Hour/8-Hour Date

XIV. Logs, Reports, and Recordkeeping

Site logs are maintained by the team leader. These are to include historical data, personnel authorized to visit the site, all records, standard operating procedures, any air monitoring logs, SOPs, and attachments to plans.

XV. General

The number of persons visiting the site shall be held to a minimum. No more than 8 people per UXOSO shall be allowed on-site. The more persons on-site, the greater the potential for an accident. The UXOSO may modify this ASSHP if site conditions warrant it and if it does not risk the safety and health of the team members. This modification shall be coordinated with the team members, and the UXOSO shall notify CEHND PM-SO of the change as the situation allows.

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XVI. Natural Resources

The following is a list of threatened and endangered species:

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Safety Briefing Checklist
(Check subjects discussed)

Location: _____ Date: _____

General Information

Purpose of visit: _____

Identification of key site personnel: _____

Training and medical requirements: _____

Specific Information

Site description and past uses: _____

Results of previous studies: _____

Potential site hazards: _____

MEC safety procedures: _____

Site SOPs: _____

Site control and communications: _____

( ) Emergency Hand Signals

Emergency Response: _____

( ) Location of First Aid Kit

( ) Emergency Phone Numbers and Location

( ) Location of Nearest Medical Facility and Location of Map to Facility

PPE and Decontamination: _____

Note: Stress the following during the briefings: If an unanticipated hazardous condition arises, stop work, evacuate the immediate area, and notify the UXOSO.

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Plan Acceptance Form:
Abbreviated Site Safety and Health Plan

For:

I have read and agree to abide by the contents of this Abbreviated Site Safety and Health Plan and I have attended the Safety Briefing for the aforementioned site.

Name (printed)	Office	Signature	Date

Person presenting the safety briefing:

Signature	Date

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Equipment List

(The following items may be necessary to support the non-intrusive site visit)

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CH2MHILL

Explosives Usage and Munitions Response (MR)
Standard of Practice HSE&Q-610

Attachment 2: Opportunity Risk Assessment (ORE)

17.0 PROJECTS INVOLVING OR POTENTIALLY INVOLVING THE USE OF EXPLOSIVES, MATERIALS POTENTIALLY PRESENTING AN EXPLOSIVE HAZARD (MPPEH), MUNITIONS AND EXPLOSIVES OF CONCERN (MEC), AND RELATED ACTIVITY.

Administrative Information: (Fill in or highlight appropriate information)

Project Name:
Project Number:
Project Location: (Address, City, State, Zip Code, Country)
Address
City:
State:
Zip Code:
Country:
Contracting Organization:
Client Organization:
Department of Defense
Department of State
Department of Energy
Department of Interior
Other
Client Organization Name:
Contract:
U.S. Army Corps of Engineers
Navy
Air Force
Marine Corps
Other

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PART A:

Common questions for Explosives Usage, Munitions Response (MR), and Controlled Detonation Chamber (CDC) projects. (Highlight Appropriate Number)

Scoring criteria

0 = none, 1 - 2 = Low Risk 3 Moderate Risk 4 - 5 High Risk

17.A1 Client Scope of Work E&MR Risk Factor	
Project Risk Category?	**Check Correct Item**
Military Munitions	
Military Explosives	
Commercial Explosives	
Commercial Ammunition	
Commercial Pyrotechnics	
HTRW	

17.A2 Client – END LAND USE	
Which factor best describes the project end land use?	**Point Value**
Like Use –	0
Not Yet Determined –	1
Limited Public Access – livestock grazing/wildlife preserve/historic area	2
Public Access – Farming/Agriculture	3
Unrestricted – Commercial	4
Unrestricted – Residential	5

17.A3 Chemical Warfare Materiel (CWM)	
Which factor best describes this risk factor?	**Point Value**
None	0
No-specific reference - but possible	3
CWM Known or Suspected	5

17.A4 Are Munitions and Explosives of Concern (MEC) Suspected?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
No	1
Don't Know	3
Yes	5

17.A5 Does Owner acknowledge that it will retain ownership of, and responsibility for MEC & wastes?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Yes	1
Don't Know	3
No	5

17.A6 Does Client indemnify CH2M HILL from third party claims for: Liability, Workers Comp, Pollution, etc.	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Yes	1
Don't Know?	3
No	5

17.A7 Is Owner responsible for obtaining necessary permits?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Yes	1
Don't Know	3
No	5

17.A8 Will CH2M HILL write site-specific work/safety plan for this project?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Yes	1
Don't Know	3
No	5

17. A9 Will CH2M HILL subcontract MR or Explosive operational actions?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
No	1
Don't Know	3
Yes	5

17.A10 Will CH2M HILL be responsible for MPPEH to include scrap?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
No	1
Don't Know	3
Yes	5

17.A11 Is CH2M HILL HILL responsible for the disposal of Solid Waste and Hazwaste?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
No	1
Don't Know	3
Yes	5

17.A12 Are commercial explosives required?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
No	1
Don't Know	3
Yes	5

17.A13 Is Explosives storage required on site?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
No	1
Don't Know	3
Yes	5

17.A14 Are there adjacent facilities/operations?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
No	1
Don't Know	3
Yes	5

17.A15 Are there inhabited buildings in close proximity to the site?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
No	1
Don't Know	3
Yes	5

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17.A16 Are there public transportation routes in close proximity to the site or airport operations?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
No	1
Don't Know	3
Yes	5

17.A17 Will explosive safety procedures adversely affect schedule?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
No	1
Don't Know	3
Yes	5

17.A18 Are there emergency response services in close proximity to site (e.g., fire, hospital)?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Yes	1
Don't Know	3
No	5

17.A19 Are there sensitive environments that need to be considered?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
No	1
Don't Know	3
Yes	5

PART B:

Explosives Usage Project Questions

17.B1 Source of Explosives	
Which factor best describes the source?	**Check (x)**
Vendor - Authorized ATF&E Dealer	
Government Furnished	
Client Furnished	
Local Manufactured (Binary Explosives)	
Subcontractor Provided	
Transferred from another CH2M HILL project	

17.B2 Explosive Operations General RISK Requirements/Concerns	
Which factors apply to regulatory conformance risk factor?	**Check (x)**
State Blasting License (Individual)	
State Blasting License (Corporation)	
State Explosive Storage Permit (Fire Marshal Inspection)	
Vehicle Inspection (state of registration) for hazard materials transportation	
Hazard Materials License (federal and/or state)	
Operator – Commercial Drivers License with Hazmat Endorsement	
Miss Utilities Permit – underground gas lines, pipelines, alarms, internet, fiber optics, cable crossings, communications, sewer lines – Ground Shock/vibrations	
Airport/flight paths – Notice to Airmen (NOTAM) – Airspace	
Navigable Waterways – Notice to Mariners (NOTM)	
Power lines/ Radar/ Microwave tower/Antenna – Electro Magnetic Radiation Hazards	
Military - training corridor/area/test area/research and development area	
Need to establish a Temporary Open Detonation Area	
Need to establish an Explosive Holding Area	
Need to establish an Explosive Inspection Area for MPPEH/MD	
Need to establish a storage area for MEC	
Need to establish a storage area for MPPEH	

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17.B3 Explosive Storage Risk Factors	
Which factor best describes this risk factor Magazine Condition?	**Point Value**
Not Applicable	0
Fire Inspector Permit/ground tests documents/ventilator and doors and locks and hasps IAW NFPA Code 495	1
	2
Do Not Know	3
	4
Surplus excess	5

17.B4 Explosive Transportation	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Within project area – private roads	1
	2
Public Roads	3
	4
Federal Roads (interstate)	5

17.B5 Explosive Security	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Provided by Military	1
	2
Don't Know	3
	4
Not Provided by Others	5

17.B6 Is underwater work required?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
No	1
Don't Know	3
Yes	5

PART C:

Munitions Response Project Questions

17.C1 Type of Munitions Response (MR) project	
Which factor best describes this risk factor?	**Point Value**
Environmental Records Search and Confirmation Study – Non-intrusive actions	0
Escort and/or Avoidance Activities – (site visit, reconnaissance, sediment sampling, develop wells, perform O&M, land survey, area preparation, design work, etc.)	1
Construction Support Trenching, Excavation, Soil Sifting, In Situ Treatment, Demolition, Land Clearing/grubbing etc.)	2
Demilitarization/ MPPEH/ Blasting/	3
Removal Action	4
Demining, IEDs	5

17.C2 What is Potential Land Use?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Same Use	1
Wildlife Preserve	2
Commercial	3
Industrial	4
Residential	5

17.C3 Type of Munitions Constituent (MC) Contaminated Soil and/or Groundwater	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Low concentrations of explosives measured in ppb/ppm	1
High concentrations of explosives measured in ppb/ppm	2
High concentrations of explosives measured in ppb/ppm - No explosive hazard	3
Soil with 5% to 10% energetic material by weight - initiation hazard	4
Soil with >10% energetic material by weight - explosive hazard	5

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17.C4 Type of MEC Disposal	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Discarded Military Munitions (DMM)	1
MEC Unfused	2
MEC Fused but safe for movement	3
Munitions requiring disassembly prior to demilitarization	4
Unknown deteriorated material	5

17.C5 Is an explosive safety submission (ESS) anticipated by the Client?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
No	1
	2
Don't Know	3
	4
Yes	5

17.C6 Is underwater work required?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
No	1
Don't Know	3
Yes	5

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PART D:

Controlled Detonation Chamber (CDC) Project Questions

17.D1 Type of MEC Hazard	
Which factor best describes this risk factor?	**Point Value**
Small arms ammunition up to and including 0.50-caliber	0
Demilitarization	1
MPPEH	3
Fireworks	4
CWM	5

17.D2 Quality and Completeness of Inventory	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Subject to Direct Inspection and Verification by CH2M HILL	1
Inspection/Verification by Others	3
Client Statement	5

17.D3 Condition of MEC	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Unserviceable ammunition (Code H)	1
MEC Unfused	2
MEC Fused but safe for movement	3
Munitions requiring disassembly prior to demilitarization	4
Unknown deteriorated material	5

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17.D4 Will CH2M HILL provide CDC operator services?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Yes	1
Don't Know	3
No	5

17.D5 If CDC leased to Owner, will CH2M HILL train Owner's operators?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Yes	1
Don't Know	3
No	5

17.D6 Will Owner accept CH2M HILL rejection of MEC deemed unsuitable for CDC destruction?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Yes	1
Don't Know	3
No	5

17.D7 Are all MEC items of type, size and condition previously destroyed in CDC?	
Which factor best describes this risk factor?	**Point Value**
Not Applicable	0
Yes	1
Don't Know	3
No	5

PART E:

Risk Management Approaches

List as a risk element any answers that have a point value of 3 or higher (Section A, B, C & D) and any item not addressed which you think requires further comment. For each risk element identified, outline your proposed risk management strategy. Such strategies include obtaining more information; MEC avoidance; engineering controls; reduction of risk through contractual protections, procedures, and project controls; managing through insurance and bonding; acceptance with contingencies; pricing strategies including contingency pricing; and liability control through limitations of liability contract language.

17.__	
Risk Management Strategy	

17.__	
Risk Management Strategy	

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Risk Management Strategy	

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Risk Management Strategy	

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17. ___	
Risk Management Strategy	

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Risk Management Strategy	

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Risk Management Strategy	

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Risk Management Strategy	

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Risk Management Strategy	

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Risk Management Strategy	

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Risk Management Strategy	

Attachment 3: Glossary, Acronyms, and Abbreviations

Active munitions inventory (or stockpile): The supply of chemical and conventional military munitions that is available for issue and use for combat, training, demonstrations, research, development, testing, or evaluation. (See **munitions stockpile** and **demilitarization inventory**.)

Active range: An operational military range that is currently in service and being regularly used for training, demonstrations, research, development, testing, or evaluation.

AEDA: ammunition, explosives, and dangerous articles.

Anomaly avoidance: Techniques employed by EOD or UXO personnel at sites with known or suspected MEC to avoid any potential surface MEC or subsurface anomalies. This usually occurs at mixed-hazard sites when HTRW investigations must occur before an MEC removal action is executed. Intrusive anomaly investigations are not authorized during ordnance avoidance operations.

Anomaly: Any item that is seen as a subsurface irregularity after geophysical investigation. This irregularity should deviate from the expected subsurface ferrous and nonferrous material at a site.

AP: armor piercing: Munitions that may or may not contain HE and are designed to penetrate hard targets.

APERS: antipersonnel munitions: May be loaded with high explosives or incendiary fillers and are designed to kill, wound, or obstruct personnel.

APT: armor-piercing tracer: Munitions, designed to penetrate hard targets, that contain a pyrotechnic element that produces bright light and/or smoke to aid in visual tracking of the munitions in flight.

ATV: all-terrain vehicle.

BD: base detonating: Impact fuse designed to function when the projectile comes in contact with the surface of the target. The fuse is located in the base or tail of the munitions.

bgs: below ground surface.

BRAC: Base Realignment and Closure.

CAD: cartridge-actuated device: An explosive device designed to produce gas pressure to expel or eject an item.

Cal: caliber: The diameter of a projectile or the bore of a weapon (i.e., .50-cal, 3-inch, 90-millimeter).

CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act.

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Chemical warfare materiel (CWM): An item configured as ammunition, containing a chemical substance intended to kill, seriously injure, or incapacitate a person through its physiological effects. Also includes V- and G-series nerve agents, H-series blister agent, and lewisite in other-than-munitions configurations. Due to their hazards, prevalence, and military-unique application, chemical agent identification sets (CAIS) are also considered CWM. CWM does not include riot control agents, chemical herbicides, smoke- and flame-producing items, or soil, water, debris, or other media contaminated with a chemical agent.

Closed range: A military range that has either been taken out of service as a range and has been put to new uses that are incompatible with range activities, or that is no longer considered to be a potential range area. A closed range is still under the control of a DOD component.

Construction support: Support provided by qualified UXO personnel during construction activities at potential MR sites to ensure the safety of construction personnel from the harmful effects of MEC. When it is determined that the probability of encountering MEC is low (current or previous land use leads to a determination that MEC may be present), a two-person UXO team will stand by in case the construction contractor encounters a suspected MEC. When it is determined that the probability of encountering a MEC is moderate to high (current or previous land use leads to a determination that MEC was employed or disposed of in the parcel of concern, e.g., open burn and open detonation areas), UXO teams are required to conduct subsurface MEC clearance for the known construction footprint, either in conjunction with the construction contractor or before construction.

Controlled detonation chamber (CDC): Also known as the Donovan Blast Chamber (DBC), the CDC is a system for controlled detonation of MEC and MEC-related materials. It is capable of repeated controlled detonations of a suite of energetic materials that are currently demilitarized by OB/OD. This offers the DOD an alternative to OB/OD while at the same time increasing throughput, efficiency, and safety and controlling air, soil, water, and noise pollution. The CDC system meets all state and federal air discharge regulations.

CQC: Contractor Quality Control.

CTT: closed, transferring, and transferred (refers to a subset of military ranges).

DAC: Defense Ammunition Center.

DDESB: Department of Defense Explosives Safety Board.

DERP: Defense Environmental Restoration Program.

Demilitarization ("demil"): The process that removes the military characteristics from unused munitions that are either unsuitable for continued storage, excess to DOD needs, or about to be released from DOD control. Demilitarization applies equally to munitions in unserviceable or serviceable condition. Used (i.e., fired) munitions items also sometimes undergo demilitarization. There are many demilitarization methods, such as recovery, recycling, remanufacture, disassembly, reclamation, mutilation, alteration, melting, burning, detonating, destruction, treatment, and disposal. Methods involving R3 currently constitute approximately two-thirds of the DOD demilitarization programs.

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Demilitarization (demil) inventory: The demilitarization inventory consists of excess, obsolete, and unserviceable munitions. Munitions are moved from the active inventory to the demilitarization inventory after it is determined that they are not economically repairable, they are obsolete, or they are excess to DOD needs and cannot be sold under the Foreign Military Sales program. (Also see **active munitions inventory** and **munitions stockpile**.)

DENIX: Defense Environmental Network and Information Exchange.

Department of Defense Components: The Office of the Secretary of Defense, the Military Departments and Services, the Joint Staff, the Unified and Specified Combatant Commands, the Defense Agencies, the DOD Field Activities, and the National Guard.

Department of Defense Explosives Safety Board (DDESB): A Joint Service board comprising a chairperson, voting representatives from each of the Armed Services, and a permanent military and civilian secretariat to perform operational and administrative functions. The DDESB provides impartial and objective advice to the Secretary of Defense and DOD components on explosives safety matters. (See DOD 6055.9-STD for a detailed assignment of DDESB functions.)

DGPS: differential global positioning system.

Discarded military munitions (DMM): Military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include unexploded ordnance, military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations. (10 U.S.C. 2710(e)(2))

DLA: Defense Logistics Agency.

DMM: discarded military munitions.

DOD: U.S. Department of Defense.

DODD: Department of Defense Directive.

DODIG: Department of Defense Inspector General.

DOI: U.S. Department of Interior.

DRMO: Defense Reutilization and Marketing Office.

DRMS: Defense Reutilization and Marketing Service.

EBS: environmental baseline survey.

Emergency response (to munitions- or explosives-related or UXO emergencies): An immediate response by explosives and munitions emergency response personnel (i.e., DOD EOD personnel) to control, mitigate, or eliminate the actual or potential threat encountered during an explosives or munitions emergency. The response action may include in-place or on-site render-safe procedures, treatment, or destruction of the explosives or munitions or

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their transport to another location where these operations may be conducted. (See 40 CFR Part 260 et seq., the Military Munitions Rule.)

Energetic material: A component or item of ammunition that is designed to produce the necessary energy required for ignition, propulsion, detonation, fire, or smoke, thus enabling the item to function. Also a material (e.g., corrosive or oxidizer) that is inherently dangerous and capable of causing serious damage and that requires regulated handling to avoid accidents in connection with its existence and use.

EOD: explosive ordnance disposal.

EPA: U.S. Environmental Protection Agency.

EPCRA: Emergency Planning and Community Right-to-Know Act.

ERGM: extended-range guided munitions.

ESOH: Environmental, Safety, and Occupational Health.

ESOHPB: Environmental, Safety, and Occupational Health Policy Board.

Essential personnel. Personnel whose duties require them to remain within an ESQD arc for one or more of the following reasons:

a. Direct involvement in an ammunition and explosives handling operation.

b. Provision of mission-required services.

c. Provision of mission-related repairs and/or tests.

ESTCP: Environmental Security Technology Certification Program.

Exclusion zone (EZ): A safety zone established around an MR work area. Only project personnel and authorized, escorted visitors are allowed within the EZ. Examples of EZs are safety zones around MEC-intrusive activities and safety zones where MEC is intentionally detonated. (See DDESB-KO, 27 January 1990.)

Explosive Equivalent. The amount of a standard explosive which, when detonated, will produce a blast effect comparable to that which results at the same distance from the detonation or explosion of a given amount of the material for which performance is being evaluated. It is usually expressed as a percentage of the total net weight of all reactive materials contained in the item or system. For the purpose of this manual, TNT is used for comparison.

Explosive Ordnance Disposal (EOD): Includes detecting, identifying, field evaluating, rendering safe, and final disposing of MEC.

Explosive Ordnance Disposal (EOD) Personnel: Military members who have graduated from the Naval School, EOD. They have received highly specialized training to provide time-critical MEC hazard mitigation services during both peacetime and wartime. EOD personnel are trained and equipped to perform render-safe procedures (RSP) on nuclear, biological, chemical, conventional, and improvised explosive devices. (Note that EOD personnel are distinguished from UXO Technicians, who are civilian contractor or

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government personnel with specialized training and qualifications in the long-term remediation of MEC.)

Explosive Safety Quantity Distance (ESQD): The prescribed minimum distance between sites storing or handling hazard Class 1 explosive material and specified exposures (i.e., inhabited buildings, public highways, public railways, other storage or handling facilities, or ships, aircraft, etc.) to afford an acceptable degree of protection and safety to the specified exposure. The size of the ESQD arc is proportional to the NEW present.

Explosive Safety Submission (ESS): The document that serves as the specifications for conducting work activities at the project. The ESS details the scope of the project, the planned work activities, potential hazards, and the methods for their control.

Explosive Siting Plan (ESP): The document that serves as a DDESB Permit approving the site-specific storage locations, quantities, and safe distances for explosive operations.

Explosive soil: Mixtures of explosives in soil, sand, clay, or other solid media at concentrations such that the mixture itself is explosive. The following also defines an explosive soil: The concentration of a particular explosive in soil necessary to present an explosion hazard depends on whether an explosive is classified as "primary" or "secondary." Primary explosives are those extremely sensitive explosives (or mixtures thereof) that are used in primers, detonators, and blasting caps. They are easily detonated by heat, sparks, impact, or friction. Examples of primary explosives include lead azide, lead styphnate, and mercury fulminate. Secondary explosives are bursting and boostering explosives (i.e., they are used as the main bursting charge or as the booster that sets off the main bursting charge). Secondary explosives are much less sensitive than primary explosives. Soil containing 10 percent or more by weight of any mixture of secondary explosives is considered "explosive soil." Soil containing propellants (as opposed to primary or secondary high explosives) may also present explosion hazards.

°F: degrees Fahrenheit.

FAR: Federal Acquisition Regulations.

FFA: Federal Facilities Agreement.

FFCA: Federal Facilities Compliance Act.

FOST: finding of suitability to transfer.

Frag: fragment or fragmentation: Munitions material projected away from the point of detonation at a high velocity.

Free from explosive hazard: Material that has been inspected for explosives and determined not to present a danger of explosion or combustion from explosive or energetic materiel.

FUDS: formerly used defense sites.

GIS: geographic information system.

GPS: global positioning system.

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Hazardous waste: A solid waste that meets the following criteria: (1) is or contains a hazardous waste listed in 40 CFR Part 261, or (2) exhibits characteristics of ignitability, corrosivity, reactivity, and/or toxicity. (Refer to 40 CFR § 261.3 for further explanation.)

HE: high explosive: Explosive that normally detonates rather than burns.

HEAT: high-explosive antitank: Ordnance designed to defeat armor by the use of a shaped charge.

HEI: high-explosive incendiary: High-explosive-filled ordnance with additional ingredients to give a fire-producing effect.

HQMC: Headquarters, U.S. Marine Corps.

ICM: improved conventional munition.

Impact area: The identified area within a range intended to capture or contain ammunition, munitions, or explosives and resulting debris, fragments, and components from various weapon system employments. In simple terms, normally the target area where live-fire rounds or bombs impact the earth.

Improved conventional munition (ICM): ICMs or submunitions, cluster bombs, and cargo rounds are considered sensitive-fused munitions and require special authority to enter contaminated areas.

Inactive range: An operational military range that is not currently being used but is still under military control, and which the military both considers to be a potential range area and has not put to a new use that is incompatible with range activities. A potential range area is defined as meeting one of three criteria:

(1) Mobilization and force projection: ranges that are held by a DOD component for the purpose of preparing individuals and units for worldwide deployment, redeployments, or demobilization in response to war, stability, and support operations or projected training requirements that would exceed current active range capabilities;

(2) Force structure: ranges held as inactive during realignment, reorganization, stationing, or reequipping of units projected to use these ranges under new training requirements; or

(3) Future: ranges that are held by DOD components for future use in support of National Security Policy or DOD component doctrine that ensures the capability to produce, establish, and maintain conditions needed for operational success.

Inhabited Building Distance (IBD): The minimum distance permitted between an inhabited building and an ammunition or explosives location for the protection of administration, quarters, industrial, and other similar areas within a naval shore establishment. Inhabited building distances shall be provided between ammunition or explosives locations and the boundary of a shore establishment of the nearest point beyond the boundary where such inhabited structures could be erected.

Integrated Training Area Management (ITAM): A U.S. Army program designed to improve range conditions by inventorying and monitoring land conditions, determining

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carrying capacity of the land in terms of the training requirements, and providing for land rehabilitation and maintenance measures.

Intentional detonation: An intentional detonation is a planned, controlled detonation.

Intrusive activity: An activity that involves or results in the penetration of the ground surface at an area known or suspected to contain MEC. Intrusive activities can be of an investigative or removal action nature.

IR: Installation Restoration.

ITAM: Integrated Training Area Management (a U.S. Army program).

JOCG: Joint Ordnance Commanders Group.

JUXOCO: Joint UXO Coordination Office.

Material that presents a potential explosive hazard (MPPEH): Military munitions, including: their components; munitions packaging material; residues from research, development, testing, and evaluation (RDT&E), production, use (to include range scrap), operational and quality testing, or demilitarization of munitions; or any other materials, equipment, or facilities potentially contaminated with explosives. MPPEH includes both end items and residues derived from processing end-items within United Nations Organization (UNO) Hazard Class (HC). It also includes munitions-related items, pieces, models, training aids, etc., that are suspected but not confirmed to be wholly inert.

Maximum credible event (MCE): The worst single event that could occur at any time with maximum release of a chemical agent from a munition, container, or process as a result of an unintended, unplanned, or accidental occurrence.

MEC: munitions and explosives of concern.

MIL SPECS/STDS: military specifications and standards.

Military munitions: All ammunition products and components produced or used by or for the DOD or the U.S. Armed Services for national defense and security, including military munitions under the control of the DOD, the U.S. Coast Guard, the U.S. DOE, and the National Guard. The term includes confined gaseous, liquid, and solid propellants, explosives, pyrotechnics, chemical and riot control agents, smokes, and incendiaries used by DOD components, including bulk explosives and chemical warfare agents, chemical munitions, rockets, guided and ballistic missiles, bombs, warheads, mortar rounds, artillery ammunition, small arms ammunition, grenades, mines, torpedoes, depth charges, cluster munitions and dispensers, demolition charges, and devices and components thereof. It does not include: wholly inert items; improvised explosive devices; and nuclear weapons, devices, and components thereof. However, it does include nonnuclear components of nuclear devices, managed under DOE's nuclear weapons program after all required sanitation operations under the Atomic Energy Act of 1954, as amended, have been completed.

Military range: A designated land or water area set aside, managed, and used to conduct research on, develop, test, and evaluate military munitions and explosives, other ordnance, or weapon systems, or to train military personnel in their use and handling. Ranges include

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firing lines and positions, maneuver areas, test pads, detonation pads, impact areas, and buffer zones with restricted access and exclusionary areas.

MLLW: mean lower low water.

Most probable event (MPE): The most likely event, as a result of an accidental, unplanned, or unintended detonation of an item of ordnance, that could occur during MR activities. The event must be realistic, with reasonable probability of occurrence.

MPPEH: munitions that present a potential explosive hazard.

MT: mech time or mechanical time: fuses designed usually for airburst. MT fuses are located in the nose of the munition.

Munitions and explosives of concern (MEC): Military munitions that are UXO or have been abandoned, as defined in the EPA Munitions Rule. Also includes soil, facilities, equipment, or other materials contaminated with a high enough concentration of explosives that it presents an explosive hazard.

Munitions constituents (MC): Any materials originating from military munitions, including explosive and/or non-explosive materials, and emission, degradation, or breakdown products. [The following additional explanation is offered for purposes of this SOP: Munitions constituents are the substances or chemical residues that result from the proper functioning or use of munitions (e.g., residues created and remaining in the soil, water, or air from the burning or explosion of energetic material) or that are present in MEC. Such constituents may or may not present an immediate risk of acute physical injury from fire or explosion resulting from accidental or unintentional detonation or ignition of MEC or energetic materials. Similarly, such constituents may or may not result in environmental contamination requiring a response (i.e., response action).]

Munitions Debris (MD): Metal fragments resulting from the intended use of munitions or detonations.

Munition with the Greatest Fragmentation Distance (MGFD). The munition with the greatest fragment distance that is reasonably expected (based on research or characterization) to be encountered in any particular munition response area (MRA) or munitions response site (MRS).

Munitions Response Area (MRA): Any area on a defense site that is known or suspected to contain UXO, DMM, or MC. Examples include former ranges and munitions burial areas. A munitions response area is comprised of one or more munitions response sites.

Munitions Response Site (MRS): A discrete location within a MRA that is known to require a munitions response.

Munitions Rule Implementation Policy: Detailed guidance and procedures issued by the Services that explains how DOD will implement and comply with the EPA Military Munitions Rule.

Munitions stockpile: Munitions in the active and demilitarization inventories as well as unused waste munitions as defined in the EPA's Military Munitions Rule (MMR). (See **active munitions inventory** and **demilitarization inventory**.)

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Munitions: see **military munitions**.

Net Explosive Weight (NEW): The actual weight of explosive mixture or compound including the TNT equivalent of other energetic material which is used in the determination of explosive limits and ESQD arcs.

Non-stockpile chemical warfare materiel: CWM (defined above) that is not included in the chemical stockpile. Non-stockpile CWM is divided into five categories: (1) buried CWM; (2) recovered chemical weapons (items recovered during range clearing operations, from chemical burial sites, and from research and development testing); (3) former chemical weapon production facilities; (4) binary chemical weapons; and (5) miscellaneous CWM (unfilled munitions and devices and equipment specially designed for use directly in connection with employment of chemical weapons).

OB: open burn.

OCR: Office(s) of Collateral Responsibility.

OD: open detonation.

ODEP: Office of Defense Environmental Programs.

ODUSD (I&E): Office of the Deputy Under Secretary of Defense (Installations and Environment).

OE Safety Specialist: a USACE employee involved in the execution, supervision, or oversight of ordnance-related activities inside the exclusion zone who has graduated from the U.S. Naval EOD School, Indian Head, MD. An OE Safety Specialist shall be on-site each day during intrusive and MEC destruction activities. The OE Safety Specialist is on-site to ensure that the contractor establishes the appropriate daily safety routines at the beginning of UXO field operations, to perform quality assurance oversight, to verify contractor employee UXO qualifications, to advise the contractor on UXO procedures, to coordinate with the PM, and to facilitate EOD response when needed.

OEESCM: Operational and Environmental Executive Steering Committee for Munitions.

Open burn (OB): A controlled open-air process by which excess, unserviceable, and obsolete munitions are destroyed to eliminate their inherent explosives safety hazards. DOD OB units contain the munitions with pans or pads to minimize environmental contamination. DOD OB units are permitted as "miscellaneous units" in EPA's environmental permitting process.

Open detonation (OD): A process used for the treatment of unserviceable, obsolete, and/or waste munitions whereby an explosive donor charge initiates the munitions to be detonated. Although surface detonations can be performed under certain circumstances, most munitions are treated in 4- to 6-foot-deep pits for safety purposes. Most OD sites are permitted as miscellaneous units as part of the EPA environmental permitting process. DOD's units are generally permitted as combined OB/OD facilities.

Operational range: A military range that is currently under military control and management; includes both active ranges (currently in service or use) and inactive ranges (not in current use or service).

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OPR: Office(s) of Primary Responsibility.

OSD: Office of the Secretary of Defense.

OU: Operable Unit.

OUSD (AT&L): Office of the Under Secretary of Defense (Acquisition, Technology, and Logistics).

PD: point detonating: impact fuse, designed to function when the projectile comes in contact with the surface of a target; located in the nose of the munition.

Potential Explosion Site (PES): The location of a quantity of explosives that will create a blast, fragment, thermal, and/or debris hazard in event of an accidental explosion of its contents. Quantity limits for ammunition/explosives at a PES are determined by the distance to an exposed site.

POL: petroleum, oil, and lubricants.

PPE: personal protective equipment.

Primer: Small, sensitive explosive component used as the first element in the explosive train.

Proj: projo or projectile: A weapon that is projected through a tube or barrel into the air toward a target.

PSE: preliminary source evaluation.

PTT: powder train time fuse: Fuses designed usually for airburst, normally used with illumination rounds to light up the battlefield.

QA: quality assurance.

QC: quality control.

Quantity-distance (Q-D): the quantity of explosives material and distance separations that provide defined types of protection. These relationships are based on levels of risk considered acceptable for the stipulated exposures and are tabulated in the appropriate Q-D tables provided in DOD 6055.9-STD. Separation distances are not absolute safe distances but are relative protective safe distances. Greater distances than those shown in the Q-D tables shall be used whenever possible.

R&D: research and development.

RAB: Restoration Advisory Board.

RAC: Remedial Action Contract.

Range clearance: An operation or procedure conducted to remove and properly dispose of munitions or munitions fragments. (e.g., MEC, "duds," etc.). Several types or degrees of clearance may be conducted (e.g., surface clearance based on visual inspection of the surface; shallow clearance where an area is systematically swept with detectors—normally to a depth of 20-24 inches; etc.) Range clearance, though technically applicable to any range category (closed, transferred, active, etc.) is often considered as occurring only at active,

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operational ranges. Clearance operations at these active ranges are normally conducted as part of range maintenance activities to maintain or enhance operational safety conditions at the range facility. Even though it is possible for MEC to cause environmental contamination (pollution of soil, surface water, groundwater, etc., from the chemical constituents present in munitions), range clearance is focused on removing and safely disposing of munitions/ordnance items or fragments—not the removal or treatment of any chemical residues or constituents from the munitions or associated environmental contamination. Cleanup of environmental contamination or pollution is normally achieved by removal or remedial actions.

Range: see **military range**.

RCRA: Resource Conservation and Recovery Act.

RCWM: recovered chemical warfare material.

RDT&E: research, development, test, and evaluation.

Regional Environmental Coordinator (REC): A senior military officer or DOD civilian assigned to one of ten EPA regions who is responsible for the dissemination of information and coordination of environmental matters and public affairs among military installations and environmental regulatory organizations within their respective region. RECs have a liaison role and fully adhere to the Services' chain of command.

Remedial actions/remediation/remedial action process: Longer-term activities that complete the cleanup of contamination (or a contaminated site or location) if a removal action has not achieved or cannot achieve the required degree of cleanup for the contamination problem. A distinction is sometimes made between the control or cleanup measures to be implemented, which are called "remedial actions," and the identification, evaluation, decision-making, and design and construction steps required to implement the control measures. These steps collectively are called the "remedial action process."

Removals/removal action(s): Relatively quick actions designed to address imminent threats to human health and the environment posed by releases or spills of hazardous substances. Removals should satisfy one or more of the following tests:

(1) **Imminent threat:** the site or situation poses an imminent threat to public health.

(2) **Source control:** the removal action either removes the source of contamination off-site or effectively contains it on-site so that continuing releases to the environment are prevented or reduced.

(3) **Access limitation:** the removal action substantially reduces the possibility of human exposure to hazardous substances. The EPA has categorized removal actions as emergency, time-critical, and non-time-critical. Each of these categories possesses its own criteria and procedural requirements.

Resource recovery and recycling (R3): Technologies and processes used by DOD to demilitarize military munitions. These include reuse, sale "as is" (e.g., Foreign Military Sales), conversion to a commercial product for sale or industrial use, or disassembly, modification, and partial or whole use for a military application.

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Response(s) or response action(s): Responses or response actions are broadly defined in environmental law and regulations as any scientific or engineering investigation, evaluation, decision-making, design, or implementation step taken in response to (i.e., to clean up) a release or spill of hazardous substances. Removals and remedial actions (or remedial action processes) are subcategories of response actions. Procedural requirements (established in environmental regulations) for these two types of actions differ substantially, but their definitions are almost as broad as for "responses," allowing the terms to be used almost interchangeably. The various terms are best defined by the procedural requirements imposed on them by the applicable environmental regulations.

RI/FS: remedial investigation/feasibility study.

ROD: Record of Decision.

Senior UXO Supervisor (SUXOS): Supervises all contractor on-site UXO activities. This individual must be a graduate of the U.S. Army Bomb Disposal School, Aberdeen Proving Ground, MD, or the U.S. Naval EOD School, Indian Head, MD. Must have at least 15 years of combined active-duty military EOD and contractor UXO experience, to include at least 10 years in supervisory positions.

SERDP: Strategic Environmental Research and Development Program.

SHPO: State Historic Preservation Officer.

Single Manager for Conventional Ammunition (SMCA): A DOD executive agent responsibility performed by the U.S. Army Operations Support Command. The Secretary of the Army is DOD's SMCA. The U.S. Army OSC is the day-to-day operator of the SMCA and serves as the central program manager for the execution of most of DOD's demilitarization requirements. The objectives and responsibilities of the SMCA can be found in DOD Directive 5160.65.

Sustainable range management: Management of a military range in a manner that supports national security objectives and maintains the operational readiness of the Armed Forces and ensures the long-term viability of the range while protecting human health and the environment. [The following additional explanation is offered for purposes of this SOP: A comprehensive DOD approach that develops and implements the policies, plans, practices, and procedures necessary to achieve sustainable ranges. Sustainable ranges are managed and operated in a manner that supports their long-term viability and utility to meet the national defense mission. Sustainable ranges will implement the planning, management, coordination, and public outreach necessary to ensure viable continuity of test and training operations and long-term coexistence with neighboring communities and natural ecosystems.]

Sustainable use: Actions taken to ensure that ranges maintain the ability to conduct training, research, development, testing, and evaluation of munitions in support of the national defense mission while minimizing adverse effects to human health and the environment.

SUXOS: Senior UXO Supervisor.

SWMU: solid waste management unit.

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TNT equivalent: Considering the peak overpressure produced by detonation of a given weight of TNT as 100 percent, the TNT equivalency of an explosive is the amount of overpressure produced by detonation of an identical quantity of propellant under comparable conditions, expressed as a percentage.

Transferred range: A military range that is no longer under the control of a DOD component and has been leased, transferred, or returned to another entity (including other federal, non-DOD entities) for use.

Transferring range: A military range that is proposed to be leased or transferred from DOD to another entity or disposed of by conveying title to a non-federal entity. An active range will not be considered a "transferring range" until the transfer is imminent.

TRI: Toxic Release Inventory (required by the EPCRA).

Unexploded ordnance (UXO): Military munitions that have been primed, fused, armed, or otherwise prepared for use and that have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installation, personnel, or materiel and that remain unexploded by malfunction, design, or any other cause. UXO presents an immediate risk of acute physical injury from fire or explosion resulting from accidental or unintentional detonation.

Unintentional detonation: A detonation not planned in advance.

USACE: U.S. Army Corps of Engineers.

Used or fired military munitions: Those military munitions that meet the following criteria: (1) have been primed, fused, armed, or otherwise prepared for use, and have been fired, dropped, launched, projected, placed, or otherwise used; (2) munitions fragments, (e.g., shrapnel, casings, fins, and other components, to include arming wires and pins) that result from the use of military munitions; or (3) malfunctions or misfires (e.g., fail to properly fire or detonate).

USFWS: U.S. Fish and Wildlife Service.

USGS: U.S. Geological Survey.

UST: underground storage tank.

UTM: Universal Transverse Mercator.

UXO: unexploded ordnance.

UXO personnel: Contractor personnel who have completed specialized military training in EOD methods and have satisfactorily performed the EOD function while serving in the military. Various grades and contract positions are established based on skills and experience.

UXO Quality Control Specialist (UXOQCS): Contractor personnel with the responsibility of enforcing the contractor's Quality Control Program for all MR-related evolutions; conducting quality control inspections of all UXO and explosives operations for compliance with established procedures; and directing and approving all corrective actions to ensure that all MR-related work complies with contractual requirements.

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UXO Safety Officer (UXOSO): Contractor personnel with the responsibility of enforcing the contractor's SSHP. This individual must, therefore, be in the field whenever possible to observe operations. Must have the same minimum qualifications as the UXO Technician III. In addition, must have the specific training, knowledge, and experience necessary to implement the SSHP and verify compliance with applicable safety and health requirements.

UXO Technician II: must be a graduate of the U.S. Army Bomb Disposal School, Aberdeen Proving Ground, MD; the U.S. Naval EOD School, Indian Head, MD; U.S. Naval EOD School, Eglin AFB, FL; or a DOD-equivalent certified course. Must have a minimum of five years of military EOD or contractor UXO experience.

UXO Technician III: supervises a UXO team. Must be a graduate of the U.S. Army Bomb Disposal School, Aberdeen Proving Ground, MD; the U.S. Naval EOD School, Indian Head, MD; U.S. Naval EOD School, Eglin AFB, FL; or a DOD-equivalent certified course. This individual must have a minimum of ten years of military EOD or contractor UXO experience.

UXO: unexploded ordnance.

UXOQCS: UXO Quality Control Specialist.

UXOSO: UXO Safety Officer.

Waste military munitions: A military munition that is a solid waste per 40 CFR §266.202. Such a waste military munition may also be a hazardous waste if it meets the definition found in 40 CFR §261.3. Waste munitions are hazardous wastes when they exhibit the hazardous waste characteristic of ignitability, corrosivity, reactivity, or toxicity, or are listed as hazardous wastes.

WP: white phosphorus: A screening smoke that burns on contact with air and can be used as an incendiary.

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CH2MHILL

Explosives Usage and Munitions Response (MR)
Standard of Practice HSE&Q-610

Attachment 4: Explosives Management Check List

N/A	Check List Item	PM Date Completed	MR Review Date	MR QC NTP Date
	Identify Contract and SOW Requirements			
	Complete Corporate Opportunity Risk Evaluation (ORE), Paragraph 17 Explosives Usage and MR Projects			
	Complete Project Site Specific Work Plans: (Explosive Management Plan, & Explosive Siting Plan*)			
	Obtain State/local (if required) Explosive Permit* for CH2M HILL to use high explosives within the state and or local jurisdiction.			
	Obtain State/local (if required) Permit* for CH2M HILL to site explosives magazine within the state and or local jurisdiction.			
	Identify CH2M HILL licensed Blaster* (if self-performing)			
	Complete CH2M HILL ATF&E "Explosives Procurement Work Sheet" for Review and obtain approval from MR Operations Manager			
	Request copy with original signature of ATF&E Type 20 Explosives Manufacture License* from CH2M HILL License Holder			
	Request "Authorization Letter*" identifying "Responsible Persons" and "Possessor of Explosives" that are authorized to order, receive, store, and use explosives under the CH2M HILL ATF&E Type 20 Explosives Manufacturer License from the License Holder			
	Complete "Materials Purchase Requisition Form*" for Contracting (Must be in corporate name of CH2M HILL, Inc & authorized by the CH2M HILL ATF&E License Holder or MR Market Segment Director)			
	Vender Identified by contracting (If sole source - justification is required)			
	Vender required to provide a copy of their ATF&E License* to CH2M HILL for evaluation and certification by CH2M HILL ATF&E License Holder			
	Purchase Order* is provided to the vender with a copy of our ATF&E Type 20 Manufacturer of High Explosives License and Authorization Letter for Responsible Persons and Possessor of Explosives			
	Award the purchase order to the selected vender and			

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N/A	Check List Item	PM Date Completed	MR Review Date	MR QC NTP Date
	identify Possessor of Explosives authorized to receive explosives at the project site, telephone number and address of receiving location			
	Vender accepts purchase order and holds for contracting release of shipment			
	Vender identifies carrier and provides a shipment schedule with copy of manifest* to CH2M HILL contracting and contracting notifies the Project Manager			
	Establish Explosives Storage Area (Security, Lightening Protection, Grounding)			
	Schedule State and or local jurisdiction site inspection for “Explosive Storage” (Magazines) if required.			
	Magazine storage area inspected and approved* for storage by local jurisdictions.			
	CH2M HILL contracting notifies vender to release shipment			
	Notify ATF&E servicing office for CH2M HILL ATF&E License*, local ATF&E office*, and local jurisdictions* of storage of explosives and provide an Explosives Siting Plan that includes ATF Form 5400.13/5400.16, Explosives Storage Magazine Description Worksheet*.			
	Post CH2M HILL ATF&E Type 20 License on the project site			
	CH2M HILL “Responsible Person” or Possessor of Explosives” person receives shipment (presents identification to transporter, verifies manifest, and inventories shipment to ensure accuracy between purchase order and manifest. Discrepancies should be resolved IAW the project Explosive Management Plan)			
	Explosive materials are properly inventoried (date shift codes, acquisition dealer, (permit address), POC), and stored IAW project Explosives Management Plan			
	Material Safety Data Sheets (MSDS) for explosives materials are on-site			
	Magazine Data Cards (Daily Summary of Magazine Transactions*) are completed and maintained IAW project Explosives Management Plan			
	Magazine has two mortise type 5 pin high security locks			
	Security Checks conducted a minimum of every 72 hours and documented*			
	Responsible person or possessor of explosives has control of keys			
	Daily Usage (Shot) Log maintained for expenditure of explosive materials including target materials			
	Weekly inventories of all explosives materials conducted and documented*			
	Notify local jurisdictions and ATF&E offices when			

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N/A	Check List Item	PM Date Completed	MR Review Date	MR QC NTP Date
	explosives materials are no longer being stored*			
	*Project Manager to provide to the ATF&E License Holder completed purchase orders, manifest documents, inventories, magazine data cards, usage logs, and any other associated information for ordering, storage and use of explosives material along with an end user certification that all explosives materials have been accounted for.			
	MR Safety Officer shall conduct a quality control audit of the project explosives management plan and checklist compliance with ATF&E requirements and report on the conformance of the Project Manager & License Holder.			
	* Indicates documents that upon completion of project will be forwarded to the License Holder			

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ATTACHMENT 10

CH2MHILL

HSE&Q-111 Incident Reporting and Investigation

CLICK HERE TO GET TO ATTACHMENTS

CH2MHILL

Incident Reporting and Investigation Standard of Practice HSE-111

1.0 Introduction

This Standard of Practice (SOP) provides procedures for reporting and investigating incidents. Emergency response procedures are included in the Emergency Response Plan (ERP), as discussed in HSE-106, *Emergency Planning*.

An incident may be caused by natural forces, employees, subcontractors, or third parties in any location associated with CH2M HILL operations, including offices, warehouses, project sites, private property, or public spaces. An incident includes:

- Injury or illness
- Spill or release
- Damage to property
- Permit issue (e.g., permit violation)
- A "near-miss"
- Other (e.g., fire, explosion, bomb threat, workplace violence)

This SOP provides specific guidelines for immediate internal notification of all but the most serious incidents. It also describes procedures for accessing, creating, updating and reviewing the CH2M HILL Incident Report Form (IRF). Finally this SOP provides guidelines for conducting prompt incident investigations to determine the root causes and corrective actions to prevent recurrence.

If the severity of the incident meets any of the following criteria, implement HSE-601 "Serious Incident Notification Process", which ensures timely notification of Business Group Presidents and allows for positive control over flow of information so that the incident is handled in conjunction with the senior management team.

- Work related death of employee or CH2M HILL subcontractor
- Life threatening injury or illness of employee or CH2M HILL subcontractor
- Kidnap/missing person (employee or CH2M HILL subcontractor)
- Event that involves a fire, explosion, or property damage that requires a site evacuation or is estimated to result in greater than $50,000 in property damage.
- Spill or release of hazardous materials or substances that involves a significant threat of imminent harm to site workers, neighboring facilities, the community or the environment.
- Event that may not have any significant real impact but will attract media attention.
- Significant near miss or negative trend that will likely require work suspension or significant company resources to resolve

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2.0 Regulatory Review

Attachment 1 has a list, by country, of the regulations related to incident reporting and investigation. Compliance with the regulations listed in this attachment will be met if this SOP is followed. Contact the Regional Health and Safety Program Manager (RHSPM) for information on countries not listed in Attachment 1.

3.0 Responsibilities

3.1 Employee

The employee is responsible for:

- Providing immediate verbal notification of all incidents to the Emergency Response Coordinator (ERC) and immediate supervisor (e.g., Group Leader).
- Providing detailed information to the Human Resources Representative (HRR), upon request, for all work-related injury and illness incidents.
- Providing additional or updated information to the HRR (for injury/illness incidents) or the Regional Health and Safety Program Manager (RHSPM)/Environmental Compliance Coordinator (ECC) (for all other incidents) after the initial IRF has been submitted

3.2 Emergency Response Coordinator

The ERC is responsible for:

- Implementing emergency response procedures as directed in the ERP for all emergencies (see HSE-106, *Emergency Planning*).
- Notifying the RHSPM of all incidents.
- Creating and submitting an IRF for all non-injury incidents.
- Creating and submitting an IRF for a work-related injury/illness of a CH2M HILL subcontractor.
- Providing additional or updated information about the incident to the RHSPM/ECC after the initial IRF has been submitted.
- Conducting incident investigations as directed by the RHSPM or ECC.

3.3 Regional Health and Safety Program Manager

The RHSPM is responsible for:

- Being available (or appointing a designee, if unavailable) to receive notification of all incidents.
- Providing incident verbal notification as directed in Section 6.2 of this SOP.
- Reviewing submitted Injury/Illness, Property Damage, Near-Miss, and Other IRFs for completeness and accuracy and completing the "RHSPM Injury Evaluation" and "RHSPM/ECC Evaluation" sections of the IRF.

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- Updating the "RHSPM Injury Evaluation" and "RHSPM/ECC Evaluation" sections when additional or updated information becomes available.
- Determining the level of and directing incident investigations for Injury/Illness, Property Damage, Near-Miss, and Other incidents.

3.4 Environmental Compliance Coordinator

The ECC is responsible for:

- Being available (or appointing a designee if unavailable) to receive notification of environmental incidents and analyzing incidents for reportability and seriousness.
- Providing incident verbal notification as directed in Section 6.2 of this SOP.
- Reviewing submitted Spill/Release and Environmental/Permit Issue IRFs for completeness and accuracy and completing the "RHSPM/ECC Evaluation" section of the IRF.
- Updating the "RHSPM/ECC Evaluation" section when additional or updated information becomes available.
- Determining the level and directing incident investigations for Spill/Release and Environmental/Permit Issue incidents.

3.5 Legal and Insurance Department (LID)

The LID is responsible for:

- Assigning workers compensation case management.
- Granting approval for communication with external parties regarding incidents.
- Directing internal and external communication, reporting, and investigation of serious incidents.
- Addressing insurance issues associated with the incident.

3.6 Human Resources Representative (HRR)

The HRR is responsible for:

- Completing and submitting an IRF for CH2M HILL employee injury-related incidents.
- Updating CH2M HILL employee injury-related IRFs when additional or updated information about the incident becomes available.
- Completing and submitting necessary workers compensation forms.

3.7 Regional Human Resources Representative (RHRM)

The RHRM is responsible for:

- Ensuring that an IRF is completed for all CH2M HILL employee injury-related incidents.

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- Sharing responsibility with LID for determining appropriate workers compensation issues.

3.8 Project Manager (PM)

Project Managers are responsible for:

- Reporting incidents to the client, if necessary, after discussing with the RHSPM.
- Ensuring that unnecessary communication of serious incidents is kept to a minimum, as outlined in Section 6.2.3 of this SOP.

3.9 Area Office Manager (AOM)

Area Office Managers are responsible for:

- Reporting incidents to the building owner, if necessary, after discussing with the RHSPM.
- Ensuring that unnecessary communication of serious incidents is kept to a minimum, as outlined in Section 6.2.3 of this SOP.

3.10 Corporate Director, Health, Safety, and Environmental Protection (CDHS&E)

The CDHS&E or designee is responsible for:

- Maintaining a log of all incidents and investigations.
- Distributing summaries of incidents with periodic management reports.
- Analyzing all incidents.
- Modifying the Health, Safety, and Environmental Protection (HS&E) program as necessary to prevent future incidents.

3.11 Corporate Health, Safety, and Environmental Protection (HS&E)

The Corporate HS&E unit is responsible for maintaining all submitted IRFs and Investigation Reports.

3.12 Environmental Program Manager (EPM)

The EPM is responsible for reviewing Spill/Release and Environmental/Permit Issue IRFs and Investigation Reports to verify accuracy, consistency, and compliance with applicable federal, state, and local environmental requirements.

3.13 Health and Safety Program Manager (HSPM)

The HSPM is responsible for reviewing Injury/Illness IRFs to verify that reports are being completed in a consistent manner and in compliance with occupational safety and health recordkeeping requirements.

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4.0 CH2M HILL Policy

It is the policy of CH2M HILL to maintain an IRF for all work-related injuries and illnesses sustained by its employees in accordance with occupational safety and health recordkeeping and various state workers compensation requirements. An IRF will also be maintained for other incidents (property damage, fire or explosion, spill, release, potential violation or permit exceedance, and near-misses) as part of CH2M HILL's loss prevention and risk reduction initiative.

5.0 Definitions

5.1 Employee

The term "Employee" includes all CH2M HILL full-time, part-time, and temporary-duty employees, as well as contracted employment agency and temporary employees for which CH2M HILL is responsible for day-to-day direction. "Employee" does not include subcontractor employees who are supervised by subcontractor management. Questions regarding whether someone should be considered an employee should be directed to the RHSPM.

5.2 Work-Related Injury or Illness

Work-related injury or illness includes all injuries and illnesses that result from an event or exposure in the work environment. "Work environment" includes CH2M HILL premises and other locations where employees are engaged in work-related activities or are present as a condition of employment.

5.3 Incident

An incident may be caused by natural forces, employees, subcontractors, or third parties in any location associated with CH2M HILL operations, including offices, warehouses, project sites, private property, or public spaces. Incidents include:

- Injury or illness
- Hazardous substance exposure
- Damage to property
- Fire or explosion
- Spill, release, potential violation, or permit exceedance
- A "near-miss"

5.4 Near-Miss

A near-miss occurs when an intervening factor prevented an incident from occurring. Examples of near-miss situations include: a hard hat or other personal protective equipment (PPE) prevented an injury; secondary containment or emergency shutoff prevented a spill; or an alert co-worker prevented an accident.

5.5 Serious Incidents

The following are general criteria for determining whether an incident should be considered a serious one. Consultation with the RHSPM, CDHS&E, and LID will make the determination. The general criteria for serious incidents include:

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- Intervention by external emergency response organizations
- Hospitalization
- Spills and releases of hazardous substances exceeding the reportable quantity (RQ)
- Potential violations of law or regulation
- Estimated property damage in excess of $10,000

6.0 Incident Notification and Reporting

6.1 Emergency Reporting

Procedures for the immediate reporting of emergencies must be included in the ERP as discussed in SOP HSE-106, *Emergency Planning*. All incidents must be reported to the ERC immediately. If required, the ERC must immediately report emergency situations to the appropriate response authorities as indicated in the ERP.

6.2 Incident Verbal Notification

The following notification procedures apply to all incidents, including after an ERP (and HSE-106, *Emergency Planning*) has been implemented for emergencies.

6.2.1 Incidents

Incidents must be communicated verbally immediately, as shown in Attachment 2 (Incident Notification and Reporting Flowchart) and described as follows:

- All employees and subcontractors must immediately notify the ERC and their direct supervisor (e.g., Group Leader) of all incidents.
- The ERC must notify the RHSPM of all incidents.
- The RHSPM must notify the ECC of spills/releases and environmental/permit incidents.
- The RHSPM (or ECC for environmental incidents) refers serious incidents to the Legal and Insurance Department, which directs remaining procedures (non-serious incidents follow remaining procedures).
- The RHSPM/ECC consults with Corporate HS&E staff to determine reportability and notifies the appropriate occupational safety and health and/or environmental authorities and agencies of reportable incidents.
- The RHSPM must immediately notify the CDHS&E and the LID of any fatality or any incident that results in in-patient hospitalization of three or more employees.
- The RHSPM notifies the Project Manager (field) or Area Office Manager (office) of the incident.
- The Project Manager notifies the client of the incident, if necessary
- The Area Office Manager notifies the building owner of the incident, if necessary.
- The RHSPM/ECC directs the HRR to create an IRF for work-related injury/illness incidents.

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6.2.2 Serious Incidents

The RHSPM/ECC must refer all incidents that meet the serious incident criteria (as defined in Section 5.5) to the LID, whose representative will direct all internal and external communications, including IRF creation, agency reporting, client or building owner notification, and incident investigation (unless infeasible because of differences in time zones).

Post-emergency incident communications regarding serious incidents at a CH2M HILL office or project (regardless of the party involved) shall be considered sensitive in nature and must be controlled in a confidential manner. Internal communications regarding a serious incident may be conducted with affected project, regional, and Business Group staff but must be kept to a minimum. Communication should be oral whenever possible. If e-mail communications are necessary, the following procedures must be used:

- Address the e-mail to Peggi Spencer/COR (or Dan Smith/COR in her absence).
- Send as "Confidential" e-mail (select under "Message Options").
- Include phrase "Confidential—Attorney/Client Privileged Communication" in the title and body of the e-mail.
- Include the following as the first paragraph of the e-mail:

  > This e-mail contains information pertaining to a project site accident and must be handled with confidentiality. Do not forward this e-mail without approval of Peggi Spencer/COR or Dan Smith/COR. All e-mails pertaining to this incident must be addressed to Peggi Spencer/COR (or Dan Smith/COR in her absence). All e-mail on this issue must contain, in both subject and content, the phrase "Confidential - Attorney/Client Privileged Communication." These practices are required to maintain attorney/client privilege. All other communication regarding this incident should remain verbal unless approved by Peggi Spencer/COR or Dan Smith/COR.

6.3 Incident Report Form Completion Process

The HRR is responsible for completing the IRF for incidents where injuries to CH2M HILL employees are involved. The ERC is responsible for completing the IRF for all other incidents including property damage, spills/releases, environmental/permit issues, near-misses, and injuries to subcontractors. ***The IRF must be completed within 24 hours of the incident.*** Responsibilities for initial IRF creation are shown in Attachment 3, IRF Completion Flowchart. Refer to Appendix A for specific guidelines for accessing and completing the IRF. Any problems encountered with the electronic IRF should be referred to the regional Information Technology (IT) staff. For serious incidents, the IRF is completed only as directed by the LID.

6.4 Incident Report Form Review Process

When an initial IRF is submitted, it generates a report that is automatically sent to various staff for review and evaluation as shown in Attachment 3, IRF Completion Flowchart. CH2M HILL employee injury-related IRFs are sent to the LID and the RHSPM. The review process is as follows:

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- The LID shall review the IRF and determine, with assistance from the appropriate RHRM, the appropriate workers compensation issues.
- In the United States, the RHPSM shall review the IRF for completeness and complete the "RHSPM Injury Evaluation" and "RHSPM/ECC Evaluation" sections to determine if the incident is an OSHA-recordable injury or illness. In other countries, the RHSPM/ECC determines off-line whether the incident is recordable to the local agencies. See Attachment 1 for guidelines for Australia.
- Property Damage, Near-Miss, and Other IRFs are sent to the RHSPM. The RHSPM shall review the IRF for completeness and complete the "RHSPM/ECC Evaluation" section.
- Spill/Release and Environmental/Permit Issue IRFs are sent to the ECC. The ECC shall review the IRF for completeness and complete the "RHSPM/ECC Evaluation" section to determine if the incident is a reportable spill or violation.
- The HSPM shall review an Injury/Illness IRF for accuracy and verify that the incident is categorized consistent with local occupational safety and health recordkeeping requirements.
- The EPM shall review a Spill/Release and Environmental/Permit Issue IRF to verify accuracy, consistency, and compliance with applicable federal, state, and local environmental requirements.
- Corporate HS&E shall maintain all submitted IRFs.

6.5 Incident Report Form Updating Process

When additional or updated information becomes available, the HRR (for CH2M HILL injury-related incidents), the RHSPM (for incidents involving property damage, near-miss, or other), or the ECC (for incidents involving spills/release or environmental or permit issues) shall update the existing IRF and re-submit the form as shown in Attachment 4, IRF Updating Flowchart. The updated IRF will replace the original IRF in the system and will be routed and reviewed following the same process as described above. Refer to Appendix A, Section 4.0, for specific guidelines for updating the IRF.

7.0 Incident Investigation

The purpose of an incident investigation is to understand how the incident happened, analyze the root causes, and prevent recurrence by implementing corrective actions. To conduct an effective investigation, all information must be as detailed and comprehensive as possible. The investigation must be based on facts that clearly identify the sequence of events and the factors that contributed to the incident. The investigation team should not be involved with any punitive actions resulting from the investigation. Fairness and impartiality are essential.

Serious incidents are investigated as directed by the LID.

7.1 Non-Serious Incident Investigation Procedure

Incident investigations are to be initiated and completed as soon as possible, but no later than 72 hours after the incident has occurred. Except for serious incidents, the RHSPM or

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ECC (depending on the type of incident) shall be responsible for determining the level of the investigation. The RHSPM/ECC may conduct the investigation directly or may delegate this function to the ERC or other party, depending on the extent of the incident and staff availability. The Investigation Guidelines in Appendix B must be followed when conducting incident investigations. Typically, non-serious investigations will be documented by updating the IRF and describing the investigation facts in the Comments section. A supplemental report may be required for more extensive investigations. The RHSPM/ECC shall ensure that the Project Manager (field) or Area Office Manager (office) is made aware of investigation findings and all corrective actions, and shall verify that corrective actions are implemented to prevent further incidents.

8.0 Attachments

Attachment 1 Regulatory Requirements and Standards

Attachment 2 Incident Notification and Reporting Flowchart

Attachment 3 IRF Completion Flowchart

Attachment 4 IRF Updating Flowchart

Appendix A Incident Report Form Completion Guideline

Appendix B Incident Investigation Guidelines

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Attachment 1: Regulatory Requirements and Standards

Australia

NSW—Regulation 2001

VIC—OHS (Incident Notification) Regulations 1996

TAS—Section 61 Workplace Health & Safety Regulations 1998

WA—Work Safety & Health Act—Notification of Accidents

QLD—OHS—Incident Record/Report

NT—Section 46—Work Health Regulations

ACT—OHS Act

SA—OHS Act

United States

OSHA (29 CFR §1904.4) and various state workers compensation laws require employers to complete an injury/illness report after receiving information that a work-related injury or illness has occurred. CH2M HILL satisfies these requirements by using an IRF.

Investigations falling within the scope of the OSHA Process Safety Management Standard must meet the requirements of 29 CFR §1910.119(m).

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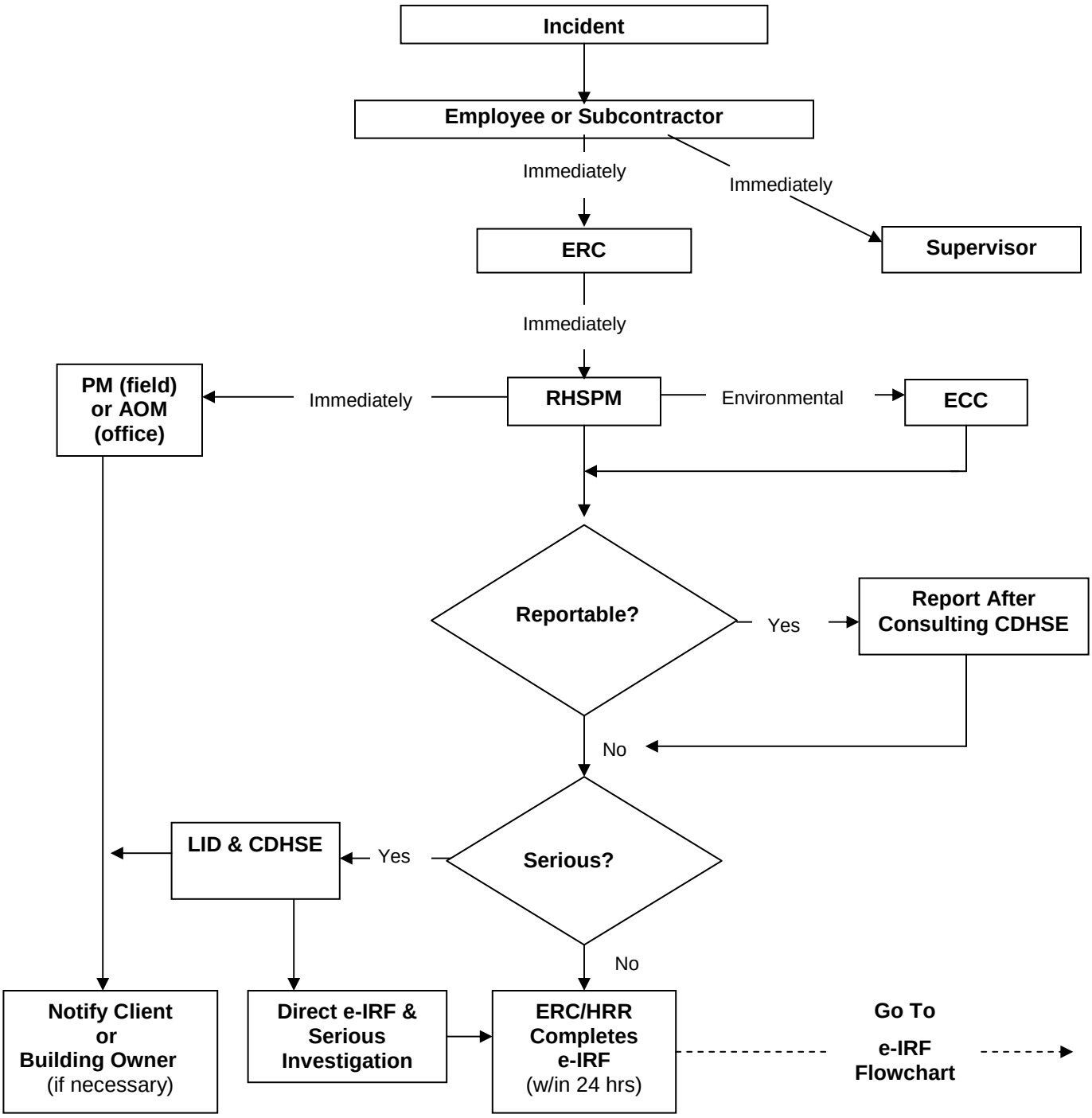
Attachment 2: Incident Notification and Reporting Flowchart



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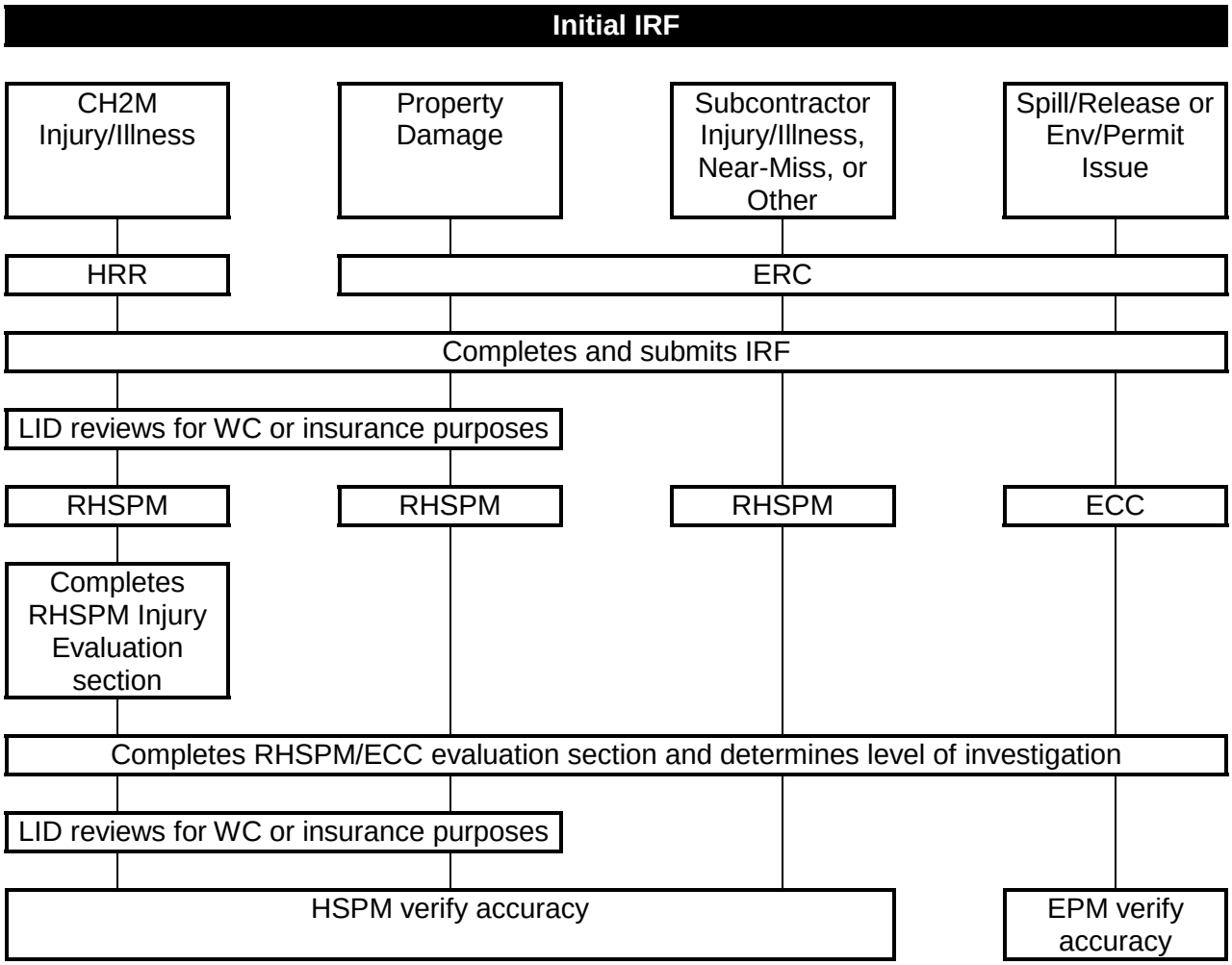
Incident Reporting and Investigation
Standard of Practice HSE-111

Attachment 3: IRF Completion Flowchart



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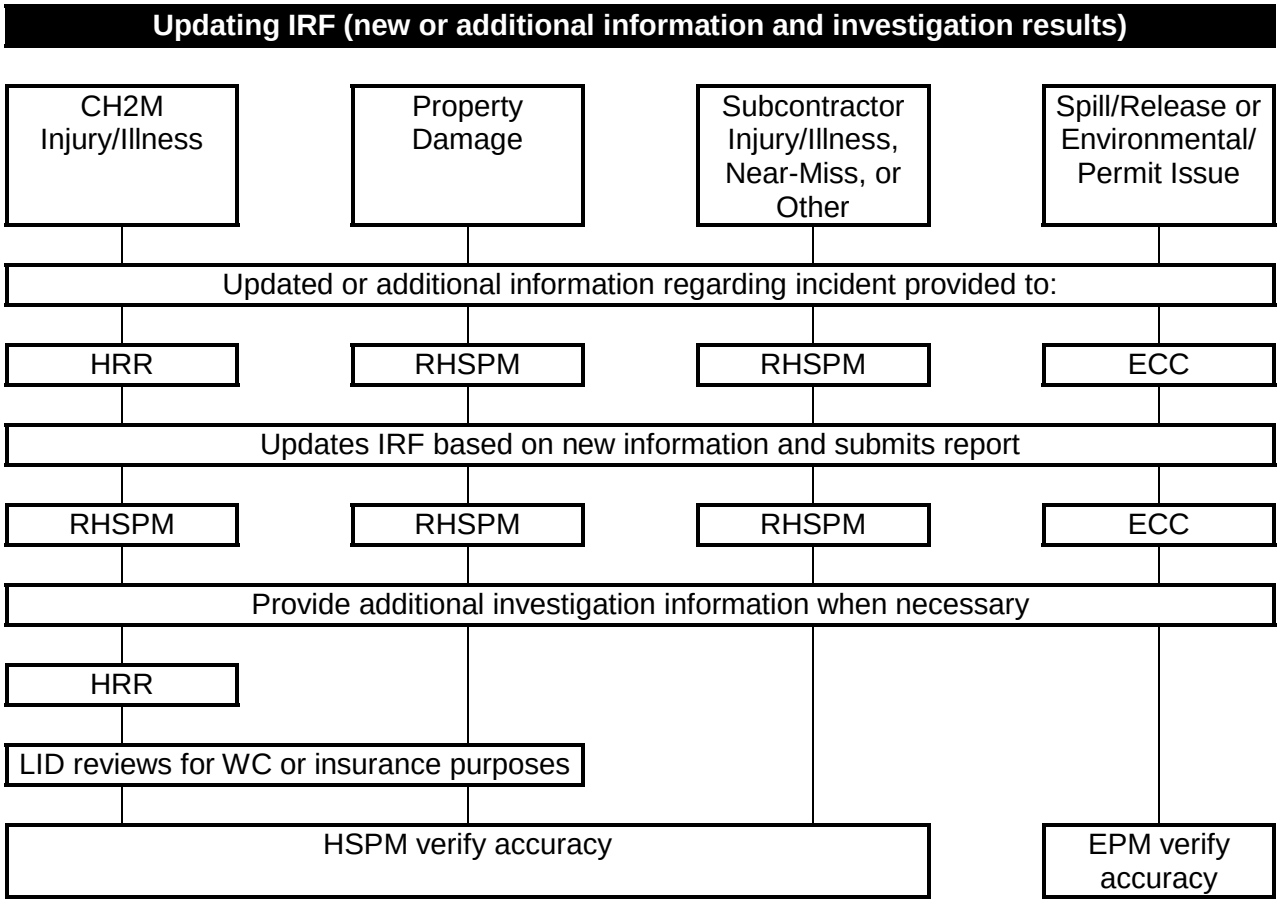
Attachment 4: IRF Updating Flowchart



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Appendix A: Incident Report Form Completion Guideline

1.0 Introduction

This guideline is provided to assist in accessing, creating, reviewing, and updating the Incident Report Form (IRF).

2.0 Access to IRF

The preferred method of submitting an IRF is by using the electronic IRF (e-IRF). The e-IRF may be accessed at the HS&E Home Page under Forms & Reports. If the e-IRF cannot be accessed, a hard copy of the form may be printed from Attachment 1. All fields on the hard copy must be completed and faxed to the Corporate HS&E Department for entry into the system. Faxed IRFs must be received within 24 hours of the incident. Problems encountered with the e-IRF should be referred to regional IT staff.

3.0 IRF Initial Entry

Human Resources Representatives (HRRs) are responsible for creating the IRF for CH2M HILL employee injury and illness incidents. The ERC is responsible for completing the IRF for all other types of incidents. An e-IRF may be created from the IRF Welcome Page by selecting the "Create" tab and then "Incident." All incidents require completion of the "Type of Incident" and "General Information" sections. Depending upon the type of incident, additional sections may require completion.

After completing the necessary information, hit the "Submit" button to generate an IRF report. If the information has been entered correctly, a separate window will momentarily appear stating that the IRF has been successfully submitted. Select the "OK" button; the completed report will open for review. Changes cannot be made to this screen; see section 4.0 to update e-IRF reports. Only HRR and HS&E staff have authority to edit existing reports. Submitted reports will be sent to the appropriate RHSPM and ECC for additional evaluation. If information has been entered incorrectly, the system will prompt the user to reenter the information. To clear the fields and reenter information, hit the "Reset" button. (Note: The "Reset" button will reset all fields on the current screen; therefore, all information on the current screen will require reentry.)

To make timely notifications to appropriate authorities, IRFs must be submitted within 24 hours of the incident occurrence.

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3.1 General Sections for All Incident Types

Type of Incident Section

Select at least one of the incident types provided on the form. More than one incident type may be selected. The "Other" option may be used for incident types not provided on the form (e.g., fires, explosions, bomb threats, workplace violence).

General Information Section

Date of Incident—Provide the date the incident occurred. If the exact date is unknown, provide an approximate date. Enter date in the "mm/dd/yyyy" format. The system will prompt the user to reenter incorrect date entries.

Time of Incident—Provide the time the incident occurred. If the exact time is unknown, provide an approximate time. Enter time in military time or the "hh:mm am or pm" format. The system will prompt the user to reenter incorrect time entries.

Type of Activity—Select the activity being performed that resulted in the incident from the pick list. If activity is not listed, select "other" and provide a brief description. Only use "other" if no other option is appropriate.

Location of Incident—Select the location where the incident occurred from the pick list. If "Company Premises" is selected, provide the CH2M HILL office location. If "Field" is selected, provide the project number, project/site name, and client name. If "In Transit" is selected, provide traveling from and traveling to.

Geographic Location of Incident—Select the CH2M HILL region where the incident occurred from the pick list.

Subcontractor Involved—If a CH2M HILL subcontractor was involved in the incident, provide the subcontractor's company name and telephone number.

Describe the Incident—Provide a brief description of the events that led to (caused) the incident. Be as specific as possible.

Verbal Notification Section

CH2M HILL Personnel Notified—Provide names, dates, and times of all CH2M HILL personnel notified in accordance with HSE-111.

Client Notified—Indicate if the Project Manager has notified the client in accordance with procedures in HSE-111, Section 6.2.

Witnesses Section

Witness information—Provide name, address, and telephone number of any witnesses to the incident.

Comments Section

Additional Comments/Changes—Provide any additional information that was not covered that will help clarify the reasons for the incident.

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3.2 Injured Employee Data Section (Complete for Injury/Illness Incidents only)

Injured Employee General Information—If a CH2M HILL employee was injured, select the "Find" button and enter the first three letters of the employee's last name. Allow the system a few seconds to search the global database. Select the injured employee from the pick list in option 2 and select "OK" in option 3. The system will automatically populate the general information fields. If the system could not locate the injured employee, select "Click to enter a subcontractor" and provide the information manually. If a CH2M HILL subcontractor was injured, select "Click to enter a subcontractor" and provide the information manually.

Injury Type—Select the injury type from the pick list. If injury type is not listed, select "Other" and provide a brief description. Use "Other" only if no other option is appropriate. If more than one injury type, select "Multiple" and provide a brief description.

Part of Body Injured—Select the body part injured from the pick list. If the body part injured is not listed, select "Other" and provide a brief description. Use "Other" only if no other option is appropriate. If more than one body part was injured, select "Multiple" and provide a brief description.

Nature of Injury—Select nature of injury from the pick list. If nature of injury is not listed, select "Other" and provide a brief description. Use "Other" only if no other option is appropriate. If more than one nature of injury, select "Multiple" and provide a brief description.

Initial Diagnosis/Treatment Date—Provide the initial date when the injury/illness was diagnosed or treated. Enter date in the "mm/dd/yyyy" format. The system will prompt the user to reenter incorrect date entries.

Type of Treatment—Select treatment from the pick list. If treatment is not listed, select "Other" and provide a brief description. Use "Other" only if no other option is appropriate. If more than one treatment, select "Multiple" and provide a brief description.

Required Days Off—Provide the number of days the doctor required the employee to be away from work. Do not count days in which the employee chooses to stay away from work without the doctor's instruction. Do not count initial day of injury or onset of illness. Do not count days on which the employee would not have worked even if the employee had been able to work (e.g., holidays, vacations, weekends). This number may need to be updated if the doctor changes initial instructions.

Restricted Days of Work Activity—Provide the number of days the doctor restricted the employee's work activity. Restricted days include: (1) days employee was assigned to another job on a temporary basis, (2) days employee worked at a permanent job less than full time, and (3) days employee worked at his/her permanent job but could not perform all the duties normally conducted. Do not count initial day of injury or onset of illness. Do not count days on which employee would not have worked even if the employee had been able to work (e.g., holidays, vacations, weekends). This number may need to be updated if the doctor changes initial instructions.

Equipment Malfunction—Select "Yes" if equipment malfunction caused or led to the incident.

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Routine Task—Select "Yes" if incident occurred during a routine task.

Describe How You May Have Prevented This Accident—Provide a brief description of how this incident could have been avoided or prevented.

Physician Information—Provide name, address, and telephone number of physician visited.

Hospital Information—Provide name, address, and telephone number of hospital visited.

Emergency Room Information—Provide name, address, and telephone number of emergency room visited.

3.3 Property Damage Section (Complete for Property Damage incidents only)

Property Damaged—Provide a brief description of the property, including all vehicles, equipment, structures, etc.

Property Owner—Indicate if the property is owned by CH2M HILL or, if not, who owns the damaged property.

Damage Description—Provide a brief description of the physical damage on each damaged item.

Estimated Amount—Provide the estimated dollar value of damage or cost to repair.

3.4 Spill or Release (Complete for Spill/Release incidents only)

Substance—Provide the type of substance spilled or released to the environment.

Estimated Quantity—Provide the estimated quantity of the substance spilled/released.

Facility—Provide the name, address, and telephone number of the facility where the incident occurred.

Movement Off Property—Select "Yes" if the substance that was spilled/released moved off the property where the work was being performed.

Spill/Release From—Select from the pick list the type of container the substance was in prior to the spill/release. If the container type is not listed, select "Other" and provide a brief description. Use "Other" only if no other option is appropriate.

Spill/Release To—Select from the pick list where the substance ended up after the spill/release. If area is not listed, select "Other" and provide a brief description. Use "Other" only if no other option is appropriate.

3.5 Environmental/Permit Issue Section (Complete for Environmental/Permit Issue incidents only)

Describe Environmental or Permit Issue—Where a federal, state, or local law or regulation may have been violated, describe the requirement and how it was violated.

Permit Type—Select the type of permit that was exceeded from the pick list. If the permit type is not listed, select "Other" and provide a brief description. Use "Other" only if no other option is appropriate.

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Permitted Level or Criteria—Provide the level or criteria exceeded (e.g., 5.0 ppm lead or surface water quality criteria).

Permit Name and Number—Provide name and number of permit exceeded (e.g., NPDES No. ST1234).

Substance and Estimated Quantity—Provide substance name and estimate the quantity of the exceedance.

Duration of Permit Exceedance—Provide an estimate of how long the exceedance lasted.

4.0 IRF Updating

The HRR (for incidents involving CH2M HILL injuries) or the ERC (for all other incidents) must update the IRF when additional or updated information becomes available. New or additional treatment, diagnosis, lost workdays, or restricted days may change nonrecordable cases to recordable cases, or more accurate calculations may result in a reportable spill. Therefore, IRFs shall be updated when additional or updated information is obtained. The RHSPM and ECCs must update the "RHSPM/ECC Evaluation" section when appropriate. The following steps must be used when updating existing IRFs. (Note: Any changes will overwrite the previous field information. It is recommended that the existing report be printed prior to updating. Lost information can then be reentered by reviewing the printed copy.)

1. Access the IRF system.
2. At the welcome page, select "Reports" tab, then "Query."
3. Reports may be queried on almost any IRF field. If the IRF number is known, query by General Information>Incident-number. If the employee name is known, query by Injury>Injured employee. Several parameters may be selected to narrow the search.
4. Once query parameters are selected, click the "Search" button. In a few seconds the IRFs that match the parameters will be displayed.
5. Click the IRF number to view and edit the IRF.
6. Any field may be edited; however, you are required to provide your name, date, and brief summary of the edits made under "Additional comments/changes."
7. After all the changes have been made, click the "Submit" button. Edits will be saved and sent to the appropriate RHSPM and ECC.

5.0 RHSPM/ECC Evaluation

The RHSPM and ECC are responsible for reviewing IRF reports for accuracy and completeness, and for completing additional evaluation sections. RHSPMs are required to complete the RHSPM Injury Evaluation and RHSPM/ECC Evaluation sections for Injury/ Illness Reports, Property Damage, Near-Miss, and Other reports. ECCs are required to complete the RHSPM/ECC Evaluation and ECC Evaluation sections for Spill/Release and Environmental/Permit Issue reports.

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Questions regarding Injury/Illness, Property Damage, Near-Miss, and Other reports should be directed to the HSPM. Questions regarding Spill/Release and Environmental/Permit Issue reports should be directed to the EPM.

5.1 RHSPM Injury Evaluation Section

Work Related—In general, an incident is considered work related when it results from an event or exposure in the work environment. The work environment includes CH2M HILL premises and other locations where employees are engaged in work-related activities or are present as a condition of employment. CH2M HILL premises include company restrooms, hallways, and lunchrooms, but exclude parking and recreational facilities. Incidents occurring on CH2M HILL premises are typically work related. Incidents occurring off CH2M HILL premises are also considered work related if: (1) the employee was engaged in a work-related activity, (2) the employee was present at the location as a condition of employment, or (3) the employee was in travel status and was engaged in work or travel function. If the employee was engaged in an activity for personal use or enjoyment while off CH2M HILL premises, the incident would not be considered work related. Determining work relationships can be difficult. For complex cases, call the HSPM for clarification.

Incident Status—Distinguishing between injuries and illnesses is determined by the original event or exposure that caused the incident, not by the resulting condition. Injuries are caused by instantaneous events and exposures; anything other than instantaneous is classified as an illness. Animal, insect, and snake bites are classified as injuries. Back injuries are classified as injuries. Repetitive motion disorders are classified as illnesses.

Fatality Date—This field is to be used only for an injury or illness that is fatal. The OSHA 200 log requires a fatality date, and this may be different from the date of injury or illness. Enter date in the "mm/dd/yyyy" format.

Illness Category—This field is to be used only for recordable illnesses. The OSHA 200 log requires that recordable illnesses be categorized within one of the seven categories provided on the IRF. Choose only one category. The seven illness categories, with examples of each, are listed below:

- Occupational skin diseases or disorders—Contact dermatitis, eczema, or rash caused by primary irritants and sensitizers or poisonous plants; oil acne; chrome ulcers; chemical burns or inflammations.
- Dust diseases of the lungs (pneumoconioses)—Silicosis, asbestosis, and other asbestos-related diseases, coal worker's pneumoconiosis, byssinosis, siderosis, and other pneumoconioses.
- Respiratory conditions due to toxic agents—Pneumonitis, pharyngitis, rhinitis, or acute congestion due to chemicals, dusts, gases, or fumes: farmer's lung.
- Poisoning (systemic effects of toxic materials)—Poisoning by lead, mercury, cadmium, arsenic, or other metals; by carbon monoxide, hydrogen sulfide, or other gases; by benzol, carbon tetrachloride, or other organic solvents; by insecticide sprays such as parathion or lead arsenate; by other chemicals such as formaldehyde, plastics, and resins.

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- Disorders due to physical agents (other than toxic materials)—Heatstroke, sunstroke, heat exhaustion, and other effects of environmental heat; freezing, frostbite, and effects of exposure to low temperatures; caisson disease; effects of ionizing radiation (isotopes, x-rays, radium); effects of nonionizing radiation (welding flash, ultraviolet rays, microwaves).
- Disorders associated with repeated trauma—Noise-induced hearing loss; synovitis, tenosynovitis, and bursitis; Raynaud's phenomenon; and other conditions due to repeated motion, vibration, or pressure.
- All other occupational illnesses—Anthrax, brucellosis, infectious hepatitis, malignant and benign tumors, food poisoning, histoplasmosis, or coccidioidomycosis.

Illness Diagnosed or Recognized—All commonly recognized and diagnosed illnesses are recordable. Commonly recognized illnesses are those that are simple to detect and can be identified without specialized medical training, such as poison ivy. Commonly recognized illnesses are recordable on the date the signs/symptoms are present. Complex illnesses (e.g., silicosis, asbestosis, and carpal tunnel syndrome) can be identified (diagnosed) only by properly trained medical personnel and become recordable only after they have been diagnosed. An individual who reports wrist pain should not be reported as recordable until a diagnosis has been made of a work-related illness. For injuries, select "Not diagnosed nor recognized."

Medical Treatment—A guideline is provided in Attachment 2 for distinguishing between first aid and medical treatment. Distinguishing between first aid and medical treatment can be difficult; for complex cases call the HSPM for clarification.

Loss of Consciousness—Self-explanatory.

Restricted Work or Motion—The number of restricted days is provided in the "Incident Information" section that is completed by the HRR. This number may need to be updated if the doctor changes initial instructions. The HRR is responsible for updating the restricted workdays; the RHSPM should verify that this is being done.

Transfer to Another Job—Self-explanatory.

Lost Workdays—The number of lost workdays is provided in the "Incident Information" section that the HRR completes. This number may need to be updated if the doctor changes initial instructions. The HRR is responsible for updating the lost workdays; the RHSPM should verify that this is being done.

OSHA Recordable—A flowchart is provided in Attachment 3 for determining OSHA recordability. Recordability for incidents occurring outside the United States is not recorded in this section. Such determinations must be documented in the "Comment" section of the IRF. A flowchart is provided in Attachment 4 for determining recordability in Australia. Questions regarding recordability should be directed to the HSPM.

OSHA Log Date—This field is to be used only for recordable incidents in the United States. For recordable injuries, this is the date of the injury. For recordable illnesses, this is the date the illness was diagnosed or recognized. Illnesses are recordable only after they have been diagnosed or recognized. This field, along with the "OSHA Recordable" field, is used to

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determine the recordable cases for the H&S quarterly report. Enter date in the "mm/dd/yyyy" format.

OSHA Log Location—This field is to be used only for recordable incidents in the United States. OSHA requires that each establishment maintain an OSHA 200 log and that recordable cases occurring at the establishment be entered onto the establishment log, regardless of where the employee normally reports for work. An establishment is defined as any operation with a continuous duration of 1 year or more. That means projects lasting more than 1 year are required to maintain their own OSHA 200 log.

From the pick list, choose the appropriate OSHA log location code. This should be the same as the region identified under the geographic location field. If a code is not available for an establishment project, one must be created. The code used, as well as the project's name and location, must be provided to the HSPM.

5.2 RHSPM/ECC Evaluation Section

Comments—Provide any additional information that was not included in the responses to other questions that will help clarify and update the case. This may include doctor's instructions from specific visits to assist in updating lost and restricted workdays and may include the specific reasons why this case is recordable or not.

Initial Determination of Cause(s)—Provide the root cause(s) of the incident to prevent recurrence. The form in Attachment 1 will be used to determine the cause of the incident. This form will be kept in project and/or regional HS&E files.

Corrective Actions/Lessons Learned—Indicate corrective actions required to address the situation and prevent recurrence. Provide lessons learned/suggestions that might have prevented the specific case or that may prevent future incidents of the same nature.

5.3 ECC Evaluation Section

Hazardous Substances and RQs—Indicate the status of the substance involved (CERCLA hazardous substance or extremely hazardous substance) in the spill or release and the applicable Reportable Quantity (RQ) by referring to the *BNA Spill Reporting Procedures Guide.*

Reportable to Agency—Indicate if the spill, release, or environmental issue is required to be reported to the regulatory agency. For example, "The exceedance is reportable to the State Water Quality Board because it was considered a bypass event under the terms of the NPDES permit." This determination should have already been made when the incident was verbally communicated. Research applicable regulations to determine reportability. The agency should ***not*** be contacted to assist in making a determination. The incident should be reported after a determination is made. Note that most spills/releases must be reported within 24 hours.

State Reason—Provide the rationale behind the decision of whether or not to report the incident. For example, "The 0.03 ppm concentration of benzene in the mixture contained in the 50 gallons spilled did not exceed the federal or state RQ."

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6.0 Attachments

Attachment A-1 Incident Report (Hard Copy)
Attachment A-2 Treatment Classification Table
Attachment A-3 OSHA Recordability Flowchart
Attachment A-4 Australia Reportable Injury/Illness Guidelines

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CH2MHILL

Attachment A-1: Incident Report Form (Hard Copy)

Fax completed form to:
425.462.5957
CH2M HILL Seattle Office
Attention: Corporate HS&E Department

Type of Incident (Select at least one)

☐ Injury/Illness ☐ Property Damage ☐ Spill/Release
☐ Environmental/Permit Issue ☐ Near-Miss ☐ Other

General Information (Complete for all incident types)

Preparer's Name: _____ Preparer's Employee Number: _____
Date of Report: _____ Date of Incident: _____ Time of Incident: _____ am/pm

Type of Activity (Provide activity being performed that resulted in the incident)

☐ Asbestos Work
☐ Confined Space Entry
☐ Construction Mgmt—Haz Waste
☐ Construction Mgmt—Non-Haz Waste
☐ Demolition
☐ Drilling—Haz Waste
☐ Drilling—Non-Haz Waste
☐ Drum Handling
☐ Electrical Work
☐ Excavation Trench—Haz Waste
☐ Excavation Trench—Non Haz
☐ Facility Walkthrough
☐ General Office Work
☐ Keyboard Work
☐ Laboratory
☐ Lead Abatement
☐ Motor Vehicle Operation
☐ Moving Heavy Object
☐ Other (Specify) _____
☐ Process Safety Management
☐ Tunneling
☐ Welding
☐ Wetlands Survey
☐ Working from Heights
☐ Working in Roadways
☐ WWTP Operation

Location of Incident (Select one)

☐ Company Premises (CH2M HILL Office: _____)
☐ Field (Project #: _____ Project/Site Name: _____ Client: _____)
☐ In Transit (Traveling from: _____ Traveling to: _____)
☐ At Home

Geographic Location of Incident (Select region where the incident occurred)

☐ Northeast ☐ Corporate ☐ Latin America
☐ Southeast ☐ Canadian
☐ Northwest ☐ Asia Pacific
☐ Southwest ☐ Europe Middle East

If a CH2M HILL subcontractor was involved in the incident, provide their company name and phone number: _____

Describe the Incident (Provide a brief description of the incident): _____

Injured Employee Data (Complete for Injury/Illness incidents only)

If CH2M HILL employee injured
Employee Name: _____ Employee Number: _____

If CH2M HILL Subcontractor employee injured
Employee Name: _____ Company: _____

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CLICK HERE TO GET TO ATTACHMENTS

Injury Type

- ☐ Allergic Reaction
- ☐ Amputation
- ☐ Asphyxia
- ☐ Bruise/Contusion/Abrasion
- ☐ Burn (Chemical)
- ☐ Burn/Scald (Heat)
- ☐ Cancer
- ☐ Carpal Tunnel
- ☐ Concussion
- ☐ Cut/Laceration
- ☐ Dermatitis
- ☐ Dislocation
- ☐ Electric Shock
- ☐ Foreign Body in Eye
- ☐ Fracture
- ☐ Freezing/Frostbite
- ☐ Headache
- ☐ Hearing Loss
- ☐ Heat Exhaustion
- ☐ Hernia
- ☐ Infection
- ☐ Irritation to Eye
- ☐ Ligament Damage
- ☐ Multiple (Specify)

_____

- ☐ Muscle Spasms
- ☐ Other (Specify)

_____

- ☐ Poisoning (Systemic)
- ☐ Puncture
- ☐ Radiation Effects
- ☐ Strain/Sprain
- ☐ Tendonitis
- ☐ Wrist Pain

Part of Body Injured

- ☐ Abdomen
- ☐ Ankle(s)
- ☐ Arms (Multiple)
- ☐ Back
- ☐ Blood
- ☐ Body System
- ☐ Buttocks
- ☐ Chest/Ribs
- ☐ Ear(s)
- ☐ Elbow(s)
- ☐ Eye(s)
- ☐ Face
- ☐ Finger(s)
- ☐ Foot/Feet
- ☐ Hand(s)
- ☐ Head
- ☐ Hip(s)
- ☐ Kidney
- ☐ Knee(s)
- ☐ Leg(s)
- ☐ Liver
- ☐ Lower (Arms)
- ☐ Lower (Legs)
- ☐ Lung
- ☐ Mind
- ☐ Multiple (Specify)

_____

- ☐ Neck
- ☐ Nervous System
- ☐ Nose
- ☐ Other (Specify)

_____

- ☐ Reproductive System
- ☐ Shoulder(s)
- ☐ Throat
- ☐ Toe(s)
- ☐ Upper Arm(s)
- ☐ Upper Leg(s)
- ☐ Wrist(s)

Nature of Injury

- ☐ Absorption
- ☐ Bite/Sting/Scratch
- ☐ Cardiovascular/Respiratory System Failure
- ☐ Caught In or Between
- ☐ Fall (from Elevation)
- ☐ Fall (Same Level)
- ☐ Ingestion
- ☐ Inhalation
- ☐ Lifting
- ☐ Mental Stress
- ☐ Motor Vehicle Accident
- ☐ Multiple (Specify)

_____

- ☐ Other (Specify)

_____

- ☐ Overexertion
- ☐ Repeated Motion/Pressure
- ☐ Rubbed/Abraded
- ☐ Shock
- ☐ Struck Against
- ☐ Struck By
- ☐ Workplace Violence

Initial Diagnosis/Treatment Date: _____

Type of Treatment

- ☐ Admission to hospital/medical facility
- ☐ Application of bandages
- ☐ Cold/heat compression—multiple treatment
- ☐ Cold/heat compression—one treatment
- ☐ First-degree burn treatment
- ☐ Heat therapy—multiple treatment
- ☐ Multiple (specify)

_____

- ☐ Heat therapy—one treatment
- ☐ Nonprescription medicine
- ☐ None
- ☐ Observation
- ☐ Other (specify)

_____

- ☐ Prescription—multiple dose
- ☐ Prescription—single dose
- ☐ Removal of foreign bodies
- ☐ Skin removal
- ☐ Soaking therapy—multiple treatment
- ☐ Soaking therapy—one treatment
- ☐ Stitches/sutures
- ☐ Tetanus
- ☐ Treatment for infection
- ☐ Treatment of 2nd/3rd-degree burns
- ☐ Use of antiseptics—multiple treatment
- ☐ Use of antiseptics—single treatment
- ☐ Whirlpool bath therapy—multiple treatment
- ☐ Whirlpool therapy—single treatment
- ☐ X-rays negative
- ☐ X-rays positive/treatment of fracture

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Number of days doctor required employee to be off work: _____
Number of days doctor restricted employee's work activity: _____
Equipment Malfunction : Yes ☐ No ☐ Activity was a Routine Task: Yes ☐ No ☐
Describe how you might have prevented this injury:
_____

Physician Information
Name: _____
Address: _____
City: _____
Zip Code: _____
Phone: _____

Hospital Information
Name: _____
Address: _____
City: _____
Zip Code: _____
Phone: _____

Property Damage (Complete for Property Damage incidents only)

Property Damaged: _____ Property Owner: _____
Damage Description: _____
Estimated Amount: $ _____

Spill or Release (Complete for Spill/Release incidents only)

Substance (attach MSDS): _____ Estimated Quantity: _____
Facility Name, Address, Phone No.: _____
Did the spill/release move off the property where work was performed?: _____
Spill/Release From: _____ Spill/Release To: _____

Environmental/Permit Issue (Complete for Environmental/Permit Issue incidents only)

Describe Environmental or Permit Issue: _____
Permit Type: _____
Permitted Level or Criteria (e.g., discharge limit): _____
Permit Name and Number (e.g., NPDES No. ST1234): _____
Substance and Estimated Quantity: _____
Duration of Permit Exceedance: _____

Verbal Notification (Complete for all incident types) (Provide names, dates and times)

CH2M HILL Personnel Notified: _____
Client Notified: _____

Witnesses (Complete for all incident types)

Witness Information (First Witness)
Name: _____
Employee Number (CH2M HILL):_____
Address: _____
City: _____
Zip Code:_____
Phone: _____

Witness Information (Second Witness)
Name: _____
Employee Number (CH2M HILL: _____
Address: _____
City: _____
Zip Code:_____
Phone :_____

Additional Comments:
_____
_____

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Attachment A-2: Treatment Classification Table

FIRST AID TREATMENT	MEDICAL TREATMENT
	Treatment of **INFECTION**
Application of **ANTISEPTICS** during first visit to medical personnel	Application of **ANTISEPTICS** during second or subsequent visit to medical personnel
Treatment of **FIRST-DEGREE BURN(S)**	Treatment of **SECOND- OR THIRD-DEGREE BURN(S)**
Application of **BANDAGE(S)** during any visit to medical personnel	Application of **SUTURES** (stitches)
Use of **ELASTIC BANDAGE(S)** during first visit to medical personnel	Application of **BUTTERFLY ADHESIVE DRESSING(S)** or **STERI STRIP(S)** in lieu of sutures
Removal of **FOREIGN BODIES NOT EMBEDDED IN EYE** if only irrigation is required	Removal of **FOREIGN BODIES EMBEDDED IN EYE**
Removal of **FOREIGN BODIES FROM WOUND**; if procedure is **UNCOMPLICATED** and is, for example, by tweezers or other simple technique	Removal of **FOREIGN BODIES FROM WOUND**; if procedure is **COMPLICATED** because of depth of embedment, size, or location
Use of **NONPRESCRIPTION MEDICATIONS** and administration of single dose of **PRESCRIPTION MEDICATION** on first visit for minor injury or discomfort	Use of **PRESCRIPTION MEDICATIONS** (except a single dose administered on first visit for minor injury or discomfort)
SOAKING THERAPY on initial visit to medical personnel or removal of bandages by **SOAKING**	Use of hot or cold **SOAKING THERAPY** during second or subsequent visit to medical personnel
Application of hot or cold **COMPRESS(ES)** during first visit to medical personnel	Application of hot or cold **COMPRESS(ES)** during second or subsequent visit to medical personnel
Application of **OINTMENTS** to abrasions to prevent drying or cracking	**CUTTING AWAY DEAD SKIN** (surgical debridement)
Application of **HEAT THERAPY** during first visit to medical personnel	Application of **HEAT THERAPY** during second or subsequent visit to medical personnel
Use of **WHIRLPOOL BATH THERAPY** during first visit to medical personnel	Use of **WHIRLPOOL BATH THERAPY** during second or subsequent visit to medical personnel
NEGATIVE X-RAY DIAGNOSIS	**POSITIVE X-RAY DIAGNOSIS** (fractures, dislocations, etc.)

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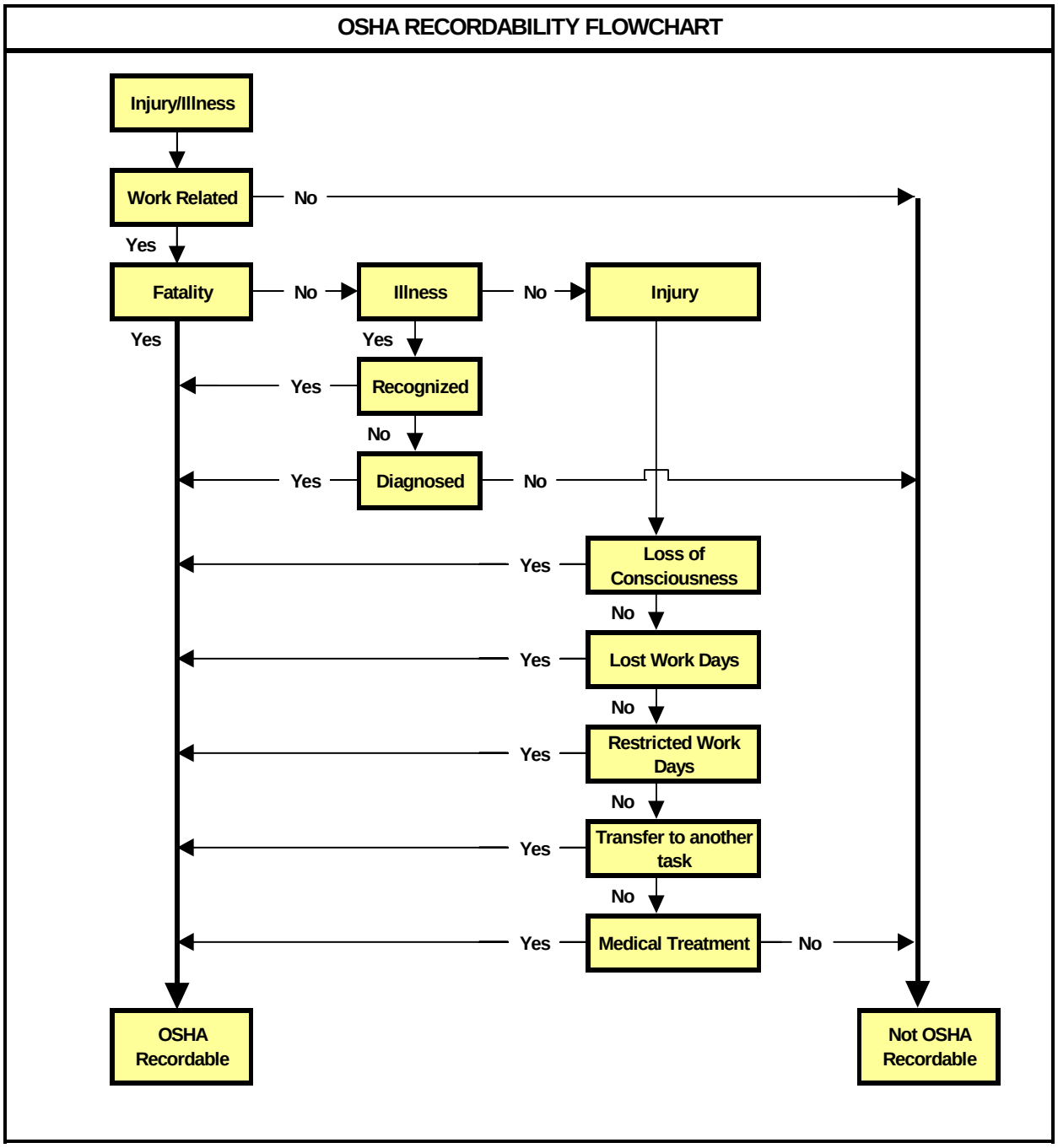
Attachment A-3: OSHA Recordability Flowchart



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Attachment A-4: Australia Reportable Injury/Illness Guidelines

All work-related incidents must be reported within 24 hours to Corporate HS&E. However, only certain incidents must be reported to the local agencies. In Australia, the following incidents are reportable to the local occupational health and safety agency within seven (7) days of occurrence:

1. An accident or occurrence incurring death of a person in the workplace
2. Amputation of a limb as a result of the workplace and its operation
3. An injury to a person that results in the person being unfit, for a continuous period of at least (7) seven calendar days, to attend the person's usual place of work, to perform his or her usual duties at his or her place of work or, in the case of a nonemployee, to carry out his or her usual duties.
4. An illness of a person that is related to work processes and results in the person being unfit, for a continuous period of at least 7 days, to attend the person's usual place of work or to perform his or her usual duties at that place of work.
5. An accident or occurrence incurring electric shock
6. Damage to any plant , equipment, building, or structure or other thing that impedes safe operation,
7. An uncontrolled explosion or fire
8. An uncontrolled escape of gas, dangerous goods, or steam
9. A spill or incident resulting in exposure or potential exposure of a person to a notifiable or prohibited carcinogenic substance (as defined)
10. An accident or occurrence where an employee is injured and admitted to hospital as an in-patient following an exposure to a hazardous substance
11. An accident or occurrence involving the collapse, overturning, or failure of a load-bearing part of a lift, crane, hoist, lifting gear, or scaffolding
12. An accident or occurrence involving the collapse of shoring or an excavation which is more than 1.5m deep
13. Removal of workers from lead risk work due to excessive blood lead levels
14. Exposure to bodily fluids that presents a risk of transmission of blood-borne diseases

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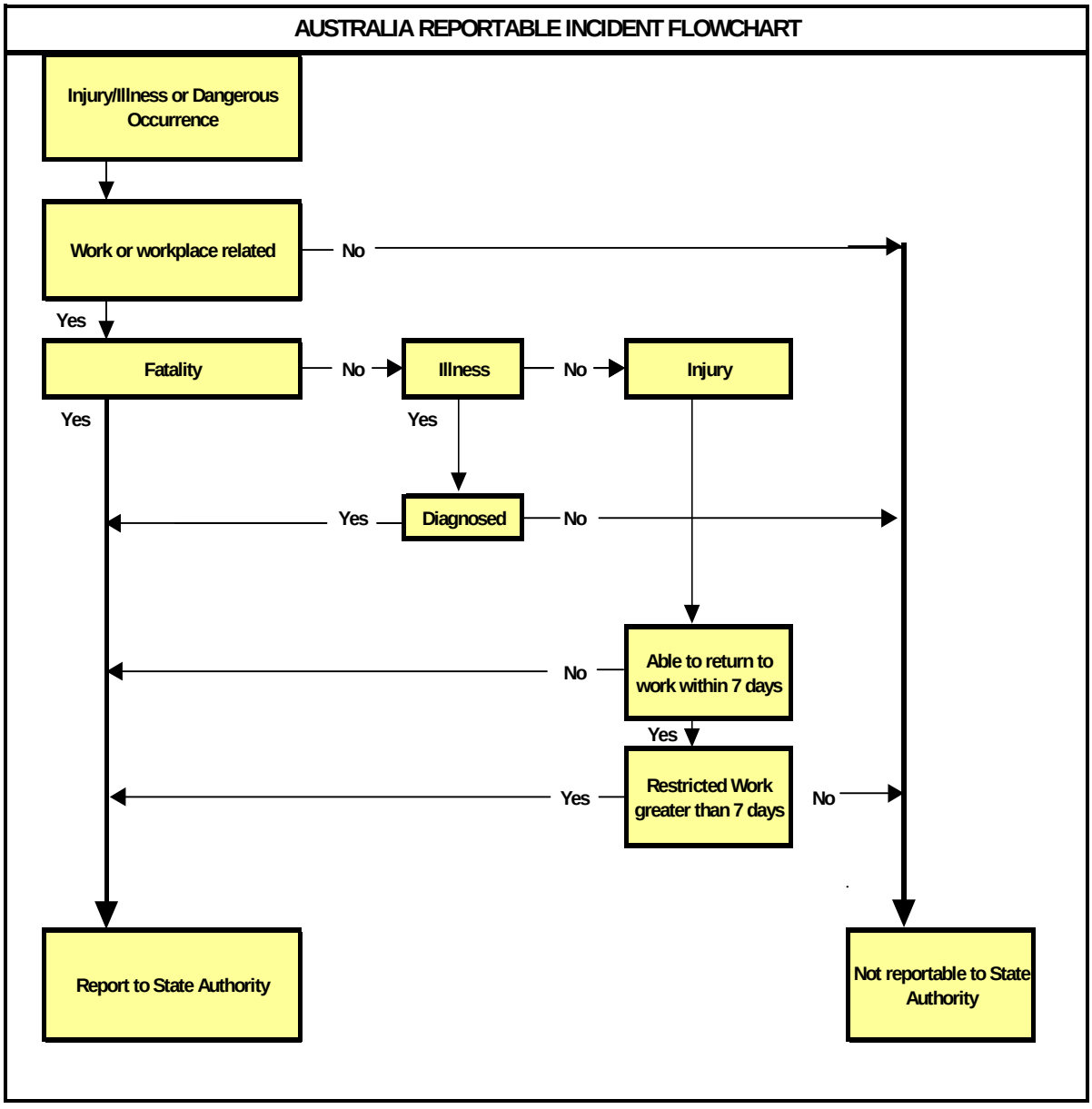
15. Any incident of violence at a place of work that results in an employee being unfit, for a continuous period of at least 7 days, to attend the employee's usual place of work or to perform his or her usual duties at that place of work

16. Any occurrence that involves a risk of:

    - Explosion or fire
    - Escape of gas, dangerous goods, or steam
    - Serious injury to, or illness of, a person
    - Substantial property damage

The following flowchart depicts when incidents must be reported to the appropriate agency in Australia.



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In addition, some states in Australia have a category of incidents known as "non-disturbance occurrences," which are serious, potentially life-threatening occurrences. Non-disturbance occurrences require immediate reporting to the authorities and often require the attendance of an inspector. These types of occurrences usually involve machinery, failure of structures or earthworks, or escape of hazardous substances.

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Appendix B: Investigation Guidelines

1.0 Introduction

This guideline is provided to assist in accessing, completing, and reviewing an incident investigation. It is important to remember the following when conducting an investigation:

- Gather relevant facts, focusing on fact finding, not fault finding.
- Draw conclusions, pitting facts together into a probable scenario.
- Determine incident root cause(s), which are basic causes on why an unsafe act/ condition existed.
- Develop and implement solutions, matching all identified root causes with solutions.

2.0 Documentation

The following should be included in the IRF to document the incident.

Description

- Provide a description of the event and the sequence of events and actions that took place prior to the incident. Start with the incident event and work backwards in time through all of the preceding events that directly contributed to the incident. The information should identify why the event took place as well as who was involved, when and where the event took place, and what actions were taken.

Cause Analysis

Using the form and flowchart in Attachment 1, the root cause of the incident will be determined. This form must be retained in the project and/or regional HS&E files.

Immediate Causes—List the substandard actions or conditions that directly affected the incident. The following are examples of immediate causes:

> ***Substandard Actions***: Operating equipment without authority; failure to warn; failure to secure; operating at improper speed; making safety device inoperable; using defective equipment; failing to use PPE; improper loading; improper lifting; improper position for task; under influence of alcohol or drugs; horseplay.
>
> ***Substandard Conditions:*** Exposure to hazardous materials; exposure to extreme temperatures; improper lighting; improper ventilation; congestion; exposure to fire and explosive hazard; defective tools, equipment, or materials; exposure to extreme noise; poor ventilation; poor visibility; poor housekeeping.

Basic Causes—List the personal and job factors that caused the incident. The following are examples of basic causes:

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Personal Factors: Capability; knowledge; skill; stress; motivation.

Job Factors: Abuse or misuse; engineering; maintenance; purchasing; supervision; tools and equipment; wear and tear; work standards.

Corrective Action Plan

Include all corrective actions taken or those that should be taken to prevent recurrence of the incident. Include the specific actions to be taken, the employer and personnel responsible for implementing the actions, and a time frame for completion. Be sure the corrective actions address the causes. For example, training may prevent recurrence of an incident caused by a lack of knowledge, but it may not help an incident caused by improper motivation.

The following are examples of management programs that may be used to control future incidents. These programs should be considered when determining specific corrective actions.

Management Programs: Accident/incident analysis; emergency preparedness; engineering controls; general promotion; group meetings; health control; hiring and placement; leadership and administration; management training; organizational rules; personal protective equipment; planned inspections; program audits; program controls; purchasing controls; task analysis and procedures; task observation

3.0 Attachments

Attachment B-1 Root Cause Analysis Form and Flowchart

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Attachment B-1: Root Cause Analysis Form and Flowchart

Root Cause Analysis Form

Root Cause Analysis (RCA)

Root Cause Categories (RCC): Select the RCC numbered below that applies for the root cause (RC) and/or contributing factor (CF) in the first column, then describe the specific root cause and corrective actions in each column.

1. **Lack of skill or knowledge**
2. **Lack of or inadequate operational procedures or work standards**
3. **Inadequate communication of expectations regarding procedures or work standards**
4. **Inadequate tools or equipment**
5. **Correct way takes more time and/or requires more effort**
6. **Short-cutting standard procedures is positively reinforced or tolerated**
7. **Person thinks there is no personal benefit to always doing the job according to standards**

RCC #	Root Cause(s)	Corrective Actions	RC[1]	CF[2]	Due Date	Completion Date	Date Verified

[1] RC = Root Cause; [2] CF = Contributing Factors (check which applies)

Investigation Team Members

Name	Job Title	Date

Results of Solution Verification and Validation

Reviewed By

Name	Job Title	Date

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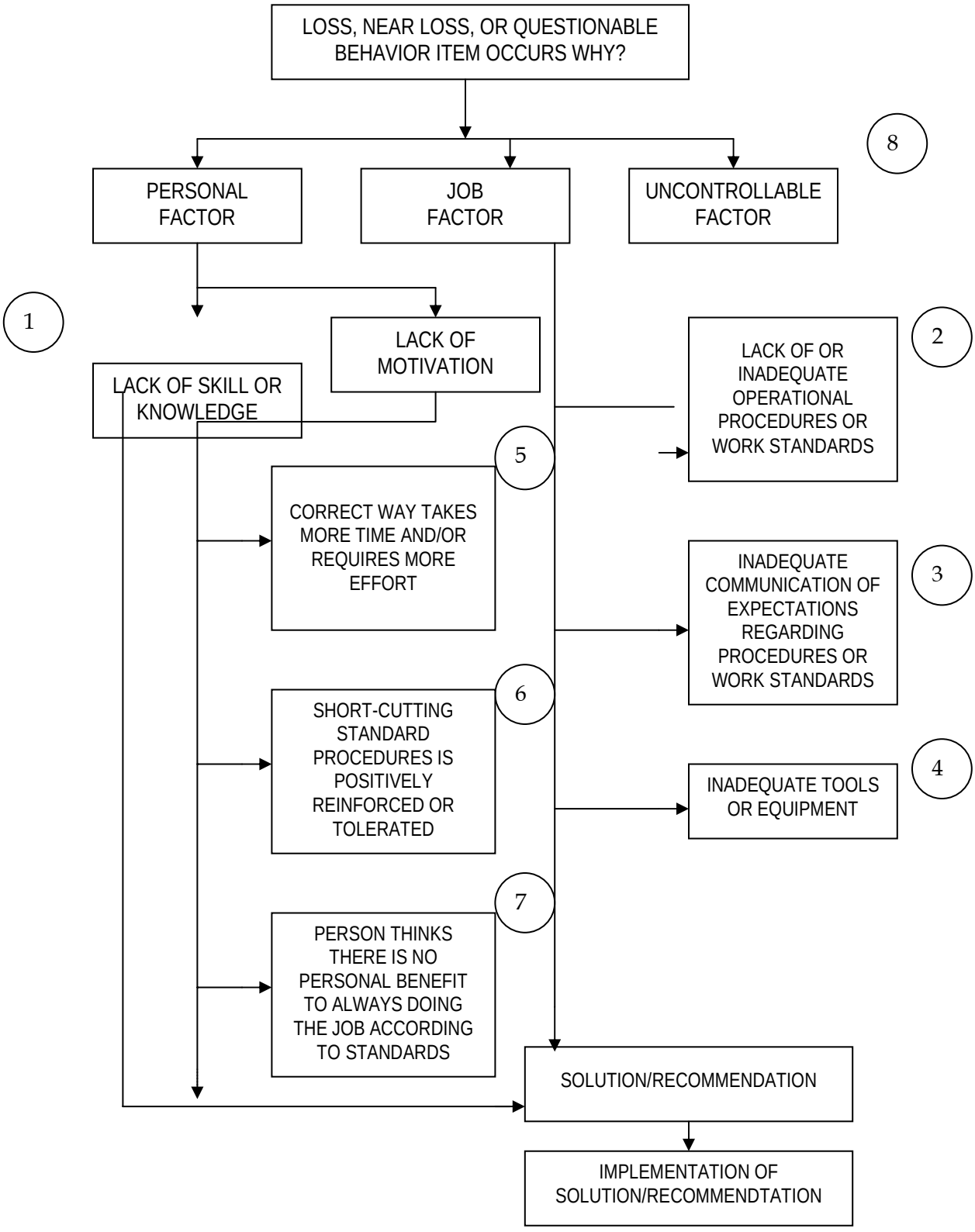
Root Cause Analysis Flowchart



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ATTACHMENT 11

CH2MHILL

HSE&Q-601 Serious Incident Reporting Process

1.0 Introduction

The purpose of this procedure is to provide direction on the required standard notification and reporting process for serious incidents. This standard ensures timely notification to the appropriate Business Group Presidents or Geographic Region Managers and allows for positive control over flow of information so that the incident is handled effectively, efficiently, and in conjunction with appropriate corporate entities. The standard notification process integrates Health, Safety, Environment & Quality (HSE&Q) and Firm Wide Security Operations (FWSO) requirements for the consistent reporting of and managing of serious events throughout our operations. The Standard of Notification applies to all CH2M HILL family of companies.

This document outlines the minimum requirements for the Serious Incident Reporting Process and is not intended as an exhaustive procedural description of the process. Exhaustive procedures for the Serious Incident Reporting Process are developed by each business group/facility or project in accordance with the direction stated herein.

2.0 Serious Incident Determination

Events which require prompt notification to senior management are determined through consideration of a number of factors including; type and seriousness of event, and need for quick Company response to expected client and public reaction. The following are general criteria for determining whether an incident on CH2M HILL owned or managed facilities or project sites is considered serious and must be immediately reported through the reporting/notification process:

- Work related death, or life threatening injury or illness of a CH2M HILL employee, subcontractor, or member of the public
- Kidnap/missing person
- Acts or threats of terrorism
- Event that involves a fire, explosion, or property damage that requires a site evacuation or is estimated to result in greater than $ 500,000 in damage.
- Spill or release of hazardous materials or substances that involves a significant threat of imminent harm to site workers, neighboring facilities, the community or the environment.

3.0 Reporting/Notification Guidelines

For all serious incidents this standard reporting process is implemented immediately so as to ultimately achieve notification to the Business Group President within 2 hours of incident onset or discovery, and notification to appropriate corporate Crisis Management Support Team (see responsibilities) within 3 hours of incident onset or discovery.

4.0 Responsibilities

4.1 Facility or Project Employees

Will:

- Provide immediate verbal notification of serious incident to their Project Manager, Facility Manager, and/or Security Manager. Initial notification of serious incident must include:

  a) Provide verbal notification to appropriate emergency responders
  b) Provide verbal notification to Facility or Project Management
  c) Notification must include:
     - Name of Facility or Project
     - Date/Time of incident
     - Location of incident (City, State, Country)
     - Type of incident (fatality, life threatening injury/illness, kidnap/missing person, act or threat of terrorism, fire/explosion, hazardous material spill, or other)
     - The number of fatalities or victims, including name and family contact information if readily available
     - Reporting party's name and contact number
     - Description of how event occurred
     - Description of immediate and/or short-term corrective actions

4.2 Facility Manager, Project Manager, and/or Security Manager

Will:

- Provide immediate verbal notification to appropriate emergency responders if not already notified
- Provide immediate verbal notification to Team Leader to assemble Local Crisis Management Team
- Provide immediate verbal notification to Crisis Manager via pager #**720.286.4911**
- Provide information to Crisis Manager on immediate and/or short-term corrective actions

4.3 Crisis Manager

Will:

- Provide immediate verbal notification to Geographic Region Managers
- Provide immediate verbal notification to Business Group/Geographic Region HSE&Q Representatives
- Provide immediate verbal notification to Corporate HSE&Q Vice President
- Assemble Crisis Management Support Team as necessary
- Ensure incident updates are maintained

4.4 Geographic Region Manager

Will:

- Allocate time to provide guidance to Local Crisis Management Team and follow incident through to resolution.

4.5 Business Group/Geographic Region HSE&Q Representative

Will:

- Provide immediate (within 2 hours of incident onset or discovery) verbal notification to Business Group President or Facility Manager.
- Immediate notification to Corporate Legal/Insurance Department via e-mail with a description of the incident, parties involved, and incident circumstances. E-mail must be completed as follows:
  - Address e-mail to Al Jerman/DEN and copy Kirby Wright/DEN, Julie Zimmerman/DEN, Keith Christopher/WDC, and Tom Horton/DEN.
  - Include the phrase "Confidential-Attorney/Client Privileged Communication" in the subject line or title of the e-mail.
  - Include the following at the end of the e-mail:

    "Content of communication is a privileged attorney-client communication or privileged attorney work product. If this message was misrouted and you are not an intended recipient, please delete it immediately and notify the sender."

4.6 Corporate HSE&Q Vice President

Will:

- Provide Corporate HSE&Q oversight support to the Business Group President and Crisis Management Support Team.

4.7 BG President or Facility Manager

Will:

- Provide immediate verbal notification to the Office of the Chief Executive Officer (OCEO) Coordinator, Bud Ahearn (or backup OCEO Coordinator Omur Akay).

4.8 OCEO Coordinator

Will:

- Make notification to OCEO
- Provide decision-making assistance or direction for incident resolution

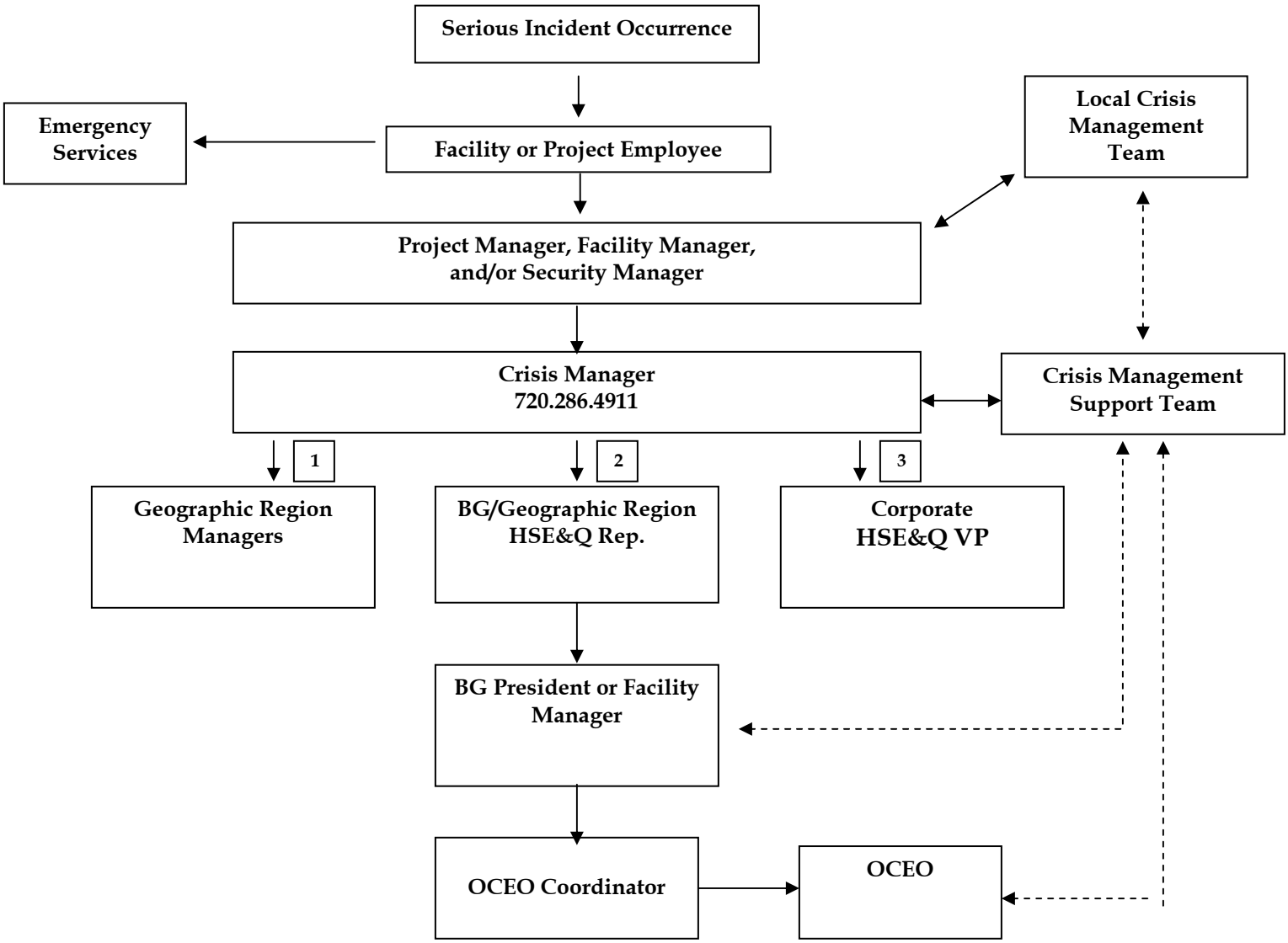
4.9 Local Crisis Management Team

- Team comprised of key local staff that is maintained at each facility and project and is activated to manage the crisis or serious event/incident on-scene. Each facility and project is responsible for staffing and managing the Local Crisis Management Team. The Local Crisis Management Team can be supplemented or augmented by members of the Crisis Management Support Team.

4.10 Crisis Management Support Team

- Team comprised of key corporate staff maintained at the corporate office and is activated to provide support, guidance, and augmentation to Local Crisis Management Operations.

5.0 Serious Incident Notification Chart



Legend:

Direct line of communication

Indirect line of communication

Definitions:

Local Crisis Management Team: Team comprised of key facility, project and/or business group personnel. Team is assembled as necessary and as appropriate to effectively manage and respond to a crisis situation (serious incident) at/on scene.

Crisis Management Support Team: Team comprised of key corporate personnel. Team is assembled as necessary and as appropriate to effectively support, direct, and /or supplement a Local Crisis Management Team.

Crisis Manager: Corporate based Crisis Manager, contactable by pager 24/7.

ATTACHMENT 12

CH2MHILL

HSE&Q-124 Injury Management/Return-to-Work

CLICK HERE TO GET TO ATTACHMENTS

Injury Management/Return-to-Work
Enterprise Standard Operating Procedure HSE&Q-124

1.0 Purpose

This Core Standard applies enterprise-wide to all CH2M HILL legal entities including CH2M HILL, Inc., CH2M HILL Constructors, Inc. (CCI), Lockwood Greene, IDC, OMI and their employees within the United States and Puerto Rico. This Core Standard outlines the mandatory components and criteria to provide for the orderly, effective and timely medical treatment and return-to-work transition of an employee who sustains a work-related injury or illness. Each legal entity must revise their existing procedures and processes, as necessary, to comply with this core standard.

1.1 References

The following programs, regulations and sources were consulted to prepare this Core Standard:

- CH2M HILL H&S Standard Operating Procedure 111, Incident Reporting and Investigation
- CH2M HILL H&S Standard Operating Procedure 601, Serious Incident Reporting

2.0 Scope and Application

This Core Standard applies to all CH2M HILL Legal Entities, their employees within the United States, including Puerto Rico. It applies to non-emergency injuries and illnesses. In case of emergency, dial 911 and follow procedures specified in the office or project Emergency Response Plan.

3.0 Definitions

3.1 Injury/Illness Early Intervention

Involves a designated physician or licensed health care professional (PLHCP) providing guidance and care to an employee as soon as a work-related injury/illness occurs.

3.2 Injury Management/Return-to-Work/Return-to-Work Program (IMRTW)

The process of providing initial and ongoing treatment, administration, and counseling to employees who have sustained a work-related injury/illness with the objective of ensuring that appropriate treatment and care has been provided for the employee's capability to safely return to assigned work duties.

3.3 Occupational Health Management Provider

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A firm in the business of providing occupational health services that includes administration of Injury/Illness Early Intervention and Injury Management/Return-to-Work.

3.4 Telephonic Case Management (TCM)

The process during the first 30 to 60 days of actively following the progress of an employee's treatment and healing to facilitate their being able to return-to-work without jeopardizing their health by a designated licensed health care professional or workers compensation case manager maintaining contact with the employee by telephone. Typically, TCM is applied in cases where the employee has sustained an injury/illness that involved medical treatment resulting in days away from work, work restriction or job transfer.

3.5 Field Case Management (FCM)

A 60-day process implemented by a designated licensed health care professional or workers compensation case manager to actively follow the progress of an employee's treatment and healing through visits with the employee and their place of work or home to facilitate their return to work without jeopardizing their health. Generally FCM is applied in cases where the employee has sustained a more severe injury/illness that involved more ongoing or long-term medical treatment resulting in days away from work, work restriction or job transfer.

4.0 Roles and Responsibilities

4.1 Business Group Presidents

Each Business Group (BG) President is responsible for the following:

- Demonstrating leadership and commitment to the Injury Management/Return-to-Work Program.
- Designating staff within the BG responsible for coordinating the Injury Management/Return-to-Work program with the Occupational Health Management firm administrating the program for their BG.

4.2 Operation Leaders/Supervisors/Group Leaders

Operation Leaders, Supervisors, or Group Leaders are responsible for:

- Verifying that H&S program requirements are implemented in the work facility and/or during project delivery.
- Ensuring that workers are informed of the Injury Management/Return-to-Work/Return-to-Work Program.
- Ensuring that suitable duties are identified and available for injured/ill workers who are determined to be medically fit to assume.
- Promptly responding to injuries or illnesses and ensuring that employees immediately call the Injury Management/Return-to-Work/Return-to-Work Program Administrator using the designated toll-free number, or as the situation requires, the Operations Leader, Supervisor, or Group Leader, places the call for the employee.

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- Promptly documenting reported incidents involving a work-related injury or illness in accordance with HSE-111,"Incident Reporting and Investigation Standard Practice," and coordinating follow-up with the H&S representative.
- Ensuring the injured/ill employee is transported safely to the occupational clinic using company vehicle, rental, or taxi service, and when the situation requires, accompany the employee or assign a designee.
- Promptly completing the CH2M HILL "Authorization to Treat" form (refer to Attachment 3) and having the employee take the completed form with him/her to the medical facility or complete the form emailed by the occupational health nurse and forward it to the medical facility within 24 hours.
- Immediately notifying the pre-designated H&S representative, Human Resources (HR) representative, or assigned BG Injury Management/Return-to-Work/Return-to-Work Coordinator of any reported work related injury or illness.
- Monitoring the recovery status of injured/ill employees with H&S, HR, or the BG Injury Management/Return-to-Work/Return-to-Work Coordinator.

4.3 Employees

Employees are responsible for:

- Complying with H&S program requirements for preventing work-related injuries and illnesses to self and others.
- Providing immediate, direct, verbal notification of any known or suspected work-related injury or illness to their immediate supervisor (e.g., Group Leader).
- Immediately contacting the Injury Management/Return-to-Work Program Administrator using the assigned toll-free number to report their injury or illness and to follow the prescribed treatment, or as the situation requires, have the Operations Leader, Supervisor, or Group Leader, place the call for him/her.

4.4 Business Group H&S Leads and Regional H&S Staff

BG H&S and Regional H&S staff are responsible for:

- Establishing and monitoring the effectiveness of H&S programs in the work facility and during project delivery.
- Identifying suitable duties to be made available to injured workers who are determined to be medically fit to assume.
- Coordinating with the Injury Management/Return-to-Work Program Administrator to identify medical clinics for new projects that may not already exist in the provider network
- Communicating to management, supervisors, and employees the requirement to immediately report all workplace injuries/illnesses to their supervisor and call the toll-free number to speak with the Injury Management/Return-to-Work Program

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Administrator occupational health nurse to receive assistance with the appropriate treatment.

- Ensuring the Injury Management/Return-to-Work Program toll-free number is prominently displayed in the work area or project site. (Refer to Attachment 4)
- Actively participating in the implementation of the program, including consulting with the employee, supervisor, HR, and the BG Injury Management/Return-to-Work Coordinator to ensure effective implementation
- Actively participating in the implementation of the program, including consulting with the employee, supervisor, HR, and the BG Injury Management/Return-to-Work Coordinator to ensure effective implementation
- Promptly following up with the Operation Leader/Supervisor/Group Leader on documenting reported incidents involving a work-related injury or illness in accordance with HSE-111,"Incident Reporting and Investigation Standard Practice."

4.5 Enterprise H&S

Enterprise H&S is responsible for:

- Development and implementation of the Injury Management/Return-to-Work Program with Legal and Insurance.
- Administrative management of the Occupational Health firm designated as the Injury Management/Return-to-Work Program Administrator.
- Periodic assessment of the Injury Management/Return-to-Work Program to determine its effectiveness, identify areas for improvement, and revise the procedure and elements of the core standard.

4.6 Legal and Insurance

The Legal and Insurance Department is responsible for:

- Overall administration of the Injury Management/Return-to-Work Program.
- Managing the Worker's Compensation Insurance Program including communication with Broker, Provider and Third-Party Administrator (TPA) regarding the expectations and requirements of the Injury Management/Return-to-Work Program.
- Implementing the Injury Management/Return-to-Work Program through the TPA and Injury Management/Return-to-Work Program Administrator, and establishing a reporting system to track worker compensation cases.
- Consulting with H&S, HR, and the BG Injury Management/Return-to-Work Coordinator to facilitate effective implementation.

4.7 Human Resources/Injury Management/Return-to-Work/Return-to-Work Coordinator

The Human Resources staffs are responsible for:

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- Communicating to management, supervisors, and employees the requirement to immediately report all workplace injuries/illnesses to their supervisor and call the toll-free number to speak with the Injury Management/Return-to-Work Program Administrator occupational health nurse to receive assistance with the appropriate treatment.
- Managing the submittal of Worker's Compensation claims to our insurance provider.
- Assisting in the documentation of incidents involving a work-related injury or illness.
- Designating an Injury Management/Return-to-Work Coordinator.
- Actively participating in the implementation of the program including consulting with the employee, OL/Supervisor/GL, H&S, Legal and Insurance to ensure effective implementation.

4.8 Injury Management/Return-to-Work Program Administrator

The Injury Management/Return-to-Work Program Administrator is an Occupational Health Management Provider whose firm provides occupational health services that includes administration of Injury/Illness Early Intervention and Injury Management/Return-to-Work.

- Secure high quality medical providers who will endorse CH2M HILL policy regarding early intervention and Injury Management/Return-to-Work.
- Establish a toll-free reporting telephone line dedicated exclusively to CH2M HILL, provide an Occupational Health Nurse, 24 hours per day/7 day per week to receive employee calls and provide triage service.
- Provide direction on treatment and schedule appointments for employee to visit a selected network medical provider for treatment.
- Provide telephonic and field case management services to ensure appropriate treatment is followed, and maintaining ongoing communication with the employee, treating physicians, and insurance carrier to ensure the employee is able to safely resume work duties in a timely manner.
- Monitoring the employee's recovery status and providing feedback to their supervisor, H&S. HR, and Legal and Insurance to facilitate the employee assuming work duties in a timely manner.

5.0 Requirements

The following requirements outline the mandatory components and criteria that each business group must comply with when implementing this core standard. Each business group must implement the requirements of this Core Standard using their policies, procedures, processes, training and contracting documents.

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5.1 General Requirements

CH2M HILL employees must immediately report workplace injuries/illnesses however minor, to their supervisor in accordance with HSE-111. When non-emergency work-related injuries or illnesses occur, the injured/ill employee immediately contacts his/her supervisor and calls the Injury Management/Return-to-Work toll-free number (Refer to Attachment 1, Injury Management/Return-to-Work Flow Chart). The employee's supervisor, Operation or Group Leader must ensure the employee calls the Injury Management/Return-to-Work toll-free number or place the call for him/her. Based on the outcome of the conversation with the Injury Management/Return-to-Work Occupational Nurse, an assessment will be made for the appropriate treatment and case management of the employee's injury/illness to facilitate recovery and the ability to assume work duties in a timely manner.

5.1.1 Workplace Injuries/Illnesses Requiring Emergency Services and Notification

In the event of a life threatening injury or illnesses immediately contact emergency services for response and treatment. Reporting of the incident must follow the CH2M HILL Serious Incident Reporting Procedure, HSE-601. After emergency services has responded and provided treatment and transport for the seriously injured/ill employee, the supervisor must contact the Injury Management/Return-to-Work Program Administrator toll-free number and brief the occupational health nurse on the incident for follow-up (Refer to Attachment 2, Emergency Procedure for Injury Management/Return-to-Work).

5.2 Subcontractors

Subcontractors shall not participate in the CH2M HILL Injury Management/Return-to-Work Program.

5.3 Injury Management/Return-to-Work Program Administrator Requirements

The Occupational Health firm designated as the Injury Management/Return-to-Work Program Administrator will be responsible for providing Early Medical Intervention services that include interviewing the injured or ill employee, performing a nursing assessment and triage decision process to determine the severity and appropriate treatment, followed by providing direction to the employee and their supervisor on what the treatment protocol will entail. Based on the severity and complexity of the employee injury or illness, the Injury Program Administrator will provide ongoing case management, initially by telephone, and in situations requiring longer –term follow-up (> 60 days) provide field case management.

5.4 Worker Compensation Carrier and Third-Party Administrator Requirements

The CH2M HILL worker compensation carrier and third-party administrator will coordinate with the Injury Management/Return-to-Work Program Administrator by sharing documentation on workers compensation cases and partnering on implementing treatment plans, telephonic and/or field case management activities.

5.5 Injury Management/Return-to-Work Operational Approach by the Program Administrator

The Occupational Health firm contracted as the Injury Management/Return-to-Work Program Administrator will implement the following operational approach:

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- Establish a toll free reporting telephone line that is dedicated exclusively to CH2M HILL employees.
- When CH2M HILL employees experience a work-related injury or illness, they will use the toll-free number immediately to contact the occupational health nurse to receive an assessment of their injury/illness and follow the prescribed treatment protocol.
- In the event of a life threatening or serious injury requiring immediate medical attention, the occupational health nurse must instruct or assist the employee to immediately contact local emergency services for immediate response. After the employee's emergency medical needs have been attended to, the Injury Management/Return-to-Work Administrator occupational health nurse must be contacted by the supervisor for providing telephonic or field case management services.
- The occupational health nurse will implement triage protocol determining whether treatment is first-aid or requires referring the employee for medical treatment to a preferred provider within an established clinic network. All network clinics will have been educated on expected protocol and expectations for treatment.
- A consultation between the occupational health nurse and the attending physician will occur on the treatment protocol and any subsequent follow-up. In cases where a physician-to-physician consultation is preferred, the Medical Director of the Occupational Health firm will contact the treatment physician.
- A plan will be developed by the occupational health nurse for follow-up care and schedule ongoing examinations, or facilitate referral for rehabilitation (physical therapy, occupational therapy, vocational counseling) when needed.
- The occupational health nurse will contact the employee's supervisor, HR, and H&S, either by email, telephone or both, on the treatment plan and to coordinate appropriate work duties for the employee after initial consultation and treatment. Further, the occupational health nurse will email an electronic copy of the CH2M HILL "Authorization to Treat" form for the Supervisor to complete and forward to the medical facility/clinic within 24 hours.
- Documentation and communication of the ongoing treatment plan and progress will be provided to the employee, workers compensation TPA, Legal and Insurance, and HR, along with appropriate information to be shared with the OL/Supervisor/GL and H&S. The Occupational Health firm must expressly, through contract, be responsible for compliance with the federal Health Insurance Portability and Accountability Act (HIPAA) and state medical privacy laws when documenting and disseminating medical information.
- The treatment plan will be established with realistic goals and based on CH2M HILL policy and applicable workers compensation law.
- The occupational health nurse will continue to provide either telephonic or field case management for the employee until return to full-duty is realized or the workers compensation case is closed.

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- Reports on the status of existing cases will be provided by the Occupational Health firm to the Legal and Insurance Representative, and applicable cases to the BG H&S, HR or BG Injury Management/Return-to-Work Coordinator will be provided monthly.

5.6 H&S Requirements

Based on the extent of the employee's injury or illness and the treatment plan developed by the occupational nurse, the H&S representatives for the project and/or BG will provide employee work activity information to assist in the development of the employee treatment and recovery plan.

6.0 Training Requirements

CH2M HILL employees will receive training on key elements of the Injury Management/Return-to-Work Program as part of new employee orientation, as part of project start-up, annually, and periodically based on identified need by H&S (Enterprise, BG, Regional, Project) representatives.

7.0 Assessment Requirements

Periodic assessment of the effectiveness of the Injury Management/Return-to-Work Program will be conducted by the Enterprise H&S Programs & Services Director with the Enterprise Workers Compensation Program Manager.

8.0 Recordkeeping

Recordkeeping for the Injury Management/Return-to-Work Program will be maintained by the Occupational Health firm designated as the Injury Management/Return-to-Work Program Administrator, Workers Compensation Carrier and Third-Party Administrator, and the Enterprise Legal and Insurance Department.

9.0 Revision Log

Revision	Date	Description	File Name

Attachment 1 – CH2M HILL Injury Management/Return-to-Work Flow Chart

Attachment 2 – CH2M HILL Emergency Procedure for Injury Management/Return-to-Work

Attachment 3 – CH2M HILL Authorization to Treat Form

Attachment 4 – CH2M HILL Injury Management/Return-to-Work Poster

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Attachment 1 – CH2M HILL Injury Management/Return-to-Work Flow Chart

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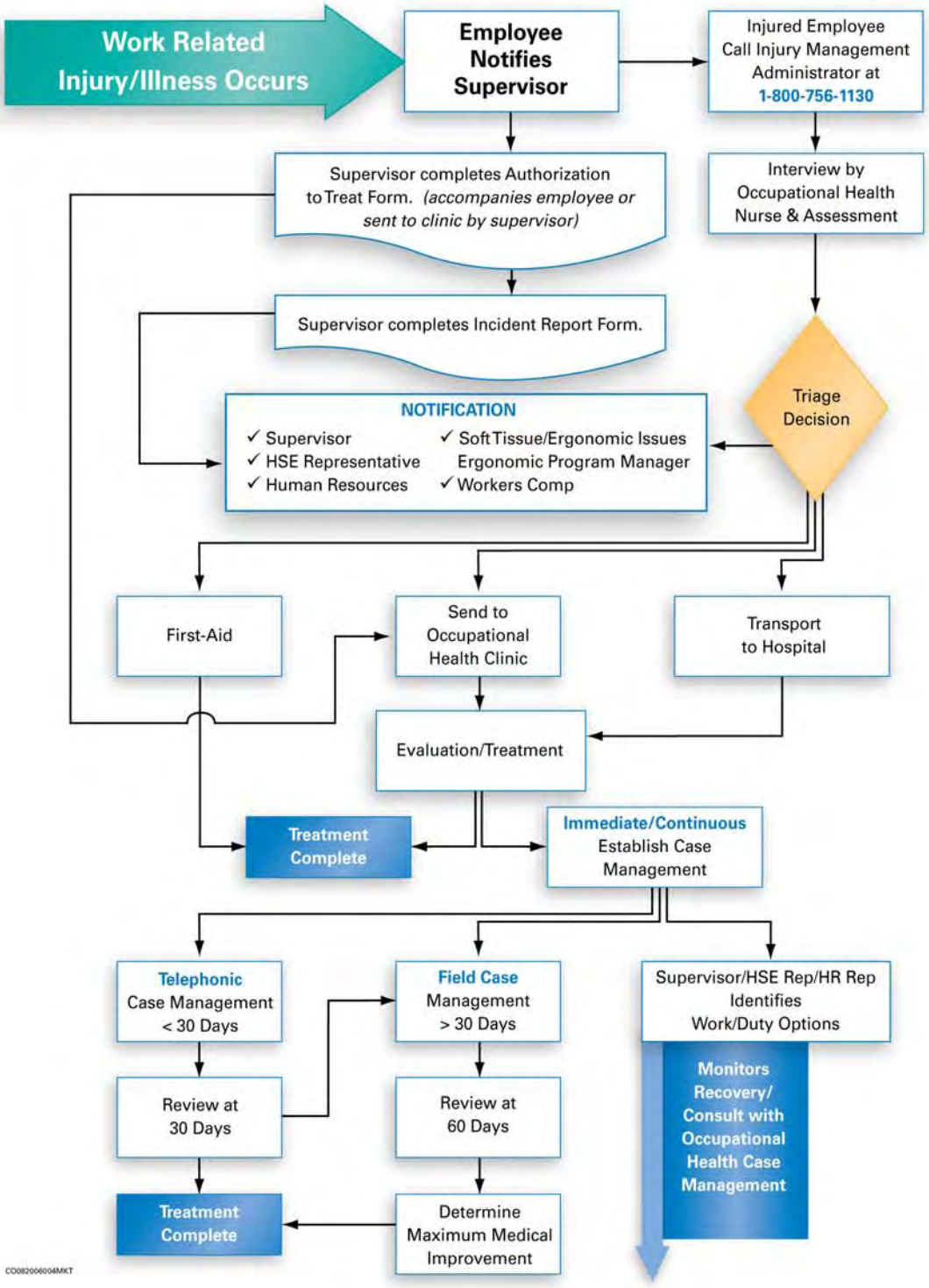
CH2M HILL Injury Management/Return-to-Work Program



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Attachment 2 – CH2M HILL Emergency Procedure for Injury Management/Return-to-Work

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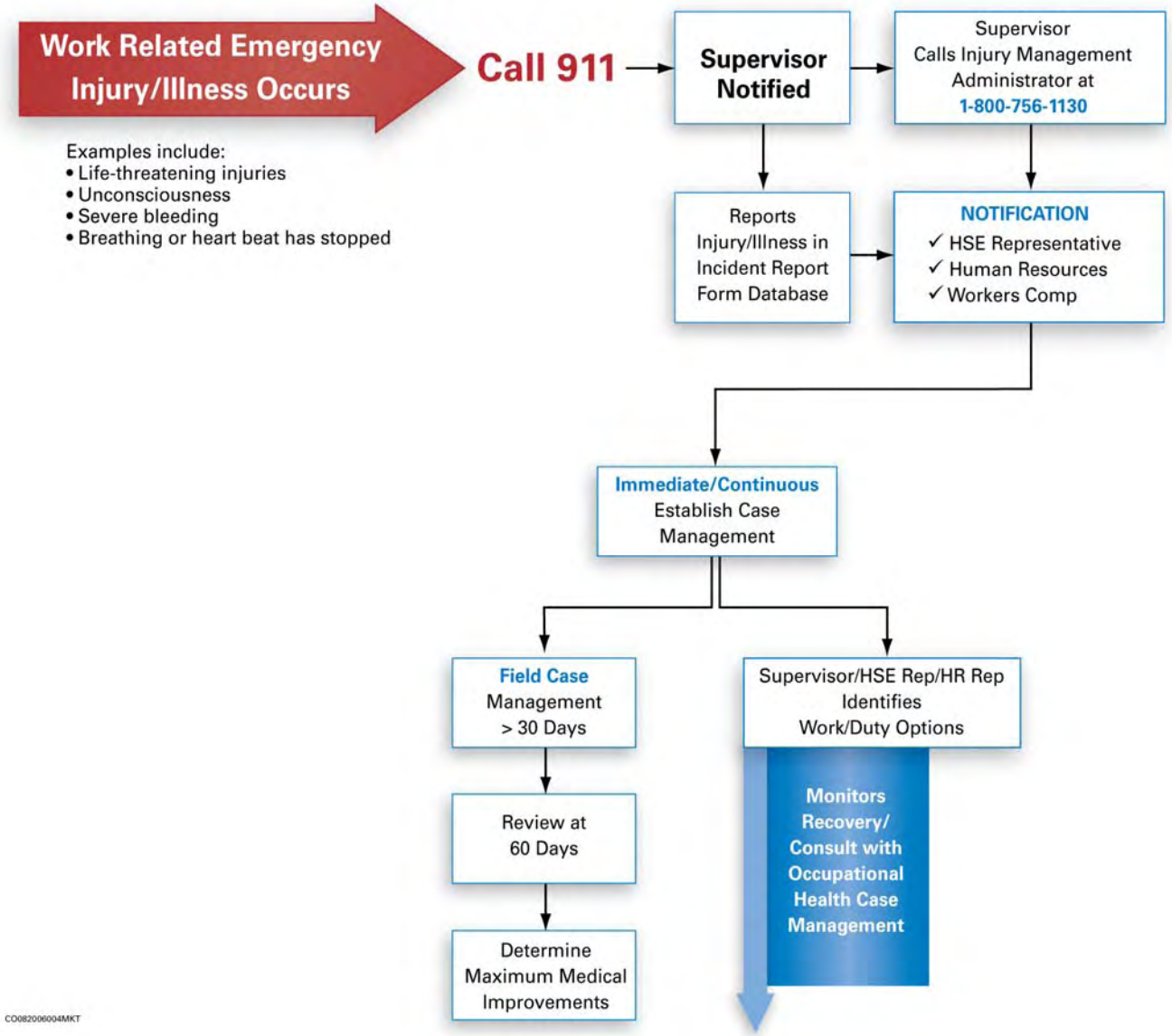
CH2M HILL Emergency Procedure
Injury Management/Return-to-Work Program



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Attachment 3 – CH2M HILL Authorization to Treat Form

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Initial Medical Treatment Form

To be completed by CH2M HILL Supervisor – Send with employee visiting medical facility or forward within 24 hours.

Employee name: _____Date of Injury:_____

Supervisor: _____ HS Representative:_____

Visit Authorized by: _____Phone #:_____

CH2M HILL Workers Compensation Administrator: Cambridge

Send Bills to: CH2M HILL
Attn: Jennifer Rindahl
P.O. Box 22508
Denver, Colorado 80222-0508

To be completed by medical provider:

Physician's name: _____ Phone #: _____

Address: _____

CH2M HILL employee: _____ has been treated for:_____

It is the policy of CH2M HILL to provide temporary modified duty whenever possible for employees with physical restrictions resulting from an occupational injury or illness.

☐ Released to full duty

☐ Released to restricted duty only (list restrictions below)

☐ Out of work until _____(date)

Please list any physical restrictions:

_____

_____

Expected duration of restricted duty? _____

CH2M HILL would like the best and most efficient care extended to all our employees. Please recommend over-the-counter (OTC) medication as a suitable alternative when medically feasible.

☐ Prescribed medication:_____

☐ Recommended OTC alternative:_____

Date of follow-up appointment:_____

Physician's signature: _____ Date: _____

Please return this form to the injured employee and FAX to Health Resources at 1-800-853-2641. If you want to discuss the employee's work restrictions, please call the person listed in the "Visit Authorized by" field

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Attachment 4 – CH2M HILL Injury Management/Return-to-Work Poster

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CH2MHILL

Experienced a work-related injury or illness?

Notify your supervisor,
then contact the company Occupational Health Nurse:

1-800-756-1130

For more information about our Injury Management / Return to Work program
visit us on the VO at Company Resources | Corporate Groups | Health, Safety, Environment & Quality

World-class safety starts with you!

HSE&Q

CH2MHILL

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ATTACHMENT 3

Investigation-Derived Waste Management Plan

Final

Master Investigation-Derived Waste Management Plan

U.S. Naval Ammunition Support Detachment (NASD) & Former Vieques Naval Training Range (VNTR) Vieques Island, Puerto Rico

Contract Task Orders 007 & 039

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

LANTDIV CLEAN III Program
Contract N62470-02-D-3052

Prepared by

CH2MHILL

4350 W. Cypress Street
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Tampa, Florida 33607-4155

May 2007

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List of Acronyms

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
EPA	Environmental Protection Agency
IDW	Investigation-Derived Waste
IDWMP	Investigation-Derived Waste Management Plan
IR	Installation Restoration
NASD	U.S. Naval Ammunition Support Detachment
NAVFAC	Naval Facility Engineering Command
PPE	Personal Protective Equipment
TCLP	Toxicity Characteristic Leaching Procedure
VNTR	Former Vieques Naval Training Range

SECTION 1

Introduction

This Master Investigation-Derived Waste Management Plan (IDWMP) has been prepared for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) investigations at the former U.S. Naval Ammunition Support Detachment (NASD) and the Former Vieques Naval Training Range (VNTR) on Vieques Island, Puerto Rico. Investigation-derived waste (IDW) includes disposable materials used in the normal course of field operations, such as health and safety equipment and sampling equipment. IDW also includes materials generated from drilling and sampling activities, such as drill cuttings, development and purge water, and decontamination water. IDW generated during field activities will require waste management and disposal in a manner that is consistent with CERCLA regulations and minimizes potential hazards to the public. This IDWMP describes the methodologies and procedures that Navy and CH2M HILL field personnel will implement to handle, manage, and dispose of IDW at the former NASD and former VNTR.

Some examples of IDW that may be generated during field activities include:

- Soil cuttings generated during drilling
- Groundwater extracted during well development and sampling procedures
- Residual soil and water generated during the decontamination of field equipment
- Non-soil solids including used personal protective equipment (PPE) and disposable sampling equipment

SECTION 2

Waste Handling

This section describes the waste handling procedures to be followed during the field activities.

2.1 Solid IDW

Solid wastes, including soils, soil cuttings, and non-soil wastes, will be produced during field investigations. These types of solid IDW are discussed below.

2.1.1 Soils and Soil Cuttings

To the extent possible, soil cuttings generated during soil borings will be returned to the boreholes. Excess soil cuttings and soil cuttings generated during well installation will be contained in 55-gallon drums, roll-off containers, or other types of approved containers. In addition, soil that accumulates in the decontamination pad from the washing of drilling equipment will be containerized. Drums will be sealed and appropriately labeled.

At the conclusion of a drilling event, drums filled with potentially contaminated soil cuttings will be temporarily stockpiled at a location designated by Navy personnel. The Navy will then verify whether or not the material in the drums is hazardous, as specified in Title 40, Code of Federal Regulations, Part 261 (40 CFR 261). Sampling of the material in the drums will be conducted in accordance with the *Disposal of Waste Fluids and Solids* SOP.

Upon the receipt of these results, CH2M HILL will formulate a preliminary assessment of any potential hazards posed by the IDW and submit waste management recommendations to the Navy. If historical site information and the characterization sampling results do not suggest the presence of listed hazardous wastes and are below Toxicity Characteristic Leaching Procedure (TCLP) and characteristic regulatory limits, CH2M HILL will recommend that the waste management subcontractor dispose of the soil at a non-hazardous waste disposal facility.

If the composite soil samples from the drums contain contaminant concentrations above the regulatory limits, or the soil is determined to be a listed hazardous waste, the drummed soil will be considered hazardous. The waste management subcontractor will ship the hazardous waste to a regulated hazardous waste landfill.

The proposed steps for accumulating, handling, and disposing of IDW soils and soil cuttings are as follows:

1. Once soil cuttings have been returned to borehole to the extent possible, shovel excess soils and soil cuttings from the boring into 55-gallon drums or roll-off containers.
2. Stockpile drums or roll-off in the area(s) designated by the Navy.
3. Upon completion of field activities, perform waste characterization sampling appropriate for the site and potential disposal facility. Collect composite samples from

the drums and submit them to an approved offsite laboratory for the analyses required by the proposed disposal facility and any additional analyses appropriate for the particular site.

4. If the waste is considered non-hazardous, upon receipt of concurrence by the Navy, the waste management subcontractor will dispose of the soil in a non-hazardous landfill.

5. If the waste is considered hazardous, upon receipt of concurrence by the Navy, the waste management subcontractor will dispose of the waste at a regulated hazardous waste landfill where it will either be treated or stockpiled. The Navy will be responsible for signing all manifests, but may delegate this authority to CH2M HILL.

2.1.2 Non-Soil Solids

Non-soil solid material (e.g., disposable sampling equipment, personal protective equipment, etc.) may be decontaminated in accordance with the Equipment Decontamination SOP and disposed of with normal trash. Otherwise, the non-soil solid material will be placed in 55-gallon steel drums. Examples of PPE to be contained include nitrile gloves, tyveks, rubber boots, and respirator cartridges. Any expendable items that are used during sampling that are not decontaminated, such as in-line water filters, C-flex tubing, and paper towels, will also be contained in drums. Drums will be sealed and labeled appropriately and managed in accordance in accordance with the results of the soil and liquid IDW characterization results.

2.2 Liquid IDW

Groundwater as IDW will be produced during monitoring well development and groundwater purging and sampling. Groundwater will be contained in 55-gallon drums, or other types of approved containers. In addition, water generated during decontamination processes and excessive liquids separated from soil cuttings will be added to drums containing groundwater IDW. Drums will be sealed and appropriately labeled.

If groundwater is extracted from a background location or from where previous investigations have confirmed that contamination does not exist at the site, the groundwater will be discharged at grade in an area that will not affect the well being sampled or adjacent sampling locations.

At the conclusion of field activities, drums containing liquid IDW will be temporarily stockpiled at a location designated by Navy personnel. The Navy will then verify whether or not the material in the drums is hazardous, as specified in Title 40, Code of Federal Regulations, Part 261 (40 CFR 261). Sampling of the material in the drums will be conducted in accordance with the *Disposal of Waste Fluids and Solids* SOP.

Upon the receipt of these results, CH2M HILL will formulate a preliminary assessment of any potential hazards posed by the IDW and submit waste management recommendations to the Navy. If historical site information and the characterization sampling results do not suggest the presence of listed hazardous wastes and are below Toxicity Characteristic Leaching Procedure (TCLP) and characteristic regulatory limits, CH2M HILL will

recommend that the waste management subcontractor dispose of the groundwater at a non-hazardous waste disposal facility.

If the groundwater sampling results indicate contaminant concentrations above regulatory limits, or the groundwater is determined to be a listed hazardous waste, the drummed water will be considered hazardous. The waste management subcontractor will ship the liquid IDW to a regulated hazardous wastewater treatment facility.

The proposed steps for accumulating, handling, and disposing of IDW liquids are as follows:

1. If previous investigations have either confirmed or suggested the existence of contamination at the site, or if investigations have not yet been conducted at the site, groundwater will be contained in 55-gallon drums or other suitable containers. In addition, water generated during decontamination processes and excessive liquids that separated from soil cuttings will be added to drums containing groundwater IDW. The drums will be sealed and appropriately labeled.

2. If groundwater is extracted from a background location that is not associated with a site or from where previous investigations have confirmed that soil and groundwater contamination does not exist where the discharge will take place at a site, groundwater will be discharged to the ground surface in the vicinity of the well being sampled."

3 Stockpile drums in the area(s) designated by the Navy.

4 Upon completion of field activities, perform waste characterization sampling appropriate for the site and potential disposal facility. Collect composite samples from the drums and submit them to an approved offsite laboratory for the analyses required by the proposed disposal facility and any additional analyses appropriate for the particular site.

5 If the waste is considered non-hazardous, upon receipt of concurrence by the Navy, the waste management subcontractor will haul the liquid IDW to the industrial wastewater treatment facility or remove it from the island and deliver to a certified industrial landfill.

6 If the waste is considered hazardous, upon receipt of concurrence by the Navy, the waste management subcontractor will haul the liquid IDW to a regulated hazardous wastewater treatment facility where it will be treated until it meets standards for disposal as appropriate. The Navy will be responsible for signing all manifests, but may delegate this authority to CH2M HILL.

SECTION 3

General Considerations

General considerations pertinent to the generation and handling of IDW are documented in this section. These include the minimization of waste volume, drum labeling and storage, and disposal and manifesting protocol.

3.1 Minimization of IDW Volume

To minimize the volume of IDW soil generated during drilling of soil borings (not for well installation), cuttings will be used to backfill the boreholes from which they were removed to the maximum extent possible. Excess cuttings will then be contained as IDW.

Soil generated during trenching will be minimized by backfilling the trench pits with soil that was extracted from them during the excavation process. Excess soil will be graded with a backhoe in the vicinity of the filled trench.

To minimize the volume of IDW groundwater, only the minimum volume of discharge purge water necessary to stabilize the pH, conductivity, temperature, and other parameters, will be purged from wells. In addition, groundwater will not be contained if extracted from a background location not associated with a site or from where previous investigations have confirmed that contamination does not exist in soil and groundwater at the site.

3.2 Labeling Drums

Each 55-gallon drum containing IDW will be labeled with the following information: the type of IDW (groundwater, soil, PPE, etc.); the date the drum was filled and sealed; and a brief warning not to handle the drum or its contents without permission from the generator. The following is an example of the information to be included on each drum:

Investigation Derived Wastes
Purge Water from Site 2 - MW1
4-8-96
Do Not Handle - Analysis Pending
Ms. Madeline Rivera, Naval Activity Puerto Rico (NAVFAC ATLANTIC field office)

3.3 Storing IDW

Drums containing IDW will be stockpiled at an onsite location designated by Navy personnel, pending the receipt of characterization and sampling analytical results. The drums will remain at this location until the particular investigation is completed and the waste characterization results received and discussed with the Navy. Following Navy concurrence upon the recommended disposal option, the IDW will be removed by the waste management subcontractor.

ATTACHMENT 4

Data Management Plan

Final

Data Management Plan

Former U.S. Naval Ammunition Support Detachment (NASD) and Former Vieques Naval Training Range (VNTR)
Vieques Island, Puerto Rico

Contract Task Orders 007 & 039

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

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Prepared by

CH2MHILL

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List of Acronyms

AOC	Area of Concern
CAS	Chemical Abstracts Service
CD	Compact Disk
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Chain of Custody
DMC	Data Management Coordinator
DMP	Data Management Plan
EDD	Electronic data deliverable
EIS	Environmental Information Specialist
EM	Environmental Manager
ESRI	Environmental Systems Research Institute
EVS	Environmental Visualization System
EIMS	Environmental Information Management System
FDET	Field Data Entry Tool
FTL	Field Team Leader
FTP	File Transfer Protocol
GIS	Geographic Information System
GPS	Global positioning satellite
IS	Information Systems
MS	Microsoft
NASD	Naval Ammunitions Support Detachment
NAVFAC	Naval Facilities Engineering Command
NIRIS	Naval Installation Restoration Information Solution

PM	Project Manager
QA/QC	Quality Assurance/Quality Control
QAO	Quality Assurance Officer
RDMS	Relational database management system
SDG	Sample Delivery Group
SQL	Structured Query Language
SWMU	Solid Waste Management Unit
TSSDS	Tri-Service Spatial Data Standard
VB	Visual Basic
VNTR	Vieques Naval Training Range

SECTION 1

Introduction

This Data Management Plan (DMP) summarizes the data management protocol that will be utilized to support environmental investigations for the U.S. Naval Ammunition Support Detachment (NASD) and the former Vieques Naval Training Range (VNTR) on Vieques Island, Puerto Rico on behalf of the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command (NAVFAC) as part of Navy Contract N62470-95-D-6007, Comprehensive Long-Term Environmental Action Navy (CLEAN).

The DMP is broadly applicable to the management and dissemination of data generated during environmental investigations. It is intended to be a living document and will be amended or revised, as necessary, to accommodate changes in the scope of environmental investigation or data management requirements.

During field investigations at Vieques, CH2M HILL will collect a variety of environmental information that will support data analysis, reporting, and presentation. These activities will support site characterization, determination of risk to human health and the environment, and subsequent decisions for remedial action, as appropriate. To ensure quality assurance/ quality control (QA/QC) and meet current regulatory requirements, an audit trail of the information flow must be established. Each step in the data management process (data collection, storage, and analysis) must be adequately planned, executed, and documented.

1.1 EIMS Overview

The Envrionmental Information Management System (EIMS), developed to service the Navy CLEAN Installation Restoration Program, is an enterprise-wide system capable of receiving, organizing, storing, and distributing large volumes of complex environmental data in multiple formats to support the environmental characterization, restoration, and monitoring activities being performed during the Navy's field investigations. The system is composed of a central data repository, a series of data entry tools, analysis and visualization tools, and various web interfaces serving as a mode of data distribution. The system is designed in components to allow for sectional use of the system depending upon project needs.

SECTION 2

Data Management Team Organization

The CH2M HILL data management team will work together to execute the DMP and ensure that the data management scope and objectives for each project are realized. The team model presented here comprises key technology staff including Environmental, Data, Geographic Information System (GIS), and Web specialists and associated technical resources. The functional responsibilities of the EIMS team are described below. The responsibilities are identified by titles but not necessarily individual staff positions.

The Environmental Manager (EM) and the Project Manager (PM) are responsible for preparing the work plan, schedule, milestones, and coordinating efforts with the client. The EM/PM may rely on other technical resources to guide the EIMS technology-driven aspects of their projects. The PM is also responsible for ensuring data quality and performs (or delegates) data QA/QC at various times during the data management process.

The Environmental Information Specialist (EIS) assigned to the project team is responsible for the coordination of new or existing data generated by field activities or provided by laboratory analyses. The EIS coordinates contracted analytical and data validation services, ensures that analytical data are complete and consistent, enters field data results into the Field Data Entry Tool (FDET), and assists the Database Manager in resolving any data ambiguities. The EIS will conduct verification activities following receipt of electronic data and participate in QA/QC activities to resolve inconsistencies as necessary. The EIS acts as a liaison between the Database Manager, the PM, and the Project Chemist.

The Field Team Leaders (FTLs) help prepare the work plan and implement the plan in the field. FTLs assign staff members to sampling teams; assign responsibilities to team members; prepare for and coordinate sampling activities; oversee the collection, recording, and documentation of the field data; and ensure that chain-of-custody forms are completed correctly.

The Project Chemist prepares the laboratory and data validation subcontracts, ensures that the electronic data deliverable was provided in accordance with the contract, assists the EIS in communicating with laboratories and data validators as needed, assists in designating Chemical Abstracts Service (CAS) Numbers to new analytes, and maintains the regulatory criteria in the database.

The Database Manager has overall responsibility for the design, operation, and maintenance of the environmental database. The Database Manager is reponsible for the implementation and evaluation of standard operating procedures to ensure integrity of the database.

The Program Data Management Coordinator (DMC) is responsible for the CH2M HILL data management process at all Navy bases. The DMC manages and tracks data management personnel schedules and deliverables for the Navy program; coordinates database modification efforts with the Database Manager; assists with the design, development, and implementation of standard data entry and data retrieval tools; and leads the data management continuous process improvement investigation.

GIS specialists prepare maps to illustrate geographical features and area characteristics, such as topography, land use, ground cover, roads, buildings, and hydrography; digitize existing maps; edit and format spatial data; combine with attribute data from the project database; prepare topographic overlays; and display results through graphic outputs that include maps, color displays, and tabular information. Web applications specialists prepare reports for display on the World Wide Web. The Web specialist also is responsible for the development and maintenance of web-based reporting tools, calendars, and other tools for the efficient completion of the project.

The information systems (IS) Program Lead serves as the primary point of contact for the Navy regarding IS issues, coordinates resource requirements with regional the IS Staffing Lead, and provides direction and management to the Database Manager, DMC, and IS Operations Lead.

PMs execute or delegate execution of various steps during work plan development, subcontractor preparation, fieldwork activities, and report preparation to ensure that QA/QC requirements for data management are met. PMs consult the project chemist during laboratory and data validation subcontract preparation to review the subcontracts; organize a kick-off meeting prior to field investigations with field staff and EIS; distribute Project Instructions to the field staff and EIS; and review lines of communication between field staff, EIS, and the subcontractors.

SECTION 3

Data Management

This section describes the specific processes that will be used by the Data Management team to capture, perform QA/QC reviews, manage/track and report the data associated with Vieques. The data management process begins with data collection and culminates with the filing and storage of hardcopy and electronic data sets.

Data management for Vieques will involve the use of a computerized environmental data management system. The data management system will comprise two main elements: the Environmental Database—an organized and structured storehouse of data; and the data management procedures—the steps involved in the data management process.

The Environmental Database provides a centralized, secure location for environmental data of known quality that can be shared and used for multiple purposes. The data management system will assist with the information flow for the project by providing a means of cataloging, organizing, archiving, and accessing information. The data management system alone will not analyze or graphically display the data; its function is to provide an "electronic filing cabinet" for project environmental data. These data may then be used with other software for analysis, plotting, and presentation.

3.1 The Environmental Database

In support of the Navy CLEAN Program, CH2M HILL has designed and implemented a relational database management system (RDMS) that will support the storage, analysis, display, and reporting of environmental analytical data. The actual database, referred to as "EnDat" (or Environmental Database), is built using Oracle Enterprise Server v8.0.5.

The purpose of EnDat is to record information about sampling events and the analytical results associated with those events. This includes capturing where, when, and how certain information was collected, including, as appropriate, the geological and physical attributes of the place and process of collection. It also captures information on where, when, and how this information was analyzed and what results the analysis provided. EnDat provides a centralized, secure location for environmental data storage that can be shared and used for multiple purposes.

There are five primary tables in the database that store the environmental data. These are the Site, Station, Sample, Sample Method, and Lab Result tables. The rest of the database tables are either dependent tables (i.e., store finer details related to the data in the primary tables) or look-up tables (i.e., store valid values to provide input to the primary tables).

The analytical data from the laboratory are transferred electronically in an electronic data deliverable (EDD). The laboratory EDD is verified and loaded into EnDat with help from queries contained within the Microsoft (MS) Access-based Data Loader tool. This tool automates the data load so the task is performed in a time-efficient manner.

CH2M HILL and the Navy are working toward transferring analytical and geographical data into the Navy database NIRIS (Naval Installation Restoration Information Solution). NIRIS will eventually standardize and house all IR data; EnDat and NIRIS will be maintained concurrently for the near future.

3.2 Data Management Procedures

Data management procedures are a crucial part of the data management system. Established procedures are necessary to ensure consistency among data sets, internal database integrity, and a verified, usable data set. The data management tasks and procedures that will be performed for all facility data before these data are entered are:

- Creating a Unique Sample Naming Convention
- Developing Laboratory EDD Format
- Sample Tracking
- Field Data Entry
- Electronic Data Verification

3.2.1 Nomenclature

This subsection presents the station and sample naming convention that will be used at Vieques.

3.2.1.1 Unique Station Names

Field station data are information assigned to a physical location in the field at which some type of sample is collected. For example, a monitoring well that has been installed will require a name that will uniquely identify it with respect to other monitoring wells or other types of sample locations. The station name provides a key in a database to which any samples collected from that location can be linked to form a relational database structure.

Before beginning field work, the FTL will review the sampling protocol and coordinate a list of unique station identification names, or station IDs, with the EIS. The FTL will be responsible for enforcing the use of the standardized station numbering system during all field activities.

Each station will be uniquely identified by an alphanumeric code that will describe the station's attributes. These attributes are facility, site type, site number, station type, sequential station number, and possibly an additional qualifier. The naming schemes that will be used to identify field stations are documented in Table 3-1 for East Vieques (former VNTR) and Table 3-2 for West Vieques (former NASD). It should be noted that the naming schemes shown in the table are theoretical and potential; they do not imply that all sites will necessarily be sampled nor all station types included in any particular investigation.

Definition of identifiers

Site Number

The site number is assigned to a defined area of Vieques where environmental investigations will be performed. Site numbers are associated with particular environmental programs as defined by the site type. The site numbers are also formally associated with established and named areas of Vieques such as Area of Concern (AOC) B and Solid Waste Management Unit (SWMU) 1. Background and reference sites do not have site numbers associated with them.

Station

Each sample station of a given station type will be assigned a unique identification number by site. For example, on a site where there are three sample station types, there will be three station number sets starting at 01 or 001 for each station type. If there are existing sample stations for a given station type on a site, new stations will be given the next available numbers sequentially for that site. The station number must always be defined with two or three digits depending on the possibility of there being less than or greater than 100 sample stations of the same station type.

Qualifiers – (Depth Flag, Duplicate Samples, Background Samples) [optional]

Depth flags will only be used for wells. This includes groundwater monitoring wells, piezometers, recovery wells, and potable supply wells

Samples can be flagged by the letters "S" (shallow), "D" (deep), or "K" (background) depending on the screened interval and type of sample.

3.2.1.2 Unique Sample Names

Field sample data are information assigned to a physical piece of material collected in the field for which some type of analysis will be run. Before collecting samples, the FTL will review the proposed sampling protocol and coordinate a list of unique sample identification names, or sample IDs, with the EIS.

A standardized numbering system will be used to identify all samples collected during water, soil, and sediment sampling activities. The numbering system will provide a tracking procedure to ensure accurate data retrieval of all samples collected. A listing of the sample identification numbers will be maintained by the FTL, who will be responsible for enforcing the use of the standardized numbering system during all sampling activities. Sample identification for all samples collected during the investigations will use the format described below.

TABLE 3-1
East Vieques Field Station Scheme

First Segment	Second Segment	
Facility, Station Type, Site Number	**Station Type**	**Station Number, Qualifier**
AANNN	**AA**	**NNNA**
Notes: "A"= alphabetic "N"= numeric		

Facility:

E = East Vieques

Station Type:

S = Site
PI = Photo Identified Site
W = SWMU
A = AOC
PA = Possible AOC
BG = Non-site-specific basewide samples

Site Number:

01 = SWMU 01
02 = SWMU 02
04 = SWMU 04
05 = SWMU 05
06 = SWMU 06
07 = SWMU 07
08 = SWMU 08
10 = SWMU 10
12 = SWMU 12

A = AOC A
F = AOC F
G = AOC G

1 = PI-1
2 = PI-2
3 = PI-3
4 = PI-4
5 = PI-5
6 = PI-6
7 = PI-7
8 = PI-8
9 = PI-9
10 = PI-10
11 = PI-11
12 = PI-12
13 = PI-13
14 = PI-14
15 = PI-15
16 = PI-16
17 = PI-17
18 = PI-18
19 = PI-19
20 = PI-20
21 = PI-21
22 = PI-22
23 = PI-23

Site Number:

I = PAOC-I
J = PAOC-J
K = PAOC-K
L = PAOC-L
M = PAOC-M
N = PAOC-N
O = PAOC-O
P = PAOC-P
Q = PAOC-Q
R = PAOC-R
S = PAOC-S
T = PAOC-T
U = PAOC-U
V = PAOC-V
W = PAOC-W
X = PAOC-X
Y = PAOC-Y
Z = PAOC-Z
AA - PAOC-AA
BB = PAOC-BB
CC = PAOC-CC

Station Type:

DP = Direct Push Sample Location
EW - Extraction Well
GB = Geotechnical Boring
MW = Monitoring Well
PW = Purge Well
PZ = Piezometer
RW = Residential Well
SB = Soil Boring
SD = Sediment Sample Location
SG = Soil gas
SO = Soil Sample Location
ST = Stormwater
STG = Staff Gauge
SW = Surface Water Sample Location
TI = Tissue Sample
TW = Temporary Well

Station Number:

Sequential Station Number

Qualifier:

S = Shallow
D = Deep
K = Background

TABLE 3-2
West Vieques Field Station Scheme

First Segment	Second Segment	
Facility, Station Type, Site Number	**Station Type**	**Station Number, Qualifier**
AANNN	**AA**	**NNNA**

Notes: "A"= alphabetic "N"= numeric

Facility:

W = West Vieques

Station Type:

S = Site
PI = Photo Identified Site
W = SWMU
A = AOC
PA = Potential AOC
BG = Non-site-specific basewide samples

Site Number:

04 = SWMU 04
05 = SWMU 05
06 = SWMU 06
07 = SWMU 07
10 = SWMU 10
14 = SWMU 14
15 = SWMU 15

B = AOC B
C = AOC C
E = AOC E
F = AOC F
H = AOC H
I = AOC I
J = AOC J
K = AOC K
L = AOC L
R = AOC R

Station Type:

DP = Direct Push Sample Location
EW - Extraction Well
GB = Geotechnical Boring
MW = Monitoring Well
PW = Purge Well
PZ = Piezometer
RW = Residential Well
SB = Soil Boring
SD = Sediment Sample Location
SG = Soil gas
SO = Soil Sample Location
ST = Stormwater
STG = Staff Gauge
SW = Surface Water Sample Location
TI = Tissue Sample
TW = Temporary Well

Station Number:

Sequential Station Number

Qualifier:

S = Shallow
D = Deep
K = Background

Each sample will be uniquely identified by an alphanumeric code that will describe the sample's attributes. These attributes are facility, site type, site number, sample type, sample number, and possibly some additional qualifiers. Each unique set of sample attributes will be assigned a unique sample name. The naming schemes that will be used to identify field samples are documented in Tables 3-3 for East Vieques and Table 3-4 for West Vieques. It should be noted that the naming schemes shown in the tables are theoretical and potential; they do not imply that all sites will necessarily be sampled nor all station types included in any particular investigation.

Definition of identifiers

Sample Round

The sample round # is a combination of the last 2 digits of the year in which the sample was collected and a letter corresponding to the quarter of the year during which the sample was collected.

05B = 2005, second quarter (April through June)

In the event that multiple samples are collected from the same sample location during a quarter, single-digits 1 - 9 may follow the quarter identifier:

06A2 = 2006, first quarter (January through March), second sample from this particular location during this quarter.

The quarter designations are as follows:

A = 1st Quarter, January through March
B = 2nd Quarter, April through June
C = 3rd Quarter, July through September
D = 4th Quarter, October through December

Sample ID Examples

Example 1: The soil sample ID **WW01-SB04-02-06B** indicates the following information:

WWW01-SB04-02-06B => West Vieques
W**WW01-**SB04-02-06B => SWMU 4
WW01-**SB**04-02-06B => Subsurface soil sample
WW01-SB**04**-02-06B => Soil location 2
WW01-SB04-**02**-06B => Project-specific depth soil sample was collected from
WW01-SB04-02-**06B** => Sample collected in the 2nd quarter of 2006

Example 2: The groundwater sample ID **WAB-MW04-05D** is for a groundwater sample taken from a monitoring well:

WAB-MW04-05D => West Vieques
W**AB-**MW04-05D => AOC B
WAB-**MW**04-05D => Groundwater sample from a well
WAB-MW**04**-05D => Monitoring well number 4

WAB-MW04-**05D** => Sample collected in the 4th quarter of 2005

Example 3: The insitu groundwater sample ID **EPAJ-GP07-04-06A** is defined as follows:

EPAJ-GP07-04-06A	=>	East Vieques
E**PAJ**-GP07-04-06A	=>	Potential Area of Concern J (PAOC J)
EPAJ-**GP**07-04-06A	=>	Geoprobe sample
EPAJ-GP**07**-04-06A	=>	Insitu sample number 7
EPAJ-GP07-**04**-06A	=>	Project-specific depth sample was collected from
EPAJ-GP07-04-**06A**	=>	Sample collected in the 1st quarter of 2006

Example 4: The duplicate sediment sample ID **EPI23-SD103P-06A** is defined as follows:

EPI23-SD103P-06A	=>	East Vieques
E**PI23**-SD103P-06A	=>	Photo Identified Site 23
EPI23-**SD**103P-06A	=>	Sediment sample
EPI23-SD**103**P-06A	=>	Sediment sample station number 103
EPI23-SD103**P**-06A	=>	Duplicate sample of EPI23-SD103-06A
EPI23-SD103P-**06A**	=>	Sample collected in the 1st quarter of 2006

Numbering Format for QA/QC Samples

QA/QC samples will follow the following pattern:

Station # -AANNNNNN

Where the first two digits after the hyphen will be alphabetic, by QA/QC type, and the following six digits will designate the date on which the samples were collected. Eligible QA/QC sample types are:

FB	Field blank
TB	Trip blank
EB	Equipment blank

The date designation will always have six digits in a MMDDYY format. Examples of this numbering approach for QA/QC samples are:

FB100105	Field blank collected on October 1, 2005
TB072905	Trip blank collected on July 29, 2005
EB080106	Equipment blank collected on August 1, 2006

3.2.2 Laboratory Electronic Data Deliverable Format

An offsite analytical laboratory will analyze the samples and tabulate results in an electronic format specified by CH2M HILL. An example of this format, known as the EDD, is documented in Table 3-5; the exact specifications will be determined between CH2M HILL and the laboratory at the beginning of the project. In addition to the electronic deliverable, the lab will also provide a hard copy data package to the third-party validator and a compact disc (CD) of the data package to the project chemist. After the EDD from the lab has been reviewed by the EIS, it is sent to the data validator. The data validator will add data validation qualifiers to the EDD, as appropriate, and provide the validated file to the EIS.

3.2.3 Sample Tracking

The sample tracking procedure has been designed to provide the field teams, project team, program management, and the data management team with a mechanism to quickly determine the status and location of each set of analytical samples. The tracking sheet is created by the EIS to locate data and assess the status and invoicing of the project.

The sample tracking sheet contains at a minimum the Sample ID, sample matrix, date the sample was collected, date the sample was shipped, and a list of the analyses requested. The EIS creates a preliminary sample tracking sheet using the sampling instructions prior to the sampling event. As chain-of-custody forms are returned, the EIS fills in the sample tracking sheet highlighting the samples and analyses that have been collected. This tool is very useful in verifying that the sampling event is completed as planned.

The sample tracking sheet also tracks the progress of the laboratory sample delivery group and contains the sample delivery group (SDG) number, laboratory name, validator name, date the data package is due from the laboratory, date the data package and EDD are received, date the data package was sent to the data validator, date the data validation package is due, date the data validation package and updated EDD are received, laboratory invoice number, date the laboratory invoice was paid, validation invoice number, date validation invoice was paid, and date the EDD was sent to the database manger for loading into the Environmental Database. The EIS monitors the proposed due dates and contacts the laboratory if results are not received by the appropriate date.

3.2.4 Field Data Entry

During field investigations, photocopies of the logbook pages and chain-of-custody forms will be sent to the EIS at a minimum of once per week. The EIS will use these artifacts to complete the event's FDET. The FDET stores all of the station and sample information and the field parameter results. The data entry screen in the FDET is shown in Figure 3-1.

The FDET tool helps all the project personnel by facilitating data entry, providing quality control of data, and reducing time of analysis by the database team while performing the final integration effort before data are uploaded into EnDat.

The FDET tool is a desktop-based application developed using MS Access 2003. It consists of a form for data entry of stations, samples, and field results and ten summary reports that allow easy QA/QC and review of new or updated data entered in the system. The data entry form contains drop-down lists where the user is limited to the established list of valid values, thus reducing data entry errors.

Once the new sample information is recorded in the FDET, the EIS outputs the summary reports to perform a quality control check of the stations, samples, and field results. These reports can be given to the PM to approve. If the information is deemed acceptable, the EIS submits the FDET to the Database Manager for upload into EnDat. The FDET must be entered into EnDat prior to the analytical data load.

Figure 3-2 documents the site, station, and sample tables and their relationships. These tables are used in the FDET and EnDat. Detailed structure documents are also available that identify primary tables, keys, field names, and properties.

TABLE 3-3
East Vieques Field Sampling Naming Scheme

First Segment			**Second Segment**			**Third Segment**
Facility	Site Type	Site Number	Sample Type	Sample Number	Qualifier	Additional Qualifiers (sample depth, sampling round, etc.)
A	*AA*	*NNN*	*AA*	*NNN or NNNN*	*A*	*As applicable*
Notes: "A" = alphabetic "N" = numeric						

Facility:
E = East Vieques

Location Type:
PI = Photo Identified site
W = SWMU
BG = Non-site-specific background samples
A = Area Of Concern (AOC)
PA = Possible AOC

Location Number

01 = SWMU 01
02 = SWMU 02
04 = SWMU 04
05 = SWMU 05
06 = SWMU 06
07 = SWMU 07
08 = SWMU 08
10 = SWMU 10
12 = SWMU 12
A = AOC A
F = AOC F
G = AOC G
1 = PI-1
2 = PI-2
3 = PI-3
4 = PI-4
5 = PI-5
6 = PI-6
7 = PI-7
8 = PI-8
9 = PI-9
10 = PI-10
11 = PI-11
12 = PI-12
13 = PI-13
14 = PI-14
15 = PI-15
16 = PI-16
17 = PI-17
18 = PI-18
19 = PI-19
20 = PI-20
21 = PI-21
22 = PI-22
23 = PI-23
I = PAOC-I
J = PAOC-J
K = PAOC-K
L = PAOC-L
M = PAOC-M
N = PAOC-N
O = PAOC- O
P = PAOC-P
Q = PAOC- Q
R = PAOC-R
S = PAOC-S
T = PAOC-T
U = PAOC-U
V = PAOC-V
W = PAOC-W
X = PAOC-X
Y = PAOC-Y
Z = PAOC-Z
AA - PAOC-AA
BB = PAOC-BB
CC = PAOC-CC

Sample Type:
DP = Direct Push Groundwater Sample
MW = Monitoring Well
RW = Recovery Well
SB = Subsurface Soil
SD = Sediment
SG = Soil Gas
SS = Surface Soil
ST = Stormwater
SW = Surface Water
TI = Tissue
TW = Temporary Well
TB = Trip Blank
FB = Field Blank
EB = Equipment Blank

Sample Number:
1. Station Samples (*NN*)
   Well number
2. QC Samples (*NNNNNN*)
   MMDDYY : month, day, and year of sampling event

Qualifier:
S = Shallow Well
D = Deep Well
P = Duplicate sample
T = Screened Across Shallow and Deep

Additional Qualifiers:
1. QC Samples (*NN*)
   Sequential QC sample number for that day (if needed)

   Example:
   EW01-MW03-05D
   Groundwater sample collected from monitoring well 3 at SWMU 01 in the fourth quarter of 2005.

   A = 1st Quarter
   B = 2nd Quarter
   C = 3rd Quarter
   D = 4th Quarter

   EW01-EB011306
   Equipment blank collected on January 13, 2006 during sampling at SWMU 01.

Notes:

Segments are separated by a dash.
Qualifiers are as applicable only

TABLE 3-4
West Vieques Field Sampling Naming Scheme

First Segment			Second Segment			Third Segment
Facility	Site Type	Site Number	Sample Type	Sample Number	Qualifier	Additional Qualifiers (sample depth, sampling round, etc.)
A	*AA*	*NNN*	*AA*	*NNN or NNNN*	*A*	*As applicable*
Notes: "A" = alphabetic "N" = numeric						

Facility:
W = West Vieques

Location Type:
PI = Photo Identified site
W = SWMU
BG = Non-site-specific background samples
A = Area Of Concern (AOC)
PA = Possible AOC

Location Number
04 = SWMU 04
05 = SWMU 05
06 = SWMU 06
07 = SWMU 07
10 = SWMU 10
14 = SWMU 14
15 = SWMU 15

B = AOC B
C = AOC C
E = AOC E
F = AOC F
H = AOC H
I = AOC I
J = AOC J
K = AOC K
L = AOC L
R = AOC R

Sample Type:
DP = Direct Push Groundwater Sample
MW = Monitoring Well
RW = Recovery Well
SB = Subsurface Soil
SD = Sediment
SG = Soil Gas
SS = Surface Soil
ST = Stormwater
SW = Surface Water
TI = Tissue
TW = Temporary Well
TB = Trip Blank
FB = Field Blank
EB = Equipment Blank

Sample Number:
3. Station Samples (*NN*)
   Well number
4. QC Samples (*NNNNNN*)
   MMDDYY : month, day, and year of sampling event

Qualifier:
S = Shallow Well
D = Deep Well
P = Duplicate sample
T = Screened Across Shallow and Deep

Additional Qualifiers:
2. QC Samples (*NN*)
   Sequential QC sample number for that day (if needed)

   Example:
   WAB-MW03-06A
   Groundwater samples collected from monitoring well 3 at AOC B in the first quarter of 2006.

   A = 1st Quarter
   B = 2nd Quarter
   C = 3rd Quarter
   D = 4th Quarter

   WAB-EB011306
   Equipment blank collected on January 13, 2006 during sampling at AOC B.

Notes:

Segments are separated by a dash.
Qualifiers are as applicable only

TABLE 3-5
EDD Format Example

Field Name	Field Type	Req'd	Description
Sample_ID	A25	R	CH2M HILL sample ID (taken from the chain-of-custody)
Analysis_Group	A9	R	The analysis performed on the sample.
Date_Collected	D10	R	The date the sample was collected (from the chain-of-custody).
Time_Collected	T5	R	Time of sample collection (from the chain of custody) - 24h clock.
Date_Received	D10	R	The date the sample was received in the lab.
Date_Extracted	D10	RA	Extraction or preparation date.
Date_Analyzed	D10	R	The date the sample was analyzed.
Lab_Sample_ID	A15	R	The laboratory sample ID.
Dilution_Factor	N5	RA	The dilution factor used.
SDG_Number	A15	R	Laboratory code for the group of samples in a data deliverable package.
Chem_Code	A12	R	The ERPIMS parameter code.
Chem_Name	A45	R	The compound being analyzed.
CAS_Number	A6-A2-A1	R	CAS Number (Note dashes).
Ana_Value	N11	R	The analytical result.
Lab_Qual	A5	RA	The lab qualifiers, if any (e.g., U, UJ, B).
DV_Qual	A5		Left blank for data validation qualifiers
Units	A15	R	The unit of the result (e.g., mg/L).
Detect_Limit	N11	R	The minimum available sample-specific detection limit for the compound.
MDL	N11	NR	Method detection limit.
Prep_Method	A15	R	Analytical method used to analyze the sample fraction. Use ERPIMS codes.
Analysis_Method	A15	R	Analytical method used to analyze the sample fraction. Use ERPIMS codes.
Sample_Type	A15	NR	Duplicate, MS, etc. See valid value list.
Result_Type	A15	R	The laboratory QC type (e.g., SURR, IS).
Analysis_Anomaly	A15	R	NO=Normal; DL=diluted; RE: reextracted; RA= reanalyzed
PCT_Moisture	N5	RA	Percent moisture for soil samples; not applicable for aqueous samples.
Basis	A3	R	Concentrations are reported on a wet or dry weight basis. Use ERPIMS codes.
Batch	A5	NR	Laboratory code for the batch of samples included in a given run.
Method_Blank	A15	R	Laboratory name for the method blank associated with the analysis.
Lab_Code	A10	R	The ERPIMS code for the laboratory.
Comment	A 30	NR	For laboratory to note exceptions.

Notes:

R – required field
NR – not required
RA – Required as appropriate

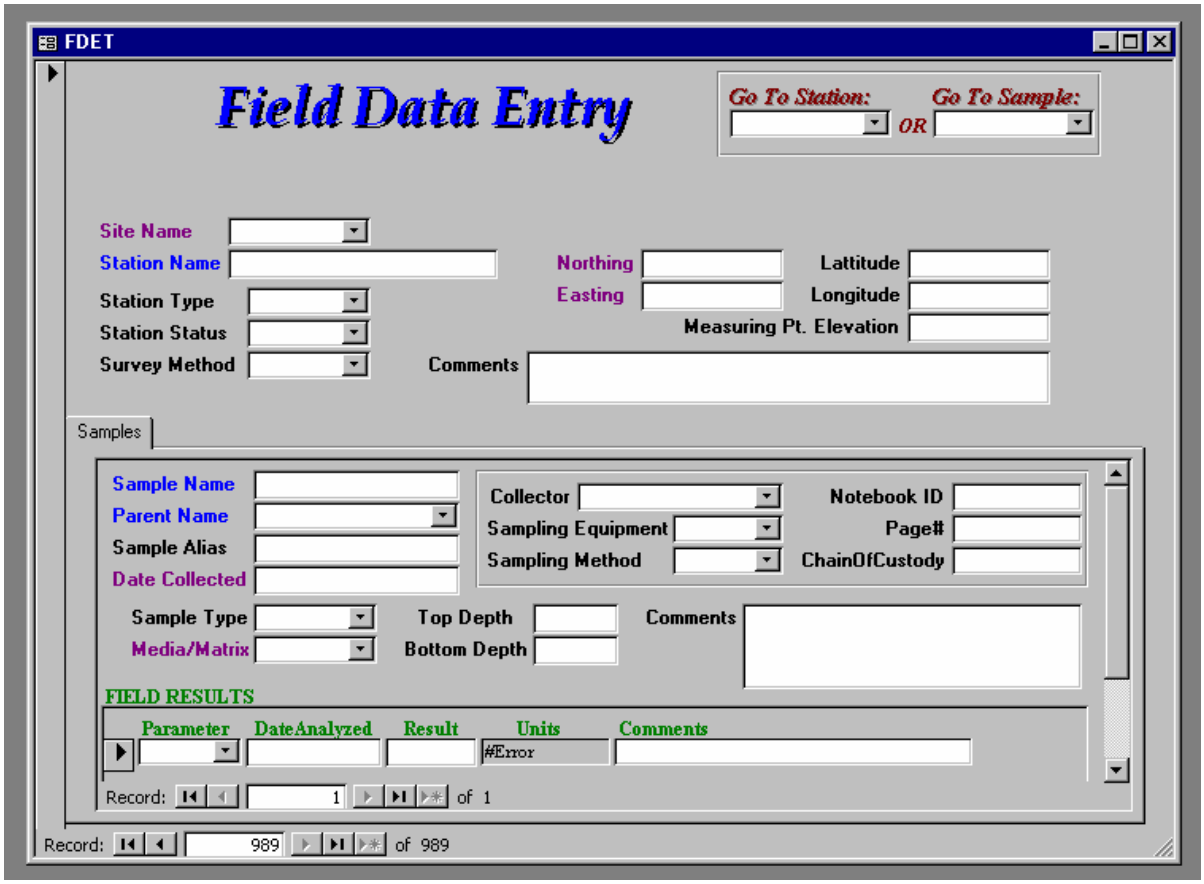

FIGURE 3-1
Data Entry Screen in Field Data Entry Tool (FDET)

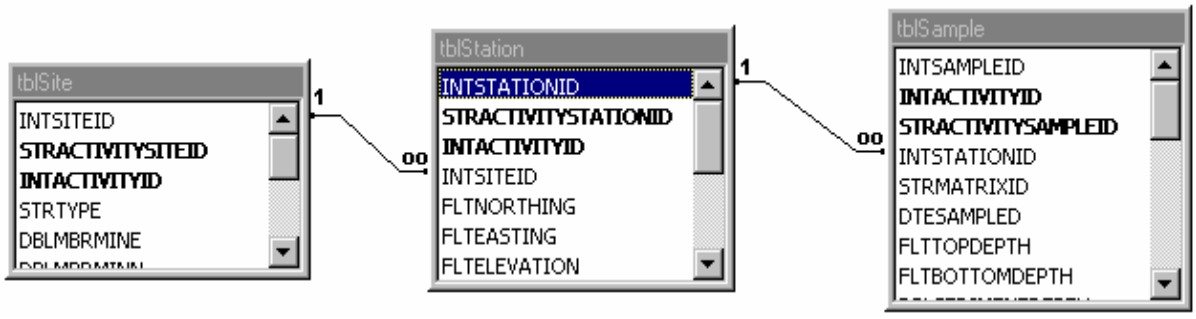

FIGURE 3-2
Relationships between Site, Stations, and Samples Tables in FDET and Environmental Database

3.2.5 Electronic Data Verification

Following receipt of laboratory results, the EIS will check the hard copy and EDD for correctness and completeness before transmittal to the data validator using the Data Management Checklist. Any discrepancies the EIS finds between the hard copy and the EDD will be discussed with the lab and a determination will be made as to whether the correction can be made by the EIS or the EDD will be returned to the laboratory for corrections and re-submittal. All issues encountered and/or corrections made are recorded in the EIS notebook.

The EIS will forward the EDD (corrected, if necessary) to the data validator, and will assist the data validator in communicating with the laboratory. After the data validator has added the validation qualifiers, the EIS will again perform a series of checks on the data using a data management checklist before sending it to the Database Manager for upload into EnDat.

Once the EIS completes the data review, the EIS produces pre-load raw and detects crosstab tables using MS Excel macros and the EDD. The EDD and these pre-load crosstab tables are given to the Project Chemist and project Quality Assurance Officer (QAO) for final review and approval before loading into EnDat. These tables can also be used by the project team for preliminary report writing until the data have been loaded into EnDat and are ready for querying using the EnStat (EnDat Statistics) tool.

3.2.6 Electronic Data Loading

The EDD is forwarded to the Database Manager for loading into the EnDat database. The Database Manager uses canned Structural Query Language (SQL) queries in the MS Access–based Data Loader tool to verify that all repeated Station IDs match those presently in EnDat and that all EDD Sample IDs are distinctive. This tool automates most of the data load process so the task is performed in a time-efficient manner.

The Database Manager communicates the status of the EnDat data load back to the EIS, and works with the EIS to resolve any data problems. A post-load report is generated by the Database Manager once the EnDat load is complete and is given to the EIS to verify that the data was loaded successful. Any discrepancies are resolved with the Database Manager.

SECTION 4

Data Visualization

This section describes the analysis tools that are provided to allow project staff the capability to access the data in the Environmental Database, generate reports, and visualize the data.

4.1 Data Report Generation

Once field and analytical data have been successfully loaded into the Environmental Database, it can be queried by the PMs, risk assessors, and EIS using EnStat. The EnStat tool, a customized Visual Basic (VB)-based application that is accessible through the desktop and Citrix, is used to generate raw data, detects, and regulatory criteria comparison reports from environmental analytical data stored in EnDat. It is also used by the ecological and human health risk assessors to generate statistics for risk assessment. A series of MS Excel macros have been created to automate the formatting of the EnStat output into raw, detects, exceedance, and statistics tables suitable for final reports.

Most of these statistics are used by either human health risk assessors or ecological risk assessors to perform environmental risk analysis.

MS Excel VBA macros have been created to automate the formatting of the EnStat output into raw, detects, exceedance, and statistics tables suitable for final reports. The Exceedance table formatting macro will highlight the detected concentrations that are above the selected screening criteria.

4.2 GIS and Mapping

This subsection documents the functionality, capability, and data storage of all mapping and GIS layers and tools developed to support the Vieques field investigations. The mapping for Vieques is done in a GIS rather than a CADD (computer-aided drawing and design) environment, as GIS provides significantly more functionality than a CADD-based system. The GIS system utilizes Environmental Systems Research Institute's (ESRI's) ArcMAP and/or ArcView applications for a majority of the mapping.

4.2.1 GIS Functionality

The GIS system assists the project team in better managing its information, understanding the results of information collected, and accessing data for more effective decision making. The system functions as a decision support tool that allows project staff to work with the information collected in a holistic manner.

CH2M HILL uses available tools to migrate map and environmental data to specialized modeling and data visualization packages as needed. For example, data can be exported from ArcView for use in a 3-D visualization tool such as EVS (Environmental Visualization System), a contouring package (ArcView Spatial Analyst, Surfer), and/or various

groundwater and subsurface modeling packages. Additionally, GIS users may take advantage of the broad range of tools available within the native ArcView environment.

4.2.2 GIS Data Storage

The GIS data adheres to the following specifications:

4.2.2.1 Mapping Specifications

Data contained in the environmental database are compatible with GIS spatial data collected as part of site environmental investigations. A GIS system facilitates environmental data visualization, mapping, report figure generation, and project tracking.

Coordinate System

All mapping and surveying performed for future investigations will conform to the following:

Coordinate System	=	UTM Zone 20N
Unit of Measurement	=	Meters
Horizontal Datum	=	North American Geodetic Datum 1983
Vertical Datum	=	North American Vertical Datum 1988

Survey data will be collected in an electronic format either from a global positioning system (GPS) survey conducted by CH2M HILL personnel, or data transfer from a licensed surveyor. The file format for survey information will be provided to the surveyor in advance of the survey.

Data Representation

Geographic data (including any aerial photographs) will be compatible with the Tri-Service Spatial Data Standard (TSSDS) where applicable. The TSSDS was developed as a single comprehensive master and environmental planning data model for U.S. Air Force, Army, and Navy installations, as well as U.S. Army Corps of Engineers civil works projects. The TSSDS was designed to complement Federal Geographic Data Committee data standards that address small-scale mapping (map scales greater than 1:24,000) with graphic and attribute data standards for entities depicted in large-scale mapping (1 inch = 400 feet [1:4,800] to 1 inch = 50 feet [1:600]).

4.2.2.2 GIS Map Layers

The GIS contains two types of map layers.

- **Base map data** – Any layers representing facilities and conditions at Vieques. These may include, but are not limited to, buildings, roads, water bodies, and aerial photographs.
- **Environmental data** – The environmental data layers contain sample station locations, as well as additional data layers which are developed by project staff to support project analysis, decision-making, and recommendations. These may include, but are not limited to, contour maps representing groundwater depths, conductivity, surface and groundwater flow vector maps, areas of high analyte concentrations, etc.

Figure 4-1 illustrates the relationship between GIS map layers:

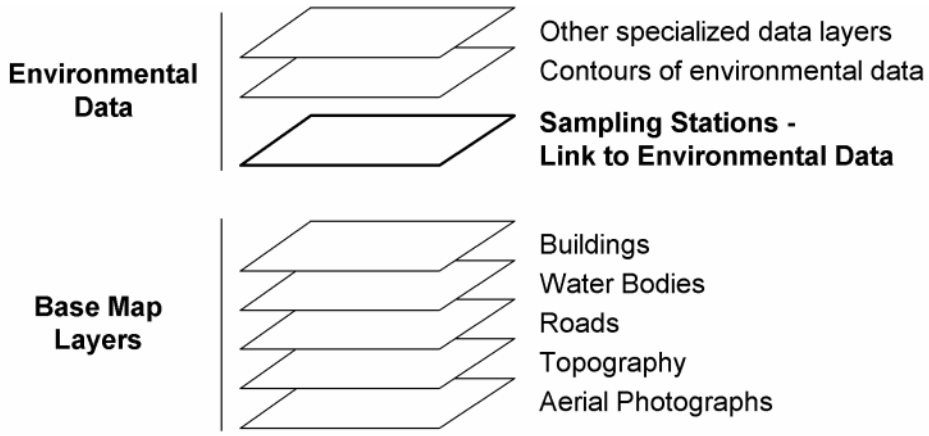

FIGURE 4-1
GIS Map Layers

4.2.2.3 Environmental Data Format

Environmental data collected for Vieques are entered into the Environmental Database for archiving, analysis, and reporting. These data are also made available to the GIS system for display, querying, and reporting. To facilitate queries and reporting from the GIS system, environmental data in the Environmental Database structure are "served" to the GIS in a series of flat-file (non-normalized) tables. Specifically, a series of *views* are created in Oracle and those views exported to the GIS. A *view* is a snapshot of data in one or more database tables that are compiled and presented in a single table enabling the viewer to easily access and understand the data. The views greatly simplify the environmental data querying from the GIS.

The following *standard data* are copied from the Environmental Database on a regular basis and provided to the GIS:

- **Sample data** – One record for each sample. Data such as sample name, station ID (link to the GIS), parent sample ID, media type, date collected, and sample depths are included in the sample data table.
- **Analytical results** – One record for each analytical result. Data including sample name, chemical name and CAS number, result value, result units, qualifiers, detect limits are included in the analytical result data table.
- **Threshold data** – Regulatory limits for any criteria. The table will contain one record for each chemical threshold for each regulatory criterion. Included are chemical name and CAS number, regulatory limit, and threshold units of measurement.

Figure 4-2 illustrates how environmental data are accessed via the desktop GIS.

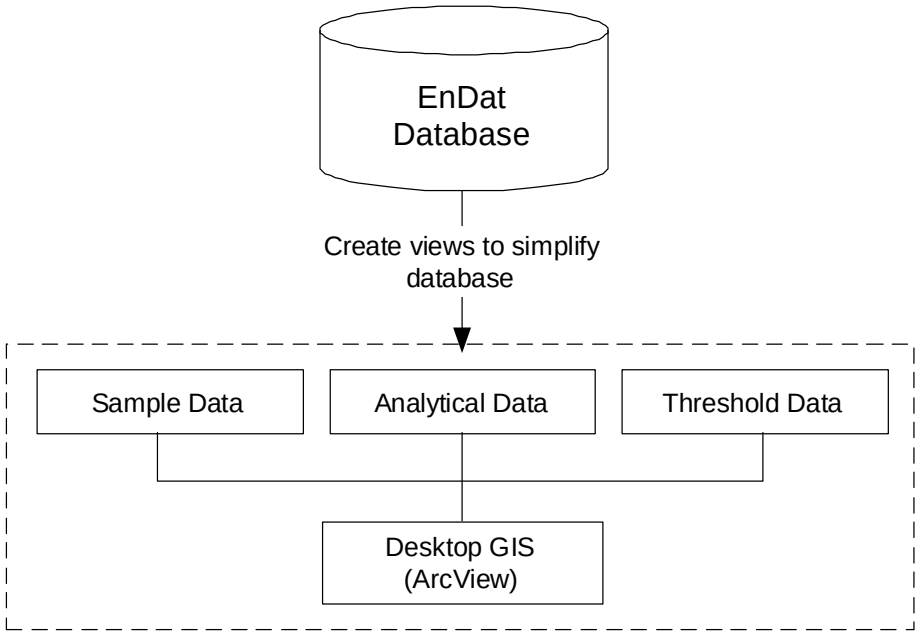

FIGURE 4-2
Environmental Data Access from the GIS

SECTION 5

Project Documentation

This section describes the storage of the documentation generated during the environmental investigations conducted at Vieques and the creation of the Administrative Record File.

5.1 Document Storage at CH2M HILL

A large variety of technical data will be generated during the course of field investigations at Vieques. A data document tracking system will be maintained so that the integrity of the data is preserved. Project tracking data, schedules, progress reports, and field notes will be maintained to monitor, manage, and document the progress of the program at Vieques.

Electronic files are housed on the Internet using the Enterprise system, which can be found at the following web address: http://vieques.lantops-ir.org/. The system provides accessibility, security, version control, and document integrity. All users receive a unique secure login and can view different areas of the website depending on their user group and privileges. Documents are stored in two main areas: the Administrative Record and Project Documents. The Administrative Record contains final documents in PDF format. All users can download and view AR Documents, while only the NAVFAC Atlantic Librarian and CH2M HILL Administrative Records Coordinator have permissions to upload and manage documents in this area of the website. Project documents include draft and final documents, figures, tables, and images. They are stored in a separate area and are divided in folders based upon subcommittee. Additionally, there is a folder for documents under review, and users with Adobe Acrobat can comment online. The public can access final documents, RAB Meeting information, contacts, and community involvement updates at the publicly-accessible Vieques IR website: http://public.lantops-ir.org/sites/public/vieques. Only designated personnel can revise and upload documents on the public website. An incremental backup of the electronic files occurs daily, while a full backup is performed once a week. CH2M HILL documents will generally exist in an Adobe PDF file format.

5.2 Archiving

The original hardcopy laboratory data deliverables will be sent from the third-party validator to CH2M HILL upon acceptance of the data validation reports. Hardcopy lab deliverables will be archived according to NAVFAC Atlantic requirements, and stored in the CH2M HILL subcontracted warehouse until completion of the project. As part of the project close-out process, laboratory hardcopy, data validation reports, field log books, and other project documents will be returned to the Navy.

Electronic data management archiving consists of an original laboratory EDD, an expanded EDD used for data loading, tracking sheets, and data validation reports. These data are stored on the Vieques File Transfer Protocol (FTP) site.

ATTACHMENT 5

Baseline Human Health Risk Assessment Protocol for Vieques Environmental Restoration Program

Baseline Human Health Risk Assessment Protocol for Vieques Environmental Restoration Program

The baseline human health risk assessment (HHRA) refers to the risks characterized under existing conditions, based on current and potential future land uses. HHRAs will be conducted to assess the potential adverse effects to human health under both current and conservative future land-use conditions. The results of the risk assessment will be used as the basis for making risk management decisions for a site, if necessary, including evaluating the need for future remedial actions or controls at a site. When an HHRA is conducted, realistic potential exposure scenarios will be evaluated. Future residential land use will be evaluated as a conservative exposure scenario, although it may not be realistic for land that is to remain non-residential, such as for conservation areas as indicated in the maps from the Puerto Rico Planning Board (Figures 1 and 2). Residential land use will be evaluated to determine whether the sites pose no unacceptable risks for unrestricted use of the site. Chemicals of potential concern (COPCs) that are detected in site media at concentrations within background levels will be retained for risk estimation, although they could reflect background conditions. Detected concentrations will not be compared with background levels to select COPCs. However, background comparisons will be made for risk management considerations in the risk characterization section of the HHRA.

The HHRAs will be conducted following U.S. Environmental Protection Agency (EPA) guidance. At the time the HHRA is prepared, the most recent version of the guidance documents and models will be used. The References Section at the end of this protocol contains a list of the current guidance documents and models planned for use.

Risk Results Format and Interim Deliverables

The HHRA tables will be presented in RAGS Part D format. The intent of providing RAGS Part D format is to ensure a clear and consistent approach to presenting HHRA information and results. Appendix A of EPA guidance (EPA, 2001) will be used to obtain RAGS Part D format worksheets for each site-specific HHRA.

A conceptual site model (RAGS Part D Table 1) will be developed to present an overview of site conditions and to identify potential sources, potential migration pathways, receptors, and exposure routes. The conceptual site model will be developed at the work plan stage and refined, as necessary, following data collection. This will serve as the basis for the exposure pathway evaluations in the baseline HHRA.

An interim deliverable of the exposure pathway analysis (RAGS Part D Tables 1-6), including exposure assumptions that will be used in each site-specific HHRA, will be submitted for review by the regulatory agencies prior to implementation in each HHRA. This step is intended to reduce the number of iterations in the risk calculations by achieving up-front concurrence on the HHRA exposure pathways, receptors, and exposure

Map Key
- Lagoons
- Rivers

Roads
- Main
- Tertiary

Land Classification
- Conservation
- Future Growth
- Rural
- Urban

Photo-Identified (PI), Potential Areas of Concern (PAOC), Areas of Concern (AOC), and Solid Waste Management Units (SMWU)

65°33'36" 65°31'32" 65°27'28" 65°23'24" 65°19'20" 65°15'16"

18°09'

18°04'

SONDA DE VIEQUES

Main Operational Area
(Includes SWMU 10, SWMU 14, SWMU 15, AOC B, AOC C, AOC E, AOC F, AOC K)

AOC I
AOC H
AOC J
AOC R
SWMU 6
SWMU 7
SWMU 5
SWMU 4
Area of Restricted Land Use

PI-1
PI-2
PI-3
PI-4
PI-5
PI-6
PI-7
PI-8
PI-9
PI-10
PI-11
PI-12
PI-13
PI-14
PI-15
PI-16
PI-18
PI-19
PI-20
PI-21
PI-22
PI 9
SWMU 4,6,7
SWMU-1
SWMU-2
SWMU-5, 8, 12; AOC-A
SWMU-10, AOC G
AOC-F

MAR CARIBE

N

6 0 12 Miles

9 0 18 Kilometers

FIGURE 1
Land Classification
Vieques, Puerto Rico

Figure produced from the Master Plan for the sustainable development of Vieques and Culebra, community meeting June 15 and 16, 2004

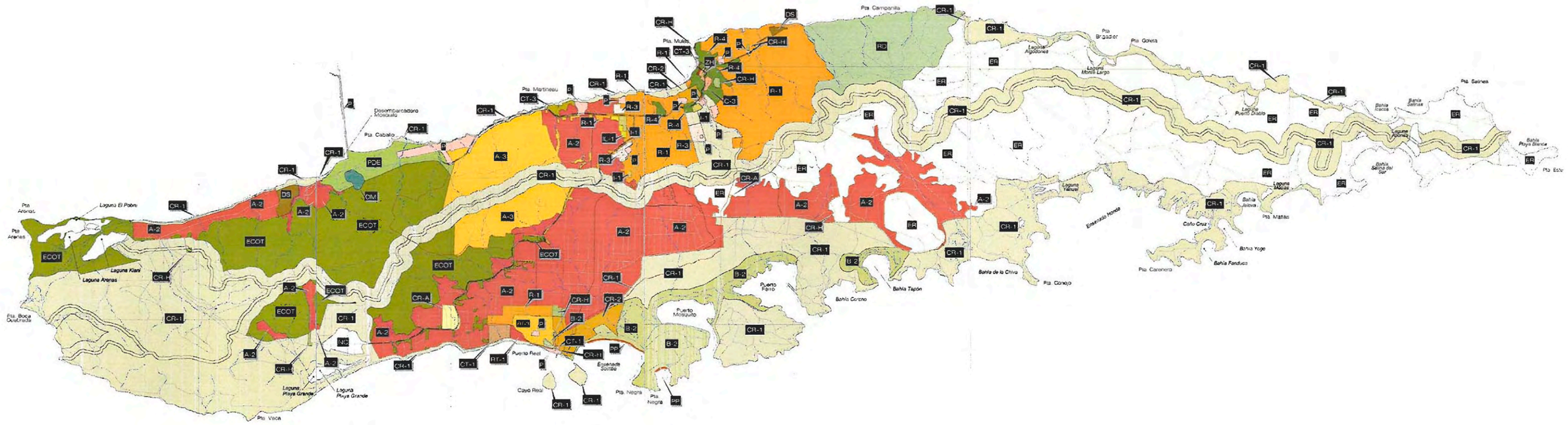

Figure produced from the Master Plan for the sustainable development of Vieques and Culebra, community meeting June 15 and 16, 2004

FIGURE 2
Zoning
Vieques, Puerto Rico

assumptions. Additionally, site-specific data to be used in HHRAs may be included for review by agency risk assessors if available and an interim data review deemed necessary by the stakeholder agencies. Also, requests for interim toxicity criteria for any chemicals for which toxicity criteria are not available in EPA databases will be provided to the EPA as part of these interim deliverables.

Risk Assessment Process

The HHRAs will include the following major components in the evaluation process:

- Data collection and evaluation, including identification of COPCs
- Exposure assessment
- Toxicity assessment
- Risk characterization

Data Collection and Evaluation

This section will include a brief summary of information pertinent to the HHRA, such as potential sources of contamination, the specific sampling locations and depths, the sampling rationale, and the analytical methods (with reference to previous section(s) of the report to minimize repeating information already discussed), screening methods used to select COPCs, and the COPCs identified for the site.

The detected constituents at each site will be screened to select the COPCs in accordance with EPA guidelines (EPA, 1989). The COPC selection process will be conservative to ensure that potential risks are not inadvertently underestimated or discounted at an early step in the assessment. The selected COPCs will be retained for further evaluation in the HHRA. When both normal and duplicate samples are available from a specific sample location, the normal sample (as opposed to the duplicate QA/QC sample) will be used in the HHRA.

The COPCs in a medium will be identified by comparing the maximum constituent concentrations against the screening criteria. If the maximum concentration of a constituent exceeds its respective screening value, the constituent will be identified as a COPC and retained for quantitative evaluation in the HHRA.

Typical media that may be available for a site consist of surface soils, subsurface soils, surface water, sediment, and groundwater. The following sources will be used to obtain the health-based screening criteria:

- Surface soil (to 1 or 2 feet below land surface (bls), depending on the site), subsurface soil (down to 6 feet bls), and sediment analytical results will be screened against the EPA Region IX Preliminary Remediation Goal (PRG) values from the Region IX PRG tables. The non-carcinogenic PRG values will be reduced by a factor of 10 (adjusted to a Hazard Quotient [HQ]=0.1) to account for the potential presence of multiple chemicals affecting the same target organ. For potential carcinogens, the Region IX "Intercalc" PRG table will be used to compare the carcinogenic-based PRG and non-carcinogenic-based PRG (HQ=0.1), and the lower of the two values will be selected as the PRG for that chemical. The residential land use PRGs will be used for selecting COPCs for the recreational and residential exposure scenarios, while the industrial PRGs will be used for selecting

COPCs for the maintenance worker, construction worker, and industrial worker scenarios.

- Surface and subsurface soils will also be screened against soil-to-groundwater protection criteria. This comparison will not be used to select the COPCs for the HHRA calculations, but will be used to help understand chemical transport potential. The leachability potential will be assessed by comparing site-specific concentrations to published EPA Soil Screening Levels (SSLs) based on a dilution/attenuation factor (DAF) of 1, or site-specific SSLs if site-specific data have been collected to permit their calculation. The site-specific SSL values will be calculated using the input factors from the data collected for each site. The site-specific DAF for SSL values will be calculated following the EPA guidance (EPA, 1996 and 2002b).

- Groundwater and surface water samples will be screened against the tap water PRGs from the latest update to the EPA Region IX PRG table. The non-carcinogenic PRG values will be reduced by a factor of 10 (adjusted to an HQ=0.1) to account for the potential presence of multiple chemicals affecting the same target organ. For potential carcinogens, the Region IX "Intercalc" PRG table will be used to compare the carcinogenic-based PRG and non-carcinogenic-based PRG (HQ=0.1), and the lower of the two values will be selected as the PRG for that chemical. The Table 2s in RAGS Part D format will also include EPA Maximum Contaminant Levels (MCLs), but the MCL comparison will not be used to select COPCs for the HHRA.

The screening values from the above sources are included in the attached QAPP Worksheet 15. The PRG values will be selected from the latest update to the EPA Region IX PRG tables available at the time the HHRA is prepared. The toxicity values on which the PRGs are based will be verified in the EPA Integrated Risk Information System (IRIS) database, and if an updated value is contained in IRIS, the PRG will be recalculated prior to its use.

A detected chemical that has no screening criteria will be compared with criteria for a surrogate chemical, if appropriate and available, or qualitatively evaluated to determine if it should be considered a COPC. Frequency of detection, concentration, historical site use or release, and availability of surrogate chemicals with PRG values will be considered. Information available in the literature and from EPA resources will also be considered for inclusion or exclusion of chemicals without screening criteria in COPC selection and subsequent risk assessment steps.

Constituents that are essential nutrients (e.g., calcium, magnesium, potassium, and sodium) will not be evaluated in the quantitative risk assessment, as they are toxic only at very high doses. Although iron and manganese are essential human nutrients and are toxic only at very high doses, they will be handled the same way as other detected constituents in the HHRA because human health-based screening levels are available for both constituents. However, the iron screening level is based on a provisional toxicity value that increases the uncertainty associated with the quantitative risk evaluation.

Commonly encountered lab contaminants (methylene chloride, bis (2-ethylhexyl)phthalate, etc.) that are detected at similar concentrations (within 10 times the concentration in QA/QC samples) in media samples and QA/QC samples, not expected to be associated with site activities, and qualified appropriately, will not be included as COPCs, in

accordance with EPA guidance for considering common laboratory contaminants (EPA, 1989).

Exposure Assessment

An exposure assessment is used to evaluate potential exposure to site media by the human receptors identified for current and anticipated future land use at a site. The exposure assessment identifies human receptors, potential exposure pathways, assumed exposure factor values, and estimated exposure point concentrations (EPCs).

Potentially Exposed Populations

Navy operations are no longer occurring on Vieques Island. Following the transfer of the former Navy property to the Commonwealth of Puerto Rico and the Department of Interior (DOI), land use planning indicates no future residential land use is likely. However, to determine whether unrestricted use of a site poses no unacceptable risk (even though residential land use is not anticipated), a residential land use scenario will be evaluated. Therefore, the following potentially exposed populations will be included in each quantitative HHRA:

- maintenance workers
- recreational receptors (adult, youth [6 to <16 years of age], and child [1 to 6 years of age])
- construction workers (including utility workers, where appropriate)
- industrial workers
- residential receptors (adult and child)

Other site-specific populations, such as subsistence anglers/crabbers and recreational anglers/crabbers, may also be included in the HHRA when appropriate. Other potentially exposed populations could access the site, such as trespassers and site visitors; however, their exposure potential is considerably lower than most of those listed above, and most consistent with the recreational scenario in terms of exposure potential and duration. Therefore, the above populations are adequate to evaluate all potential exposure scenarios. A preliminary list of exposure factors for the receptors proposed for future risk assessments is included in Tables 1 through 5. At the time the HHRA is prepared, if default exposure factors are changed in the reference documents, the exposure factor values in Tables 1 through 5 will be modified accordingly.

The adult population will be defined as 16 and older in the HHRAs, whereas, an adult population is typically referenced as 18 and older. However, a body weight of 70 kg will be used for the 16 and older population, which is the body weight typically used for the 18 and older population group. This change in adult age definition is not anticipated to have any significant effect on the risk/hazards estimates for the sites.

Maintenance Workers

Based on the likely occupational duties, it is typically assumed that a maintenance worker would have the potential for direct or indirect contact with surface soils at each site. The maintenance workers are not likely to be exposed to site groundwater during routine maintenance activities, as the nature of the activities assumed for a maintenance worker involve grounds maintenance, such as cutting grass, clearing brush, etc., and is assumed not to involve digging that would occur as part of construction activities. Maintenance workers involved in occasional landscaping activities would not be exposed to soils deeper than 2 feet.

At most or all sites, groundwater occurs at depths greater than 4 feet. Therefore, the direct exposure to groundwater pathway will not be evaluated for the maintenance worker scenario unless groundwater is at a depth of less than 2 feet, in which case the maintenance worker will be evaluated for direct exposure to groundwater.

Recreational Users

Some of the sites may be used for recreational purposes, such as hiking, picnicking, and other outdoor activities. Recreational receptors will be assumed to have direct contact with site surface soils, but not to site subsurface soil or groundwater. Exposure to surface water and sediments will be evaluated for these receptors if a site includes these media. Although some sites may be too small to reasonably assume that a receptor spends their entire recreational time there, such a scenario will be assumed as a conservatively protective exposure scenario. A default recreational outing time of 4 hours will be used since most of the sites are small (less than 1 acre) and do not include recreational water bodies suitable for swimming.

Construction Workers

A future construction worker scenario will be evaluated for surface and subsurface soil exposures. The EPCs for a construction worker will be calculated using surface and subsurface soil up to 6 feet bls. Exposures to site groundwater are not expected for this scenario, as typical construction depths (to 6 feet bls) will not encounter groundwater at most of the sites, because at most sites, depth to groundwater is approximately 33 to 71 feet bls. However, if sites include groundwater at shallow depths (<6 feet bls) typically reached during construction activities, then direct exposure through incidental ingestion, dermal contact, and inhalation (inhalation only if VOCs are among site COPCs) to site groundwater during construction will be included.

Industrial Workers

This scenario will be evaluated conservatively assuming a site will be converted into an industrial facility where a worker spends his/her entire workday at the site in direct contact with surface and subsurface (0-6 feet) soils. Depending on site-specific conditions, future development of some of these sites could potentially allow for light industrial /commercial use, which may bring industrial workers into contact with site media. Industrial workers are also assumed to be exposed to site groundwater as a potential potable water source under an industrial use scenario. This scenario will be included to conservatively evaluate a future industrial exposure scenario, using EPA exposure factors for an industrial worker scenario.

If the risks for this scenario are not within acceptable limits, the unrealistic nature of this scenario and a comparison to the other, more realistic exposure scenarios will be discussed in the uncertainties or risk management section of the HHRA.

Residents

The evaluation of a residential exposure scenario is a conservative assessment of whether site-related contamination poses an unacceptable risk for residential receptors. Residential receptors consist of child and adult receptors and are assumed to have higher exposure to site media in comparison to other receptors, such as industrial/commercial workers or recreational users. For many of the sites, the residential exposure scenario will be evaluated as a hypothetical exposure to determine whether land use controls are required. If a site poses no unacceptable risk under a residential land use scenario, then the EPA does not require land use controls. Therefore, the site is considered to pose no unacceptable risk for unrestricted use of the site. Future residents will be assumed to have direct contact with surface and subsurface soils and use site groundwater as a potable source. If the estimated risks for this scenario are not within acceptable limits, the unrealistic nature of this scenario and a comparison to the other, more realistic exposure scenarios will be discussed in the uncertainties or risk management section of the HHRA.

Exposure Quantitation

Exposure Factors

A preliminary list of exposure factors is provided in Tables 1 through 5.

Intake Estimates

For each receptor identified in the exposure assessment as having a potentially complete exposure pathway, chemical- and media-specific intakes, known as chronic daily intakes (CDIs; or subchronic daily intakes [SDIs] for exposure durations of less than seven years), will be estimated using the appropriate exposure factors and assumptions.

Chemical intakes (represented by CDI or SDI) will be expressed in terms of milligrams of chemicals contacting the body per kilogram of body weight per day (mg/kg-day). For the exposure routes to be evaluated, the following generic equation applies:

$$Exposure\ (mg/kg-day) = \frac{C\ x\ IR\ x\ ED\ x\ EF}{BW\ x\ AT}$$

Where:

C = concentration of chemical in medium (EPC)
IR = Intake or ingestion rate
EF = Exposure frequency
ED = Exposure duration
BW = Body weight
AT = Averaging time (period over which exposure will be averaged)

Route-specific intake estimates will be included in RAGS Part D tables for each site.

Exposure Point Concentrations

The EPC will be the reasonable upper-bound estimate of the mean concentration that will be contacted over the exposure period. The EPCs will be calculated using the most recent

version of ProUCL software (currently version 3.00.02). ProUCL first tests the data distribution to determine if the data fit a normal, lognormal, or gamma distribution, or if the data do not fit any of these distributions. ProUCL then recommends the appropriate upper confidence limit (UCL) calculation method, and calculates the EPC based on the data distribution. The recommendations outlined in the ProUCL software documentation will be followed to select the appropriate UCL.

In estimating the UCL, one-half the detection limit will be assumed for non-detected concentrations of COPCs. If sample sizes are small, the UCL will typically default to the maximum detected concentration as the EPC, and will be indicated in the ProUCL output.

Table 1

Exposure Factors for Soil/ Sediment Ingestion and Dermal Exposure Intakes - Non-MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Recreational	Adult	Surface Soil / Sediment	CS	Chemical Concentration in Soil/Sediment	site-specific	mg/kg	site-specific	Chronic Daily Intake (CDI) (mg/kg-day) =
			IR-S	Ingestion Rate of Soil/Sediment	100/50	mg/day	EPA, 2002	CS x IR-S x EF x ED x CF x 1/BW x 1/AT
			EF	Exposure Frequency	104	days/year	(1)	
			ED	Exposure Duration	24	years	(1)	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	8,760	days	(3)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	
	Youth	Surface Soil / Sediment	CS	Chemical Concentration in Soil/Sediment	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			IR-S	Ingestion Rate of Soil/Sediment	100/50	mg/day	EPA, 2002	CS x IR-S x EF x ED x CF x 1/BW x 1/AT
			EF	Exposure Frequency	104	days/year	(1)	
			ED	Exposure Duration	10	years	(2)	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			BW	Body Weight	39	kg	EPA 2004 (2)	
			AT-N	Averaging Time (Non-Cancer)	3,650	days	(3)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	
	Child	Surface Soil / Sediment	CS	Chemical Concentration in Soil/Sediment	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			IR-S	Ingestion Rate of Soil/Sediment	200/50	mg/day	EPA, 2002	CS x IR-S x EF x ED x CF x 1/BW x 1/AT
			EF	Exposure Frequency	104	days/year	(1)	
			ED	Exposure Duration	6	years	EPA, 2002	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			BW	Body Weight	15	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	2,190	days	(3)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	
Residential	Adult	Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			IR-S	Ingestion Rate of Soil	100	mg/day	EPA, 2002	CS x IR-S x EF x ED x CF x 1/BW x 1/AT
			EF	Exposure Frequency	350	days/year	EPA, 2002	
			ED	Exposure Duration	24	years	EPA, 2002	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	8,760	days	(3)	

Table 1

Exposure Factors for Soil/ Sediment Ingestion and Dermal Exposure Intakes - Non-MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Residential (cont.)	Child	Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			IR-S	Ingestion Rate of Soil	200	mg/day	EPA, 2002	CS x IR-S x EF x ED x CF x 1/BW x 1/AT
			EF	Exposure Frequency	350	days/year	EPA, 2002	
			ED	Exposure Duration	6	years	EPA, 2002	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			BW	Body Weight	15	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	2,190	days	(3)	
	Child/Adult Aggregate	Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			IR-S-Adj	Ingestion Rate of Soil, Age-adjusted	114.29	mg-year/kg-day	Calculated	CS x IR-S-Adj x EF x CF1 x 1/AT
			EF	Exposure Frequency	350	days/year	EPA, 2002	IR-S-Adj (mg-year/kd-day) =
			CF1	Conversion Factor 1	0.000001	kg/mg	- -	(ED-C x IR-S-C / BW-C) + (ED-A x IR-S-A / BW-A)
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	
Maintenance Worker	Adult	Surface Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			Irsoil	Ingestion Rate of Soil	100	mg/day	EPA, 2002	CS x Irsoil x EF x ED x CF x 1/BW x 1/AT
			EF	Exposure Frequency	52	days/year	(1)	
			ED	Exposure Duration	25	years	EPA, 2002	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	9,125	days	(3)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	
Construction Worker	Adult	Total Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			Irsoil	Ingestion Rate of Soil	330	mg/day	EPA, 2002	CS x Irsoil x EF x ED x CF x 1/BW x 1/AT
			EF	Exposure Frequency	250	days/year	EPA, 2002	
			ED	Exposure Duration	1	years	EPA, 2002	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	365	days	(3)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	

Table 1

Exposure Factors for Soil/ Sediment Ingestion and Dermal Exposure Intakes - Non-MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Industrial Worker	Adult	Total Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			Irsoil	Ingestion Rate of Soil	100	mg/day	EPA, 2002	CS x Irsoil x EF x ED x CF x 1/BW x 1/AT
			EF	Exposure Frequency	250	days/year	EPA, 2002	
			ED	Exposure Duration	25	years	EPA, 2002	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	9,125	days	(3)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	
Recreational	Adult	Surface Soil / Sediment	CS	Chemical Concentration in Soil/Sediment	site-specific	mg/kg	site-specific	Soil CDI (mg/kg-day) =
			SA	Skin Surface Area Available for Contact	5,700	cm^2	EPA, 2004 (5)	CS x SA x SSAF x DABS x CF x EF x
			SSAF	Soil/Sediment-to-Skin Adherence Factor	0.2/0.36	mg/cm^2-day	EPA, 2004	ED x 1/BW x 1/AT
			DABS	Dermal Absorption Factor Solids	chemical-specific	--	EPA, 2004	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			EF	Exposure Frequency	104	days/year	(1)	Sediment CDI (mg/kg-day) =
			ET	Exposure Time (sediment)	4	hr		CS x SA x SSAF x DABS x CF x EF x ET x
			ED	Exposure Duration	24	years	(1)	ED x 1/BW x 1/AT
			BW	Body Weight	70	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	8,760	days	(3)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	
	Youth	Surface Soil / Sediment	CS	Chemical Concentration in Soil/Sediment	site-specific	mg/kg	site-specific	Soil CDI (mg/kg-day) =
			SA	Skin Surface Area Available for Contact	4,100	cm^2	EPA, 2004 (5)	CS x SA x SSAF x DABS x CF x EF x
			SSAF	Soil/Sediment-to-Skin Adherence Factor	0.2/0.36	mg/cm^2-day	EPA, 2004	ED x 1/BW x 1/AT
			DABS	Dermal Absorption Factor Solids	chemical-specific	--	EPA, 2004	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			EF	Exposure Frequency	104	days/year	(1)	Sediment CDI (mg/kg-day) =
			ET	Exposure Time (sediment)	4	hr		CS x SA x SSAF x DABS x CF x EF x ET x
			ED	Exposure Duration	10	years	(2)	ED x 1/BW x 1/AT
			BW	Body Weight	39	kg	EPA 2004 (2)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	
			AT-N	Averaging Time (Non-Cancer)	3,650	days	(3)	

Table 1

Exposure Factors for Soil/ Sediment Ingestion and Dermal Exposure Intakes - Non-MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
	Child	Surface Soil / Sediment	CS	Chemical Concentration in Soil/Sediment	site-specific	mg/kg	site-specific	Soil CDI (mg/kg-day) =
			SA	Skin Surface Area Available for Contact	2,800	cm^2	EPA, 2004 (6)	CS x SA x SSAF x DABS x CF x EF x
			SSAF	Soil/Sediment-to-Skin Adherence Factor	0.2/0.36	mg/cm^2-day	EPA, 2004	ED x 1/BW x 1/AT
			DABS	Dermal Absorption Factor Solids	chemical-specific	--	EPA, 2004	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			EF	Exposure Frequency	104	days/year	(1)	Sediment CDI (mg/kg-day) =
			ET	Exposure Time (sediment)	4	hr		CS x SA x SSAF x DABS x CF x EF x ET x
			ED	Exposure Duration	6	years	EPA, 2002	ED x 1/BW x 1/AT
			BW	Body Weight	15	kg	EPA, 2002	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	
			AT-N	Averaging Time (Non-Cancer)	2,190	days	(3)	
Residential	Adult	Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			SA	Skin Surface Area Available for Contact	5,700	cm^2	EPA, 2004 (5)	CS x SA x SSAF x DABS x CF x EF x
			SSAF	Soil to Skin Adherence Factor	0.07	mg/cm^2-day	EPA, 2004	ED x 1/BW x 1/AT
			DABS	Dermal Absorption Factor Solids	chemical-specific	--	EPA, 2004	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			EF	Exposure Frequency	350	days/year	EPA, 2002	
			ED	Exposure Duration	24	years	EPA, 2002	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	8,760	days	(3)	
	Child	Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			SA	Skin Surface Area Available for Contact	2,800	cm^2	EPA, 2004 (6)	CS x SA x SSAF x DABS x CF x EF x
			SSAF	Soil to Skin Adherence Factor	0.2	mg/cm^2-day	EPA, 2004	ED x 1/BW x 1/AT
			DABS	Dermal Absorption Factor Solids	chemical-specific	--	EPA, 2004	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			EF	Exposure Frequency	350	days/year	EPA, 2002	
			ED	Exposure Duration	6	years	EPA, 2002	
			BW	Body Weight	15	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	2,190	days	(3)	
	Child/Adult Aggregate	Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			DA-Adj	Dermal Absorption, Age-adjusted	361	mg-year/kg-day	Calculated	CS x DA-Adj x DABS x CF1 x EF x 1/AT
			DABS	Dermal Absorption Factor Solids	chemical-specific	--	EPA, 2002	DA-Adj (mg-year/kg-day) =
			CF1	Conversion Factor 1	0.000001	kg/mg	- -	(ED-C x SA-C x SSAF-C / BW-C) + (ED-A x SA-A x SSAF-A / BW-A)
			EF	Exposure Frequency	350	days/year	EPA, 2002	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	

Table 1

Exposure Factors for Soil/ Sediment Ingestion and Dermal Exposure Intakes - Non-MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Maintenance Worker	Adult	Surface Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			SA	Skin Surface Area Available for Contact	3,300	cm^2	EPA, 2004 (5)	CS x SA x AF x DABS x CF x EF x
			AF	Soil to Skin Adherence Factor	0.2	mg/cm^2-day	EPA, 2004	ED x 1/BW x 1/AT
			DABS	Dermal Absorption Factor Solids	chemical-specific	--	EPA, 2004	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			EF	Exposure Frequency	52	days/year	(1)	
			ED	Exposure Duration	25	years	EPA, 2002	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	
			AT-N	Averaging Time (Non-Cancer)	9,125	days	(3)	
Construction Worker	Adult	Total Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			SA	Skin Surface Area Available for Contact	3,300	cm^2	EPA, 2004 (5)	CS x SA x SSAF x DABS x CF x EF x
			SSAF	Soil to Skin Adherence Factor	0.3	mg/cm^2-day	EPA, 2004	ED x 1/BW x 1/AT
			DABS	Dermal Absorption Factor Solids	chemical-specific	--	EPA, 2004	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			EF	Exposure Frequency	250	days/year	EPA, 2002	
			ED	Exposure Duration	1	years	EPA, 2002	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	365	days	(3)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	
Industrial Worker	Adult	Total Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			SA	Skin Surface Area Available for Contact	3,300	cm^2	EPA, 2004 (5)	CS x SA x SSAF x DABS x CF x EF x
			SSAF	Soil to Skin Adherence Factor	0.2	mg/cm^2-day	EPA, 2004	ED x 1/BW x 1/AT
			DABS	Dermal Absorption Factor Solids	chemical-specific	--	EPA, 2004	
			CF	Conversion Factor	0.000001	kg/mg	- -	
			EF	Exposure Frequency	250	days/year	EPA, 2002	
			ED	Exposure Duration	25	years	EPA, 2002	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	9,125	days	(3)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	

Notes:

(1) Based on best professional judgment.

(2) Youths from 6 to 16 years of age. Body weight is average of the mean values for boys and girls for the ages 6 through 16

(3) Calculated as the product of ED (years) x 365 days/year.

(4) Calculated as the product of 70 years assumed human lifetime (EPA, 1989a) x 365 days/year.

(5) SA includes head, hands, forearms, and lower legs.

(6) SA includes head, hands, forearms, lower legs, and feet.

Sources:

EPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, OSWER 9355.4-24, December, 2002.

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

MMOA - Mutagenic mode of action

cm^2 = Square centimeter

kg = Kilogram

kg/mg = Kilogram per milligram

mg/kg = Milligram per kilogram

mg/kg-day = Milligram per kilogram per day

mg/cm^2-day = Milligram per square centimeter per day

mg/day = Milligram per day

Table 1a

Exposure Factors for Soil/Sediment Ingestion and Dermal Exposure Intakes - Adjusted for MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Exposure Point	Receptor Age		Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Recreational	Surface Soil / Sediment	Child	Child (0-<2 yrs)	CS	Chemical Concentration in Soil/Sediment	site-specific	mg/kg	site-specific	Chronic Daily Intake (CDI) (mg/kg-day) =
				IR-S-Adj (0-2)	Age Adjusted Ingestion Rate of Soil/Sediment (0-<2 yrs)	39.7	mg-yr/day-kg	calculated	CS x IR-S-Adj (0-2) x EF x CF1 x 1/AT
				EF	Exposure Frequency	104	days/year	(1)	[for child aged 0-<2 years]
				CF	Conversion Factor	0.000001	kg/mg	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	
			Child (2-6 yrs)	CS	Chemical Concentration in Soil/Sediment	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
				IR-S-Adj (2-6)	Age Adjusted Ingestion Rate of Soil/Sediment (2-<6 yrs)	49.8	mg-yr/day-kg	calculated	CS x IR-S-Adj (2-6) x EF x CF1 x 1/AT
				EF	Exposure Frequency	104	days/year	(1)	[for child aged 2-6 years]
				CF	Conversion Factor	0.000001	kg/mg	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	
Residential	Surface Soil	Child/Adult Aggregate	Child (0-<2 yrs)	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
				IR-S-Adj (0-2)	Age Adjusted Ingestion Rate of Soil (0-<2 yrs)	39.7	mg-yr/day-kg	calculated	CS x IR-S-Adj (0-2) x EF x CF1 x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2002	[for child aged 0-<2 years]
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	
			Child/Adolescent Aggregate (2-<16 yrs)	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
				IR-S-Adj (2-16)	Age Adjusted Ingestion Rate of Soil (2-<6 yrs)	49.8	mg-yr/day-kg	calculated	CS x IR-S-Adj (2-16) x EF x CF1 x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2002	[for child/adolescent aged 2-<16 years]
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	
			Adolescent/Adult Aggregate (16-30 yrs)	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
				IR-S-Adj (16-30)	Age Adjusted Ingestion Rate of Soil (16-<30 yrs)	20.7	mg-yr/day-kg	calculated	CS x IR-S-Adj (16-30) x EF x CF1 x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2002	[for adolescent/adult aged 16-30 years]
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	
Recreational	Surface Soil / Sediment	Child	Child (0-<2 yrs)	CS	Chemical Concentration in Soil/Sediment	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
				SSAF-Adj (0-2)	Age Adjusted Soil/Sediment-to-Skin Adherence Factor (0-<2 yrs)	103	mg-yr/day-kg	calculated	CS x SSAF-Adj (0-2) x DABS x CF1 x EF x 1/AT
				DABS	Dermal Absorption Factor Solids	chemical-specific	--	EPA, 2004	[for child aged 0-<2 years]
				CF	Conversion Factor	0.000001	kg/mg	- -	
				EF	Exposure Frequency	104	days/year	(1)	
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	
			Child (2-6 yrs)	CS	Chemical Concentration in Soil/Sediment	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
				SSAF-Adj (2-6)	Age Adjusted Soil/Sediment-to-Skin Adherence Factor (2-<6 yrs)	144	mg-yr/day-kg	calculated	CS x SSAF-Adj (2-6) x DABS x CF1 x EF x 1/AT
				DABS	Dermal Absorption Factor Solids	chemical-specific	--	EPA, 2004	[for child aged 2-6 years]
				CF	Conversion Factor	0.000001	kg/mg	- -	
				EF	Exposure Frequency	104	days/year	(1)	
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	

Table 1a

Exposure Factors for Soil/Sediment Ingestion and Dermal Exposure Intakes - Adjusted for MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Exposure Point	Receptor Age		Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Residential	Surface Soil	Child/Adult Aggregate	Child (0-<2 yrs)	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
				SSAF-Adj (0-2)	Age Adjusted Soil to Skin Adherence Factor (0-<2 yrs)	103	mg-yr/day-kg	calculated	CS x SSAF-Adj (0-2) x DABS x CF1 x EF x 1/AT
				DABS	Dermal Absorption Factor Solids	chemical-specific	--	EPA, 2004	[for child aged 0-<2 years]
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	350	days/year	EPA, 2002	
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	
			Child/Adolescent Aggregate (2-<16 yrs)	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
				SSAF-Adj (2-16)	Age Adjusted Soil to Skin Adherence Factor(2-<16 yrs)	324	mg-yr/day-kg	calculated	CS x SSAF-Adj (2-16) x DABS x CF1 x EF x 1/AT
				DABS	Dermal Absorption Factor Solids	chemical-specific	--	EPA, 2004	[for child/adolescent aged 2-<16 years]
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	350	days/year	EPA, 2002	
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	
			Adolescent/Adult Aggregate (16-30 yrs)	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
				SSAF-Adj (16-30)	Age Adjusted Soil to Skin Adherence Factor(16-<30 yrs)	82.2	mg-yr/day-kg	calculated	CS x SSAF-Adj (16-30) x DABS x CF1 x EF x 1/AT
				DABS	Dermal Absorption Factor Solids	chemical-specific	--	EPA, 2004	[for adolescent/adult aged 16-30 years]
				CF1	Conversion Factor 1	0.000001	kg/mg	- -	
				EF	Exposure Frequency	350	days/year	EPA, 2002	
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	

Notes:

(1) Based on best professional judgment.

(2) Calculated as the product of 70 years assumed human lifetime (EPA, 1989a) x 365 days/year.

Sources:

EPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, OSWER 9355.4-24, December, 2002.

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mg/kg-day = Milligram per kilogram per day

mg/cm^2-day = Milligram per square centimeter per day

mg/day = Milligram per day

Table 2

Exposure Factors for Soil Inhalation Exposure Intakes - Non-MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Recreational	Adult	Emissions from Surface Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	Chronic Daily Intake (CDI) (mg/kg-day) =
			CA	Chemical Concentration in Air	Calculated	mg/m^3	EPA, 2002	CA x IN x EF x ED x 1/BW x 1/AT
			PEF	Particulate Emission Factor	site-specific	m^3/kg	see Table 6	
			VF	Volatilization Factor for volatile constituents	Calculated	m^3/kg	EPA, 2002	$CA (mg/m^3) = CS (1/PEF + 1/VF)$
			IN	Inhalation Rate	20	m^3/day	EPA, 2002	
			EF	Exposure Frequency	104	days/year	(1)	
			ED	Exposure Duration	24	years	(1)	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	8,760	days	(3)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	
	Youth	Emissions from Surface Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			CA	Chemical Concentration in Air	Calculated	mg/m^3	EPA, 2002	CA x IN x EF x ED x 1/BW x 1/AT
			PEF	Particulate Emission Factor	site-specific	m^3/kg	see Table 6	
			VF	Volatilization Factor for volatile constituents	Calculated	m^3/kg	EPA, 2002	$CA (mg/m^3) = CS (1/PEF + 1/VF)$
			IN	Inhalation Rate	20	m^3/day	EPA, 2002	
			EF	Exposure Frequency	104	days/year	(1)	
			ED	Exposure Duration	10	years	(2)	
			BW	Body Weight	39	kg	EPA 2004 (2)	
			AT-N	Averaging Time (Non-Cancer)	3,650	days	(3)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	
	Child	Emissions from Surface Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			CA	Chemical Concentration in Air	Calculated	mg/m^3	EPA, 2002	CA x IN x EF x ED x 1/BW x 1/AT
			PEF	Particulate Emission Factor	site-specific	m^3/kg	see Table 6	
			VF	Volatilization Factor for volatile constituents	Calculated	m^3/kg	EPA, 2002	$CA (mg/m^3) = CS (1/PEF + 1/VF)$
			IN	Inhalation Rate	15	m^3/day	EPA, 1997	
			EF	Exposure Frequency	104	days/year	(1)	
			ED	Exposure Duration	6	years	EPA, 2002	
			BW	Body Weight	15	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	2,190	days	(3)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	

Table 2

Exposure Factors for Soil Inhalation Exposure Intakes - Non-MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Residential	Adult	Emissions from Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			CA	Chemical Concentration in Air	Calculated	mg/m^3	EPA, 2002	CA x IN x EF x ED x 1/BW x 1/AT
			PEF	Particulate Emission Factor	site-specific	m^3/kg	see Table 6	
			VF	Volatilization Factor for volatile constituents	Calculated	m^3/kg	EPA, 2002	$CA\ (mg/m^3) = CS\ (1/PEF + 1/VF)$
			IN	Inhalation Rate	20	m^3/day	EPA, 2002	
			EF	Exposure Frequency	350	days/year	EPA, 2002	
			ED	Exposure Duration	24	years	EPA, 2002	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	8,760	days	(3)	
	Child	Emissions from Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			CA	Chemical Concentration in Air	Calculated	mg/m^3	EPA, 2002	CA x IN x EF x ED x 1/BW x 1/AT
			PEF	Particulate Emission Factor	site-specific	m^3/kg	see Table 6	
			VF	Volatilization Factor for volatile constituents	Calculated	m^3/kg	EPA, 2002	$CA\ (mg/m^3) = CS\ (1/PEF + 1/VF)$
			IN	Inhalation Rate	15	m^3/day	EPA, 1997	
			EF	Exposure Frequency	350	days/year	EPA, 2002	
			ED	Exposure Duration	6	years	EPA, 2002	
			BW	Body Weight	15	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	2,190	days	(3)	
	Child/Adult Aggregate	Emissions from Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			CA	Chemical Concentration in Air	Calculated	mg/m^3	Calculated	CA x IN-Adj x EF x 1/AT
			IN-Adj	Inhalation Rate, Adjusted	12.86	m^3-yr/kg-day	- -	
			EF	Exposure Frequency	350	days/year	EPA, 2002	IN-Adj (m^3-yr/kg-day) = (IN-A x ED-A / BW-A)
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	(IN-C x ED-C / BW-C)
Maintenance Worker	Adult	Emissions from Surface Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			CA	Chemical Concentration in Air	Calculated	mg/m^3	EPA, 2002	CA x IN x EF x ED x 1/BW x 1/AT
			PEF	Particulate Emission Factor	site-specific	m^3/kg	see Table 6	
			VF	Volatilization Factor for volatile constituents	Calculated	m^3/kg	EPA, 2002	$CA\ (mg/m^3) = CS\ (1/PEF + 1/VF)$
			IN	Inhalation Rate	20	m^3/day	EPA, 2002	
			EF	Exposure Frequency	52	days/year	(1)	
			ED	Exposure Duration	25	years	EPA, 2002	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	9,125	days	(3)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	

Table 2

Exposure Factors for Soil Inhalation Exposure Intakes - Non-MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Construction Worker	Adult	Emissions from Total Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			CA	Chemical Concentration in Air	Calculated	mg/m^3	EPA, 2002	CA x IN x EF x ED x 1/BW x 1/AT
			PEF	Particulate Emission Factor	site-specific	m^3/kg	see Table 7	
			VF	Volatilization Factor for volatile constituents	Calculated	m^3/kg	EPA, 2002	CA (mg/m^3) = CS (1/PEF + 1/VF)
			IN	Inhalation Rate	20	m^3/day	EPA, 2002	
			EF	Exposure Frequency	250	days/year	EPA, 2002	
			ED	Exposure Duration	1	years	EPA, 2002	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	365	days	(3)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	
Industrial Worker	Adult	Emissions from Total Soil	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
			CA	Chemical Concentration in Air	Calculated	mg/m^3	EPA, 2002	CA x IN x EF x ED x 1/BW x 1/AT
			PEF	Particulate Emission Factor	site-specific	m^3/kg	see Table 6	
			VF	Volatilization Factor for volatile constituents	Calculated	m^3/kg	EPA, 2002	CA (mg/m^3) = CS (1/PEF + 1/VF)
			IN	Inhalation Rate	20	m^3/day	EPA, 2002	
			EF	Exposure Frequency	250	days/year	EPA, 2002	
			ED	Exposure Duration	25	years	EPA, 2002	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	9,125	days	(3)	
			AT-C	Averaging Time (Cancer)	25,550	days	(4)	

Notes:

(1) Based on best professional judgment.

(2) Youths from 6 to 16 years of age. Body weight is average of the mean values for boys and girls for the ages 6 through 16

(3) Calculated as the product of ED (years) x 365 days/year.

(4) Calculated as the product of 70 years assumed human lifetime (EPA, 1989a) x 365 days/year.

Sources:

EPA, 1997: Exposure Factors Handbook. EPA/600/P-95/002Fa.

EPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, OSWER 9355.4-24, December, 2002.

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mg/m^3 = Milligram per cubic meter

m^3/day = Cubic meter per day

m^3/kg = Cubic meter per kilogram

Table 2a

Exposure Factors for Soil Inhalation Exposure Intakes - Adjusted for MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Exposure Point	Receptor Age		Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Recreational	Emissions from Surface Soil	Child	Child (0-<2 yrs)	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	Chronic Daily Intake (CDI) (mg/kg-day) =
				CA	Chemical Concentration in Air	Calculated	mg/m^3	EPA, 2002	CA x IN-Adj (0-2) x EF x 1/AT
				IN-Adj (0-2)	Age Adjusted Inhalation Rate (0-<2 yrs)	1.1	m^3-yr/day-kg	calculated	[for child aged 0-<2 years]
				PEF	Particulate Emission Factor	site-specific	m^3/kg	see Table 6	
				VF	Volatilization Factor for volatile constituents	Calculated	m^3/kg	EPA, 2002	$CA\ (mg/m^3) = CS\ (1/PEF + 1/VF)$
				EF	Exposure Frequency	104	days/year	(1)	
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	
			Child (2-6 yrs)	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
				CA	Chemical Concentration in Air	Calculated	mg/m^3	EPA, 2002	CA x IN-Adj (2-6) x EF x 1/AT
				IN-Adj (2-6)	Age Adjusted Inhalation Rate (2-<6 yrs)	2.0	m^3-yr/day-kg	calculated	[for child aged 2-6 years]
				PEF	Particulate Emission Factor	site-specific	m^3/kg	see Table 6	
				VF	Volatilization Factor for volatile constituents	Calculated	m^3/kg	EPA, 2002	$CA\ (mg/m^3) = CS\ (1/PEF + 1/VF)$
				EF	Exposure Frequency	104	days/year	(1)	
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	
Residential	Emissions from Surface Soil	Child/Adult Aggregate	Child (0-<2 yrs)	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
				CA	Chemical Concentration in Air	Calculated	mg/m^3	EPA, 2002	CA x IN-Adj (0-2) x EF x 1/AT
				IN-Adj (0-2)	Age Adjusted Inhalation Rate (0-<2 yrs)	1.1	m^3-yr/day-kg	calculated	[for child aged 0-<2 years]
				PEF	Particulate Emission Factor	site-specific	m^3/kg	see Table 6	
				VF	Volatilization Factor for volatile constituents	Calculated	m^3/kg	EPA, 2002	$CA\ (mg/m^3) = CS\ (1/PEF + 1/VF)$
				EF	Exposure Frequency	350	days/year	EPA, 2002	
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	
			Child/Adolescent Aggregate (2-<16 yrs)	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
				CA	Chemical Concentration in Air	Calculated	mg/m^3	EPA, 2002	CA x IN-Adj (2-16) x EF x 1/AT
				IN-Adj (2-16)	Age Adjusted Inhalation Rate (2-<16 yrs)	5.3	m^3-yr/day-kg	calculated	[for child/adolescent aged 2-<16 years]
				PEF	Particulate Emission Factor	site-specific	m^3/kg	see Table 6	
				VF	Volatilization Factor for volatile constituents	Calculated	m^3/kg	EPA, 2002	$CA\ (mg/m^3) = CS\ (1/PEF + 1/VF)$
				EF	Exposure Frequency	350	days/year	EPA, 2002	
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	

Table 2a

Exposure Factors for Soil Inhalation Exposure Intakes - Adjusted for MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Exposure Point	Receptor Age		Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Residential (cont.)	Emissions from Surface Soil	Child/Adult Aggregate (cont.)	Adolescent/Adult Aggregate (16-30 yrs)	CS	Chemical Concentration in Soil	site-specific	mg/kg	site-specific	CDI (mg/kg-day) =
				CA	Chemical Concentration in Air	Calculated	mg/m^3	EPA, 2002	CA x IN-Adj (16-30) x EF x 1/AT
				IN-Adj (16-30)	Age Adjusted Inhalation Rate (16-<30 yrs)	2.8	m^3-yr/day-kg	calculated	[for adolescent/adult aged 16-30 years]
				PEF	Particulate Emission Factor	site-specific	m^3/kg	see Table 6	
				VF	Volatilization Factor for volatile constituents	Calculated	m^3/kg	EPA, 2002	CA (mg/m^3) = CS (1/PEF + 1/VF)
				EF	Exposure Frequency	350	days/year	EPA, 2002	
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	

Notes:

(1) Based on best professional judgment.

(2) Calculated as the product of 70 years assumed human lifetime (EPA, 1989a) x 365 days/year.

Sources:

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m^3/day = Cubic meter per day

m^3/kg = Cubic meter per kilogram

Table 3

Exposure Factors for Tap Water Ingestion and Dermal Exposure Intakes - Non-MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Residential	Adult	Tap Water	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	Chronic Daily Intake (CDI) (mg/kg-day) =
			IR-W	Ingestion Rate of Water	2	L/day	EPA, 2002	CW x IR-W x EF x ED x CF1 x 1/BW x 1/AT
			EF	Exposure Frequency	350	days/year	EPA, 2002	
			ED	Exposure Duration	24	years	EPA, 2002	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	8,760	days	(1)	
			CF1	Conversion Factor 1	0.001	mg/µg	- -	
	Child	Tap Water	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	CDI (mg/kg-day) =
			IR-W	Ingestion Rate of Water	1	L/day	EPA, 1997	CW x IR-W x EF x ED x CF1 x 1/BW x 1/AT
			EF	Exposure Frequency	350	days/year	EPA, 2002	
			ED	Exposure Duration	6	years	EPA, 2002	
			BW	Body Weight	15	kg	EPA, 2002	
			AT-N	Averaging Time (Non-Cancer)	2,190	days	(1)	
			CF1	Conversion Factor 1	0.001	mg/µg	- -	
	Child/Adult Aggregate	Tap Water	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	CDI (mg/kg-day) =
			IR-W-Adj	Ingestion Rate of Water, Age-adjusted	1.1	liter-year/kg-day	calculated	CW x IR-W-Adj x EF x CF1 x 1/AT
			EF	Exposure Frequency	350	days/year	EPA, 2002	IR-W-Adj (liter-year/kd-day) =
			AT-C	Averaging Time (Cancer)	25,550	days	(2)	(ED-C x IR-W-C / BW-C) + (ED-A x IR-W-A / BW-A)
			CF1	Conversion Factor 1	0.001	mg/µg	- -	
Industrial Worker	Adult	Tap Water	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	CDI (mg/kg-day) =
			IR-W	Ingestion Rate of Water	1	L/day	EPA, 1991	CW x IR-W x EF x ED x CF1 x 1/BW x 1/AT
			EF	Exposure Frequency	250	days/year	EPA, 2002	
			ED	Exposure Duration	25	years	EPA, 2002	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-C	Averaging Time (Cancer)	25,550	days	(2)	
			AT-N	Averaging Time (Non-Cancer)	9,125	days	(1)	
			CF1	Conversion Factor 1	0.001	mg/µg	- -	

Table 3

Exposure Factors for Tap Water Ingestion and Dermal Exposure Intakes - Non-MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Resident	Adult	Tap Water	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	CDI (mg/kg-day) =
			DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
			FA	Fraction absorbed water	chemical-specific	dimensionless	EPA, 2004	
			Kp	Permeability Coefficient	chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
			τ	Lag Time	chemical-specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1 x CF2
			t*	Time to Reach Steady-state	chemical-specific	hours	EPA, 2004	
			B	Ratio of Permeability of Stratum Corneum to Epidermis	chemical-specific	dimensionless	EPA, 2004	Organics :
			t_{event}	Event Time	0.58	hr/event	EPA, 2004	t_{event}<t*: DAevent (mg/cm^2-event) =
			SA	Skin Surface Area Available for Contact	18,000	cm^2	EPA, 2004	2 x FA x Kp x CW x (sqrt((6 x τ x t_{event})/π)) x CF1 x CF2
			EV	Event Frequency	1	events/day	EPA, 2004	
			EF	Exposure Frequency	350	days/year	EPA, 2002	
			ED	Exposure Duration	24	years	EPA, 2002	t_{event}>t*: DAevent (mg/cm^2-event) =
			BW	Body Weight	70	kg	EPA, 2002	FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x
			AT-N	Averaging Time (Non-Cancer)	8,760	days	(1)	((1 + 3B + 3B^2)/(1+B)^2)) x CF1 x CF2
			CF1	Conversion Factor 1	0.001	mg/µg	- -	
			CF2	Conversion Factor 2	0.001	l/cm^3	- -	
	Child	Tap Water	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	CDI (mg/kg-day) =
			DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
			FA	Fraction absorbed water	chemical-specific	dimensionless	EPA, 2004	
			Kp	Permeability Coefficient	chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
			τ	Lag Time	chemical-specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1 x CF2
			t*	Time to Reach Steady-state	chemical-specific	hours	EPA, 2004	
			B	Ratio of Permeability of Stratum Corneum to Epidermis	chemical-specific	dimensionless	EPA, 2004	Organics :
			t_{event}	Event Time	1.00	hr/event	EPA, 2004	t_{event}<t*: DAevent (mg/cm^2-event) =
			SA	Skin Surface Area Available for Contact	6,600	cm^2	EPA, 2004	2 x FA x Kp x CW x (sqrt((6 x τ x t_{event})/π)) x CF1 x CF2
			EV	Event Frequency	1	events/day	EPA, 2004	
			EF	Exposure Frequency	350	days/year	EPA, 2002	
			ED	Exposure Duration	6	years	EPA, 2002	t_{event}>t*: DAevent (mg/cm^2-event) =
			BW	Body Weight	15	kg	EPA, 2002	FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x
			AT-N	Averaging Time (Non-Cancer)	2190	days	(1)	((1 + 3B + 3B^2)/(1+B)^2)) x CF1 x CF2
			CF1	Conversion Factor 1	0.001	mg/µg	- -	
			CF2	Conversion Factor 2	0.001	l/cm^3	- -	
	Child/Adult Aggregate	Tap Water	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	CDI (mg/kg-day) = DA-Adj x EF x EV x 1/AT
			DA-Adj	Dermally Absorbed Dose, Age-adjusted	Calculated	mg-year/event-kg	calculated	DA-Adj = (DAevent-A x SA-A x ED-A x 1/BW-A)
			EV	Event Frequency	1	events/day	EPA, 2004	+ (Daevent-C x SA-C x ED-C x 1/BW-C)
			EF	Exposure Frequency	350	days/year	EPA, 2002	
			AT-C	Averaging Time (Cancer)	25,550	days	(2)	
			CF1	Conversion Factor 1	0.001	mg/µg	- -	

Table 3

Exposure Factors for Tap Water Ingestion and Dermal Exposure Intakes - Non-MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Industrial Worker	Adult	Tap Water	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	CDI (mg/kg-day) =
			DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
			FA	Fraction absorbed water	chemical-specific	dimensionless	EPA, 2004	
			PC	Permeability Coefficient	chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
			τ	Lag Time	chemical-specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1 x CF2
			t*	Time to Reach Steady-state	chemical-specific	hours	EPA, 2004	
			B	Ratio of Permeability of Stratum Corneum to Epidermis	chemical-specific	dimensionless	EPA, 2004	Organics :
			t_{event}	Event Time	0.2	hr/event	(4)	t_{event}<t*: DAevent (mg/cm^2-event) =
			SA	Skin Surface Area Available for Contact	2,733	cm^2	EPA, 2004 (3)	2 x FA x Kp x CW x (sqrt((6 x τ x t_{event})/π)) x CF1 x CF2
			EV	Event Frequency	1	events/day	EPA, 1991	
			EF	Exposure Frequency	250	days/year	EPA, 2002	
			ED	Exposure Duration	25	years	EPA, 2002	t_{event}>t*: DAevent (mg/cm^2-event) =
			BW	Body Weight	70	kg	EPA, 2002	FA x PC x CW x (t_{event}/(1+B) + 2 x τ x
			AT-C	Averaging Time (Cancer)	25,550	days	(2)	((1 + 3B + $3B^2$)/$(1+B)^2$)) x CF1 x CF2
			AT-N	Averaging Time (Non-Cancer)	9,125	days	(1)	
			CF1	Conversion Factor 1	0.001	mg/µg	- -	
			CF2	Conversion Factor 2	0.001	l/cm^3	- -	

Notes:

(1) Calculated as the product of ED (years) x 365 days/year.

(2) Calculated as the product of 70 years assumed human lifetime (EPA, 1989a) x 365 days/year.

(3) The SA for an industrial worker exposed to tap water is based on face, forearms, and hands.

(4) Based on best professional judgment (total of 12 minutes per day).

Sources:

EPA, 1991: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.

EPA, 1997: Exposure Factors Handbook. EPA/600/P-95/002Fa.

EPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, OSWER 9355.4-24, December, 2002.

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

MMOA - Mutagenic mode of action

cm/hr = Centimeter per hour

cm^2 = Square centimeter

hr/day = Hour per day

hr/event = Hour per event

kg = Kilogram

L/cm^3 = Liter per cubic centimeter

L/day = Liter per day

mg/cm^2 -event = Milligram per square centimeter per event

mg/kg-day = Milligram per kilogram per day

mg/L = Milligram per liter

Table 3a

Exposure Factors for Tap Water Ingestion and Dermal Exposure Intakes - Adjusted for MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Exposure Point	Receptor Age		Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Residential	Tap Water	Child/Adult Aggregate	Child (0-<2 yrs)	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	CDI (mg/kg-day) =
				IR-W-Adj (0-2)	Ingestion Rate of Water, Age-adjusted (0-<2 yrs)	0.22	liter-year/kg-day	calculated	CW x IR-W-Adj (0-2) x EF x CF1 x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2002	[for child aged 0-<2 years]
				AT-C	Averaging Time (Cancer)	25,550	days	(1)	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
			Child/Adolescent Aggregate (2-<16 yrs)	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	CDI (mg/kg-day) =
				IR-W-Adj (2-16)	Ingestion Rate of Water, Age-adjusted (2-<16 yrs)	0.84	liter-year/kg-day	calculated	CW x IR-W-Adj (2-16) x EF x CF1 x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2002	[for child/adolescent aged 2-<16 years]
				AT-C	Averaging Time (Cancer)	25,550	days	(1)	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
			Adolescent/Adult Aggregate (16-30 yrs)	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	CDI (mg/kg-day) =
				IR-W-Adj (16-30)	Ingestion Rate of Water, Age-adjusted (16-<30 yrs)	0.41	liter-year/kg-day	calculated	CW x IR-W-Adj (16-30) x EF x CF1 x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2002	[for adolescent/adult aged 16-30 years]
				AT-C	Averaging Time (Cancer)	25,550	days	(1)	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
Resident (cont.)	Tap Water (cont.)	Child/Adult Aggregate (cont.)	Child/Adult Aggregate	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	Inorganics: DAevent (mg/cm^2-event) =
				DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	Kp x CW x t_{event} x CF1 x CF2
				FA	Fraction absorbed water	chemical-specific	dimensionless	EPA, 2004	Organics :
				Kp	Permeability Coefficient	chemical-specific	cm/hr	EPA, 2004	t_{event}<t*: DAevent (mg/cm^2-event) =
				τ	Lag Time	chemical-specific	hr/event	EPA, 2004	2 x FA x Kp x CW x (sqrt((6 x τ x t_{event})/π)) x CF1 x CF2
				t*	Time to Reach Steady-state	chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	chemical-specific	dimensionless	EPA, 2004	t_{event}>t*: DAevent (mg/cm^2-event) =
				t_{event}	Event Time	see below	hr/event	EPA, 2004	FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x
				CF1	Conversion Factor 1	0.001	mg/µg	- -	((1 + 3B + $3B^2$)/$(1+B)^2$)) x CF1 x CF2
				CF2	Conversion Factor 2	0.001	l/cm^3	- -	

Table 3a

Exposure Factors for Tap Water Ingestion and Dermal Exposure Intakes - Adjusted for MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Exposure Point	Receptor Age		Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
			Child	DA-Adj	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	CDI (mg/kg-day) =
			(0-<2 yrs)	SA-Adj (0-2)	Skin Surface Area, Age-adjusted (0-<2 yrs)	1,172	cm^2-year/kg	calculated	DAevent x SA-Adj (0-2) x EV x EF x 1/AT
				EV	Event Frequency	1	events/day	EPA, 2004	[for child aged 0-<2 years]
				t_{event}	Event Time (0-<6 yrs)	1.0	hr/event	EPA, 2004	
				EF	Exposure Frequency	350	days/year	EPA, 2002	
				AT-C	Averaging Time (Cancer)	25,550	days	(1)	
			Child/Adolescent	DA-Adj	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	CDI (mg/kg-day) =
			Aggregate	SA-Adj (2-6)	Skin Surface Area, Age-adjusted (2-<6 yrs)	1,685	cm^2-year/kg	calculated	DAevent x SA-Adj (2-6) x EV x EF x 1/AT
			(2-6 yrs)	EV	Event Frequency	1	events/day	EPA, 2004	[for child/adolescent aged 2-6 years]
				t_{event}	Event Time (0-<6 yrs)	1.0	hr/event	EPA, 2004	
				EF	Exposure Frequency	350	days/year	EPA, 2002	
				AT-C	Averaging Time (Cancer)	25,550	days	(1)	
			Child/Adolescent	DA-Adj	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	CDI (mg/kg-day) =
			Aggregate	SA-Adj (2-16)	Skin Surface Area, Age-adjusted (6-<16 yrs)	3,234	cm^2-year/kg	calculated	DAevent x SA-Adj (6-16) x EV x EF x 1/AT
			(6-<16 yrs)	EV	Event Frequency	1	events/day	EPA, 2004	[for child/adolescent aged 6-<16 years]
				t_{event}	Event Time (6-<30 yrs)	0.58	hr/event	EPA, 2004	
				EF	Exposure Frequency	350	days/year	EPA, 2002	
				AT-C	Averaging Time (Cancer)	25,550	days	(1)	
			Adolescent/Adult	DA-Adj	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	CDI (mg/kg-day) =
			Aggregate	SA-Adj (16-30)	Skin Surface Area, Age-adjusted (16-<30 yrs)	3,687	cm^2-year/kg	calculated	DAevent x SA-Adj (16-30) x EV x EF x 1/AT
			(16-30 yrs)	EV	Event Frequency	1	events/day	EPA, 2004	[for adolescent/adult aged 16-30 years]
				t_{event}	Event Time (6-<30 yrs)	0.58	hr/event	EPA, 2004	
				EF	Exposure Frequency	350	days/year	EPA, 2002	
				AT-C	Averaging Time (Cancer)	25,550	days	(1)	

Notes:

(1) Calculated as the product of 70 years assumed human lifetime (EPA, 1989a) x 365 days/year.

Sources:

EPA, 1991: Risk Assessment Guidance for Superfund. Vol.1: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.

EPA, 1997: Exposure Factors Handbook. EPA/600/P-95/002Fa.

EPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, OSWER 9355.4-24, December, 2002.

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

MMOA - Mutagenic mode of action

cm/hr = Centimeter per hour

cm^2 = Square centimeter

hr/day = Hour per day

hr/event = Hour per event

kg = Kilogram

L/cm^3 = Liter per cubic centimeter

L/day = Liter per day

mg/cm^2 -event = Milligram per square centimeter per event

mg/kg-day = Milligram per kilogram per day

mg/L = Milligram per liter

Table 4

Exposure Factors for Groundwater Inhalation Exposure Intakes - Non-MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Resident	Adult	Water Vapors in Bathroom	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	Chronic Daily Intake (CDI) (mg/kg-day) =
			CA	Chemical Concentration in Air from Shower	calculated	mg/m^3	- -	CA x IN x ET x EF x ED x 1/BW x 1/AT
			IN	Inhalation Rate	0.83	m^3/hr	EPA, 2002	
			ET	Exposure Time	0.58	hr/day	(1)	CA calculated based on CW using Andelman model
			EF	Exposure Frequency	350	days/year	EPA, 2002	as modified by Schaum et al.
			ED	Exposure Duration	24	years	EPA, 2002	
			BW	Body Weight	70	kg	EPA, 2002	
			AT-C	Averaging Time (Cancer)	25,550	days	(2)	
			AT-N	Averaging Time (Non-Cancer)	8,760	days	(3)	
	Child	Water Vapors in Bathroom	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	CDI (mg/kg-day) =
			CA	Chemical Concentration in Air from Shower	calculated	mg/m^3	- -	CA x IN x ET x EF x ED x 1/BW x 1/AT
			IN	Inhalation Rate	0.63	m^3/hr	EPA, 1997	
			ET	Exposure Time	1	hr/day	(1)	CA calculated based on CW using Andelman model
			EF	Exposure Frequency	350	days/year	EPA, 2002	as modified by Schaum et al.
			ED	Exposure Duration	6	years	EPA, 2002	
			BW	Body Weight	15	kg	EPA, 2002	
			AT-C	Averaging Time (Cancer)	25,550	days	(2)	
			AT-N	Averaging Time (Non-Cancer)	2,190	days	(3)	
	Adult/Child Aggregate	Water Vapors in Bathroom	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	CDI (mg/kg-day) =
			CA	Chemical Concentration in Air	Calculated	mg/m^3	Calculated	CA x CF x IN-adj x EF x 1/AT
			IN-Adj	Inhalation Rate, Adjusted	12.86	m^3-yr/kg-day	- -	
			EF	Exposure Frequency	350	days/year	EPA, 2002	IN-Adj (m^3-yr/kg-day) = (IN-A x ED-A / BW-A)
			AT-C	Averaging Time (Cancer)	25,550	days	(2)	(IN-C x ED-C / BW-C)
			CF	Conversion Factor	0.001	mg/µg	- -	

Notes:

(1) EPA Region 2 and the Andelman model as modified by Schaum et. al.

(2) Calculated as the product of 70 years assumed human lifetime (EPA, 1989a) x 365 days/year.

(3) Calculated as the product of ED (years) x 365 days/year.

Sources:

EPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, OSWER 9355.4-24, December, 2002.

EPA, 1997: Exposure Factors Handbook. EPA/600/P-95/002Fa.

MMOA - Mutagenic mode of action

hr/day = Hour per day

kg = Kilogram

m^3/hour = Cubic meter per hour

mg/kg-day = Milligram per kilogram per day

mg/kg-shower = Milligram per kilogram per shower

mg/µg = Milligram per microgram

mg/m^3 = Milligram per cubic meter

µg/L = Microgram per liter

$µg/m^3$ = Microgram per cubic meter

Table 4a

Exposure Factors for Groundwater Inhalation Exposure Intakes - Adjusted for MMOA COPCs

Former NASD, Vieques, Puerto Rico

Receptor Population	Exposure Point	Receptor Age		Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Resident	Water Vapors in Bathroom	Adult/Child Aggregate	Child (0-<2 yrs)	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	Chronic Daily Intake (CDI) (mg/kg-day) =
				CA	Chemical Concentration in Air	Calculated	mg/m^3	Calculated	CA x IN-Adj (0-2) x ET x EF x CF x 1/AT
				IN-Adj (0-2)	Inhalation Rate, Adjusted (0-<2 yrs)	1.1	m^3-yr/kg-day	Calculated	[for child aged 0-<2 years]
				ET	Exposure Time	1	hr/day	(1)	
				EF	Exposure Frequency	350	days/year	EPA, 2002	CA calculated based on CW using Andelman model
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	as modified by Schaum et al.
				CF	Conversion Factor	1/24	day/hr	- -	
			Child/Adolescent Aggregate (2-6 yrs)	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	CDI (mg/kg-day) =
				CA	Chemical Concentration in Air	Calculated	mg/m^3	Calculated	CA x IN-Adj (2-6) x ET x EF x CF x 1/AT
				IN-Adj (2-6)	Inhalation Rate, Adjusted (2-<6 yrs)	2.0	m^3-yr/kg-day	Calculated	[for child/adolescent aged 2-6 years]
				ET	Exposure Time	1	hr/day	(1)	
				EF	Exposure Frequency	350	days/year	EPA, 2002	CA calculated based on CW using Andelman model
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	as modified by Schaum et al.
				CF	Conversion Factor	1/24	day/hr	- -	
			Child/Adolescent Aggregate (6-<16 yrs)	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	CDI (mg/kg-day) =
				CA	Chemical Concentration in Air	Calculated	mg/m^3	Calculated	CA x IN-Adj (6-16) x ET x EF x CF x 1/AT
				IN-Adj (6-16)	Inhalation Rate, Adjusted (6-<16 yrs)	3.4	m^3-yr/kg-day	Calculated	[for child/adolescent aged 6-<16 years]
				ET	Exposure Time	0.58	hr/day	(1)	
				EF	Exposure Frequency	350	days/year	EPA, 2002	CA calculated based on CW using Andelman model
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	as modified by Schaum et al.
				CF	Conversion Factor	1/24	day/hr	- -	
			Adolescent/Adult Aggregate (16-30 yrs)	CW	Chemical Concentration in Water	site-specific	µg/l	site-specific	CDI (mg/kg-day) =
				CA	Chemical Concentration in Air	Calculated	mg/m^3	Calculated	CA x IN-Adj (16-30) x ET x EF x CF x 1/AT
				IN-Adj (16-30)	Inhalation Rate, Adjusted (16-<30 yrs)	2.8	m^3-yr/kg-day	Calculated	[for adolescent/adult aged 16-30 years]
				ET	Exposure Time	0.58	hr/day	(1)	
				EF	Exposure Frequency	350	days/year	EPA, 2002	CA calculated based on CW using Andelman model
				AT-C	Averaging Time (Cancer)	25,550	days	(2)	as modified by Schaum et al.
				CF	Conversion Factor	1/24	day/hr	- -	

Notes:

(1) EPA Region 2 and the Andelman model as modified by Schaum et. al.

(2) Calculated as the product of 70 years assumed human lifetime (EPA, 1989a) x 365 days/year.

Sources:

EPA, 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, OSWER 9355.4-24, December, 2002.

MMOA - Mutagenic mode of action

hr/day = Hour per day

kg = Kilogram

m^3/hour = Cubic meter per hour

mg/kg-day = Milligram per kilogram per day

mg/kg-shower = Milligram per kilogram per shower

mg/µg = Milligram per microgram

mg/m^3 = Milligram per cubic meter

µg/L = Microgram per liter

$µg/m^3$ = Microgram per cubic meter

TABLE 5
Age-Adjusted Exposure Factors
Former NASD, Vieques, Puerto Rico

			Intake Rate		Dermal			Age-Adjusted Exposure Factors				
AGE (year)	ED (years)	BW [1] (kg)	SOIL IR-S [2] (mg/day)	AIR IN [3] (m3/day)	SOIL SSAF [4] (mg/cm2-event)	EXPOSED SA [5] (cm2)	TOTAL SA [6] (cm2)	AGE GROUP	IR-S-Adj (mg-yr/day-kg)	IN-Adj (m3-yr/day-kg)	SSAF-Adj (mg-yr/day-kg)	TOTAL SA (cm2-yr/kg)
0	1	9.1	200	4.5	0.2	2,625	5,910	0-<2 yrs	39.7	1.1	103	1,172
1	1	11.3	200	6.8	0.2	2,571	5,910					
2	1	13.3	200	6.8	0.2	2,434	5,910	2-<6 yrs	49.8	2.0	144	1,685
3	1	15.3	200	8.3	0.2	2,893	6,565					
4	1	17.4	200	8.3	0.2	3,175	7,185					
5	1	19.7	200	8.3	0.2	3,255	7,860					
6	1	22.6	100	10	0.2	2,949	8,545	6-<16 yrs	28.1	3.4	180	3,234
7	1	24.9	100	10	0.2	3,182	9,265					
8	1	28.1	100	10	0.2	3,434	10,000					
9	1	31.5	100	13.5	0.2	3,657	10,650					
10	1	36.3	100	13.5	0.2	3,819	11,750					
11	1	41.1	100	13.5	0.2	4,111	12,650					
12	1	45.3	100	13.5	0.2	4,453	13,700					
13	1	50.4	100	13.5	0.07	4,916	14,750					
14	1	56	100	13.5	0.07	5,205	15,800					
15	1	58.1	100	14.5	0.07	5,386	16,350					
								2-<16 yrs	77.8	5.3	323.8	4,920
16	1	62.6	100	14.5	0.07	5,534	16,800	16-<30 yrs	20.7	2.8	82.2	3,687
17	1	63.2	100	14.5	0.07	5,641	17,150					
18	1	65.1	100	14.5	0.07	5,700	18,000					
19	1	66	100	13.25	0.07	5,700	18,000					
20	1	67.2	100	13.25	0.07	5,700	18,000					
21	1	67.2	100	13.25	0.07	5,700	18,000					
22	1	67.2	100	13.25	0.07	5,700	18,000					
23	1	67.2	100	13.25	0.07	5,700	18,000					
24	1	67.2	100	13.25	0.07	5,700	18,000					
25	1	71.5	100	13.25	0.07	5,700	18,000					
26	1	71.5	100	13.25	0.07	5,700	18,000					
27	1	71.5	100	13.25	0.07	5,700	18,000					
28	1	71.5	100	13.25	0.07	5,700	18,000					
29	1	71.5	100	13.25	0.07	5,700	18,000					

Equations and Definitions:

IR-S-Adj (mg-yr/day-kg) $\sum$ (ED * IR-S) / BW
SSAF-Adj (mg-yr/day-kg) $\sum$ (ED * EV * SSAF * SA) / BW
IN-Adj (m3-yr/day-kg) $\sum$ (ED * IN) / BW

ED - Exposure duration
BW - Body weight
IR-S - Ingestion rate for soil

SSAF - Soil-to-skin adherence factor
SA - Skin surface area
EV - Event frequency

References:

[1] EPA 1997. Exposure Factors Handbook. Tables 7-2 (adults) and 7-3 (children), mean. Values are mean of male and female. Source: National Center of Health Statistics (NCHS) 1987.

[2] EPA 1991. Standard Default Exposure Factors. Default for resident child and adult.

[3] EPA 1997. Exposure Factors Handbook. Table 5-23 - Summary of Recommended Values for Inhalation. Mean of male and female.

[4] EPA 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment).
Recommended default adherence factor for a child resident (0.2) and adult resident (0.07). For older children, the geometric mean weighted adherence factor for children playing in wet soil was used for children 6 - 12, as an estimate of a high-end soil contact activity (see Exhibit 3-3).

[5] EPA 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)
Calculated from Exhibit C-1 - Body Part-Specific Surface Area Calculations (Children). Data from Exposure Factors Handbook, Tables 6-6, 6-7 and 6-8.
Surface area of head, forearms, hands, lower legs and feet (for child <6 years); feet excluded from surface area calculation for >6 years.
Surface area for >18 is recommended default for adult resident (EPA 2004).

[6] EPA 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)
Exhibit C-1 - Body Part-Specific Surface Area Calculations (Children). Data from Exposure Factors Handbook, Tables 6-6 and 6-7.
Total Body Surface Area (50th percentile).

The EPCs for soil will be estimated for receptors using data collected from the depth intervals indicated below:

- Maintenance Workers – 0-2 feet;
- Recreational Users – 0-1 or 0-2 feet, depending on the site-specific determination of the surface soil sampling depth;
- Construction Workers – 0-6 feet;
- Industrial Workers – 0-6 feet;
- Residents – 2 sets of EPCs will be calculated: one based on samples collected from 0-1 or 0-2 feet, depending on the site-specific determination of the surface soil sampling depth (to address EPA's preferred approach); and the second based on samples collected from 0-6 feet (to address EQB's preferred approach). As a conservative approach, the higher of the two EPCs for each COPC will be used in the risk calculations. Uncertainties associated with this approach will be addressed in the uncertainty assessment section of the HHRA.

The groundwater EPCs will be calculated from the wells located in the apparent center of the plume per EPA guidance on EPCs in Groundwater (EPA, 1991a). The UCLs will be estimated using ProUCL. Unfiltered sample results will be used for the groundwater EPC estimations, unless the filtered results are shown to be a better representation of groundwater chemical conditions.

The PEFs will be calculated based on EPA guidance (**EPA, 2002b**) and will provide a site-specific PEF for residents/recreators/maintenance workers/industrial workers and a separate site-specific PEF for a construction worker. For each PEF, the area of impacted soil at each site will be used to calculate the site-specific PEFs. The PEF equations and input parameters are presented in Tables 6 and 7.

Table 6
Particulate Emission Factor - Recreator/Resident/Industrial Worker/Maintenance Worker
Former NASD, Vieques, Puerto Rico

PEF Equations:

$$Q/C_{wind} = A \times \exp\left[\frac{(\ln A_{site} - B)^2}{C}\right]$$

Exhibit D-2 (EPA, 2002)

$$PEF = Q/C_{wind} \times \frac{3{,}600 \text{sec/ hr}}{0.036 \times (1-V) \times \left(U_m/U_t\right)^3 \times F(x)}$$

Equation 4-5 (EPA, 2002)

PEF and Box Model Input Parameters

Parameter	Definition	Value	Units	Source
Q/C_{wind}	inverse ratio of the geometric mean air concentration to the emission flux at the center of a square source		m	calculated
A	Constant for Zone 9 (Miami, FL)	12.196	unitless	Exhibit D-2 (EPA, 2002)
B	Constant for Zone 9 (Miami, FL)	19.065	unitless	Exhibit D-2 (EPA, 2002)
C	Constant for Zone 9 (Miami, FL)	215.392	unitless	Exhibit D-2 (EPA, 2002)
A_{site}	Areal extent of site contamination	site-specific	acres	site-specific
PEF	particulate emission factor		m^3/kg	calculated
V	fraction of vegetative cover	0.5	unitless	Default (Eqn. 4-5)
Um	mean annual windspeed	4.69	m/s	Default (Eqn. 4-5)
Ut	equivalent threshold value of windpeed at 7 m	11.32	m/s	Default (Eqn. 4-5)
F(x)	function dependent on Um/Ut derived using Cowherd et al. (1985)	0.194	unitless	Default (Eqn. 4-5)

Source:

EPA, 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, EPA Office of Solid Waste and Emergency Response. OSWER 9355.4-24. December.

Table 7
Particulate Emission Factor - Construction Worker
Former NASD, Vieques, Puerto Rico

PEF Equations:

$$Q/C_{Sr} = A \times \exp\left[\frac{(\ln A_{site} - B)^2}{C}\right]$$

Equation 5-6 (EPA, 2002)

$$PEF_{SC} = Q/C_{Sr} \times \frac{1}{F_D} \frac{T \times A_R}{556 \times (W/3)^{0.4} \times \left(\frac{365\ d/yr - p}{365\ d/yr}\right)^3 \times \sum VKT}$$

Equation 5-5 (EPA, 2002)

$$F_D = 0.1852 + \frac{5.3537}{t_c} + \frac{-9.6318}{t_c^{\,2}}$$

Equation E-16 (EPA, 2002)

PEF and Box Model Input Parameters

Parameter	Definition	Value	Units	Source
Q/C_{Sr}	inverse ratio of the geometric mean air concentration to the emission flux at the center of a square source		m	calculated
A	Constant	12.935	unitless	default (Eqn. 5-6)
B	Constant	5.738	unitless	default (Eqn. 5-6)
C	Constant	71.771	unitless	default (Eqn. 5-6)
A_{site}	Areal extent of site contamination	site-specific	acres	site-specific
PEF_{SC}	subchronic road particulate emission factor		m^3/kg	calculated
F_D	Dispersion correction factor		unitless	calculated
t_c	duration of construction (250 days for 8 hr/day)	2,000	hr	assumed
T	total time over which construction occurs (t_c x 3600 s/hr)	7,200,000	s	assumed
A_R	surface area of contaminated road segment	274.21	m^2	default (Eqn. 5-5)
W	mean weight of vehicle [(1 car @ 2 tons/car) + (2 trucks @ 20 tons/truck)] / 3 vehicles)	14	tons	assumed
p	number of days with at least 0.01 inches of precipitation (based on measured 2005 data)	92	days/yr	Vieques-specific measured in 2005
VKT	sum of fleet vehicle kilometers traveled during the exposure duration (assumed 3 vehicles x 0.045 km/day x 250 days)	33.8	km	assumed

Source:

EPA, 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, EPA Office of Solid Waste and Emergency Response. OSWER 9355.4-24. December.

Toxicity Assessment

The human health risk assessment will include a toxicity assessment section that compiles the toxicity criteria for risk and hazard index (HI) estimates. EPA recommends that a tiered approach be used to obtain the toxicity values used to estimate non-cancer and cancer risks (EPA, 2003). Following EPA's recommended approach, the sources of toxicity values will be as follows:

1. Tier I Toxicity criteria: The EPA's IRIS database, which contains up-to-date toxicity information for numerous chemicals. IRIS includes only non-carcinogenic RfDs and cancer slope factors (CSFs) that have been verified by EPA work groups and is the EPA's preferred source of toxicity information.
2. Tier II Toxicity Criteria: For chemicals with no toxicity criteria listed on IRIS, EPA Region 2 will be contacted to obtain interim toxicity criteria from the National Center for Environmental Assessment (NCEA). These are considered the second tier of toxicity factors, which are from the Provisional Peer Reviewed Toxicity Value (PPRTV) database maintained by the EPA's NCEA and the Superfund Health Risk Technical Support Center (STSC).
3. Tier III Toxicity Criteria: If toxicity data are not available from either of the first two sources, the EPA will consider toxicity values obtained from other EPA and peer-reviewed, and non-EPA sources including the Agency for Toxic Substances and Disease Registry (ATSDR), Health Effects Assessment Summary Tables (HEAST), Cal/EPA, EPA's Office of Water, and World Health Organization (WHO).

In accordance with current Department of Defense policy, toxicity values presented in the Cal/EPA toxicity criteria database will be used for TCE until toxicity values are provided in the EPA's IRIS database. The Cal/EPA toxicity values for TCE will be used in the risk estimates presented in the RAGS Part D tables. In addition, the draft EPA toxicity values for TCE will be used to calculate a second set of risk estimates that are discussed in the uncertainty assessment section of the HHRA.

The use of provisional toxicity values in an HHRA, including those from the PPRTV database, increases the uncertainty of the quantitative risk estimates. The toxicity values that will be used for the chemicals identified as COPCs will be included in RAGS Part D format.

Dermal Toxicity Factors

Adjustments of oral toxicity values will be made to estimate the effects of doses absorbed through the skin using the EPA RAGS Part E recommended methodology.

Risk Characterization

Risk characterization is the process of integrating the previous elements of the risk assessment into quantitative or semi-quantitative expressions of risk. The quantification of risk will be used as an integral component in risk-management and remedy decision-making.

Potential human health risks will be discussed independently for carcinogenic and non-carcinogenic constituents because of the different toxicological endpoints, relevant exposure durations, and methods used to characterize risk. The constituents that could produce both

non-carcinogenic and carcinogenic effects will be evaluated in both groups. The methodology used to estimate non-carcinogenic hazards and carcinogenic risk are described in the following sections. Total risks (site-related plus background) will be calculated. The estimated risks associated with chemicals within background levels will be presented so that the portion of the total risk that is attributable to background concentrations can be seen and used in risk management decisions, in accordance with EPA guidance (2002c).

Subsequent to characterizing potential site-related risks, the risk estimates will be evaluated and considered by the risk managers at EPA, and risk management decisions will be made. EPA Superfund guidance generally considers an acceptable site cancer risk range to be within 1 to 100 in a million (10^{-6} to 10^{-4}). Generally, remedial actions are not warranted at sites with risks below 10^{-4} or HI less than 1.0 (EPA, April 1991). If the cumulative risk is less than 10^{-4}, action generally is not required, but it may be warranted if another standard (for example, MCL) is exceeded, or if other site-specific information suggests to risk managers that action is appropriate.

Non-carcinogenic Hazard Estimation Methods

Non-carcinogenic hazards are estimated by comparing the calculated exposure intake levels to reference doses (RfDs). The calculated intake of each constituent will be divided by the RfD. This ratio is referred to as the HQ:

$$HQ = Intake / RfD$$

Intake and RfD are expressed in the same units (mg/kg-day) and represent the same exposure period (i.e., chronic or subchronic). The intake and RfD also represent the same exposure route (i.e., inhalation intakes are divided by the inhalation RfDs, oral intakes are divided by the oral RfDs, and dermal intakes are divided by an adjusted oral RfD). An HQ that exceeds 1.0 (i.e., intake exceeds the RfD) indicates that there is a potential for adverse health effects associated with exposure to that constituent.

To assess the potential for non-carcinogenic health effects posed by exposure to multiple chemicals and exposure routes, an HI approach will be used (EPA, 1989). This approach assumes that non-carcinogenic hazards associated with exposure to more than one chemical and exposure route are additive. Synergistic or antagonistic interactions between chemicals are not quantified. The HI may exceed 1.0 even if all of the individual HQs are less than 1.0. The constituents may then be separated by similar mechanisms of toxicity and toxicological effects, and separate HIs may be calculated, based on each specific toxic mechanism and target organ affected.

Carcinogenic Risk Estimation

The potential for carcinogenic effects due to exposure to site-related contamination will be evaluated by estimating the excess lifetime carcinogenic risk (ELCR). The ELCR is the incremental increase in the probability of developing cancer during one's lifetime above the background probability of developing cancer.

Potential ELCRs associated with exposure to individual carcinogens will be calculated using cancer slope factors (CSFs) and the CDIs (or SDIs). For sites where ELCRs are below 0.01, the linear low-dose equation will be used to estimate the incremental probability of an

individual developing cancer over a lifetime as a result of exposure to the potential carcinogen. Estimated ELCRs are calculated by multiplying the intake by the CSF.

$$ELCR = Intake \times CSF$$

In instances where COPC intakes and risks are high (0.01 or higher), the one-hit equation will be used to estimate ELCRs:

$$ELCR = 1 - \exp(-CDI \times CSF)$$

where:

Risk = unitless probability of an individual developing cancer

exp = the exponential

CDI = chronic daily intake averaged over 70 years

CSF = cancer slope factor

Consistent with the Cancer Guidelines and Supplemental Guidance (EPA, 2005a and 2005b), COPCs which act via a mutagenic mode of action (MMOA) for carcinogenicity will be evaluated using Age-Dependent Adjustment Factors (ADAFs). For these chemicals, the Supplemental Guidance identifies three specific age groups for ADAFs: < 2 years (ADAF of 10), 2 - < 16 years (ADAF of 3), and > 16 years (ADAF of 1). Both the RAGS Part D tables and text will address the COPCs with a MMOA.

The combined risk from exposure to multiple COPCs at a site will be evaluated by adding the risks from individual COPCs. Risks will be added across the exposure pathways if an individual will be exposed through multiple exposure pathways.

Uncertainty Assessment

The risk measures used in Superfund site risk assessments are not fully probabilistic estimates of risk, but are conditional estimates based on the realization of a set of assumptions about exposure and toxicity. Thus, it will be important to specify the assumptions and uncertainties inherent in the site-specific risk assessment to place the risk estimates in proper perspective (EPA, 1989).

General Uncertainty in Data Evaluation and COPC Selection

The uncertainty related to the available dataset and the selection of COPCs at each site will be addressed by using conservative assumptions, when applicable. The uncertainty in sampling and the possibility of not sampling a contaminated site location will be discussed.

A comparison of site concentrations to background concentrations will not be used to select the COPCs. Therefore, the COPCs that are included but that may be attributable to background concentrations will be discussed.

Uncertainty Associated with Exposure Assessment

Uncertainty in the exposure assessment will be generally treated with conservative decision rules and assumptions. The uncertainties associated with the EPCs and exposure factors used in the intake equations will be discussed.

Uncertainty Associated with Toxicity Assessment

Uncertainty associated with the non-carcinogenic and carcinogenic toxicity factors will be included in RAGS Part D tables. In addition, the uncertainty associated with the oral-to-dermal adjustment factors (based on chemical-specific gastrointestinal absorption) and chemicals with missing toxicity values will be discussed.

Uncertainty in Risk Characterization

The uncertainties identified in each component of the risk assessment ultimately contribute to the uncertainty in risk characterization. The addition of ELCRs and HIs across pathways and chemicals contributes to uncertainty based on the interaction of chemicals such as additivity, synergism, potentiation, and susceptibility of exposed receptors. This concept will be discussed.

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ATTACHMENT 6

Ecological Risk Assessment Protocol for Vieques Environmental Restoration Program

Ecological Risk Assessment Protocol for Vieques Environmental Restoration Program

The ecological risk assessments (ERAs) to be performed at Vieques Island, Puerto Rico, will be conducted in accordance with the *Navy Policy for Conducting Ecological Risk Assessments* (CNO, 1999) and the Navy guidance for implementing this ERA policy (NAVFAC, 2003). The Navy ERA policy and guidance, which describe a process consisting of eight steps organized into three tiers, are conceptually similar to the eight-step ERA process outlined in U.S. Environmental Protection Agency (EPA) ERA guidance for the Superfund program (EPA, 1997; Figure 1). For both sets of guidance, Steps 1 and 2 involve conducting a Screening ERA (SERA) using very conservative assumptions. The Baseline ERA (BERA) represents Steps 3 through 7. The BERA uses more realistic assumptions and site-specific data to refine the risk estimates from the SERA for components that fail the initial screen. Step 8 addresses risk management issues. The major differences between the Navy ERA policy/guidance and the EPA ERA guidance are:

1) The Navy policy/guidance provides clearly defined criteria for exiting the ERA process at specific points (see Figure 2)

2) The Navy policy/guidance divides Step 3 (the first step of the BERA) into two distinct sub-steps (Steps 3A and 3B), with a potential exit point after Step 3A

3) The Navy policy/ guidance incorporates risk management considerations throughout all tiers of the ERA process

The ERA process to be used at Vieques Island is summarized in Table 1.

TABLE 1
Summary of the Ecological Risk Assessment Process
Vieques Island, Puerto Rico

Step	Description	Decision Required
1	Screening Problem Formulation	Complete exposure pathways exist? Sufficient data available to conduct screen?
2	Screening Ecological Effects Evaluation, Exposure Estimate, and Risk Calculation	Have all assessment endpoints been met (risks acceptable) within acceptable uncertainty? Continue on to Baseline ERA?
3A	Refinement of Conservative Exposure Assumptions	Have all assessment endpoints been met (risks acceptable) within acceptable uncertainty?
3B	Baseline Problem Formulation	Agreement on problem formulation and need for additional studies
4	Study Design and Data Quality Objectives	Agreement on study design, data quality objectives, and data analysis methods
5	Field Verification of Sampling Design	Approval of site-specific work plan and sampling and analysis plan
6	Site Investigation and Data Analysis	None
7	Risk Characterization	Have all assessment endpoints been met (risks acceptable) within acceptable uncertainty?
8	Risk Management	Agreement on remedial actions (in FS/ROD)

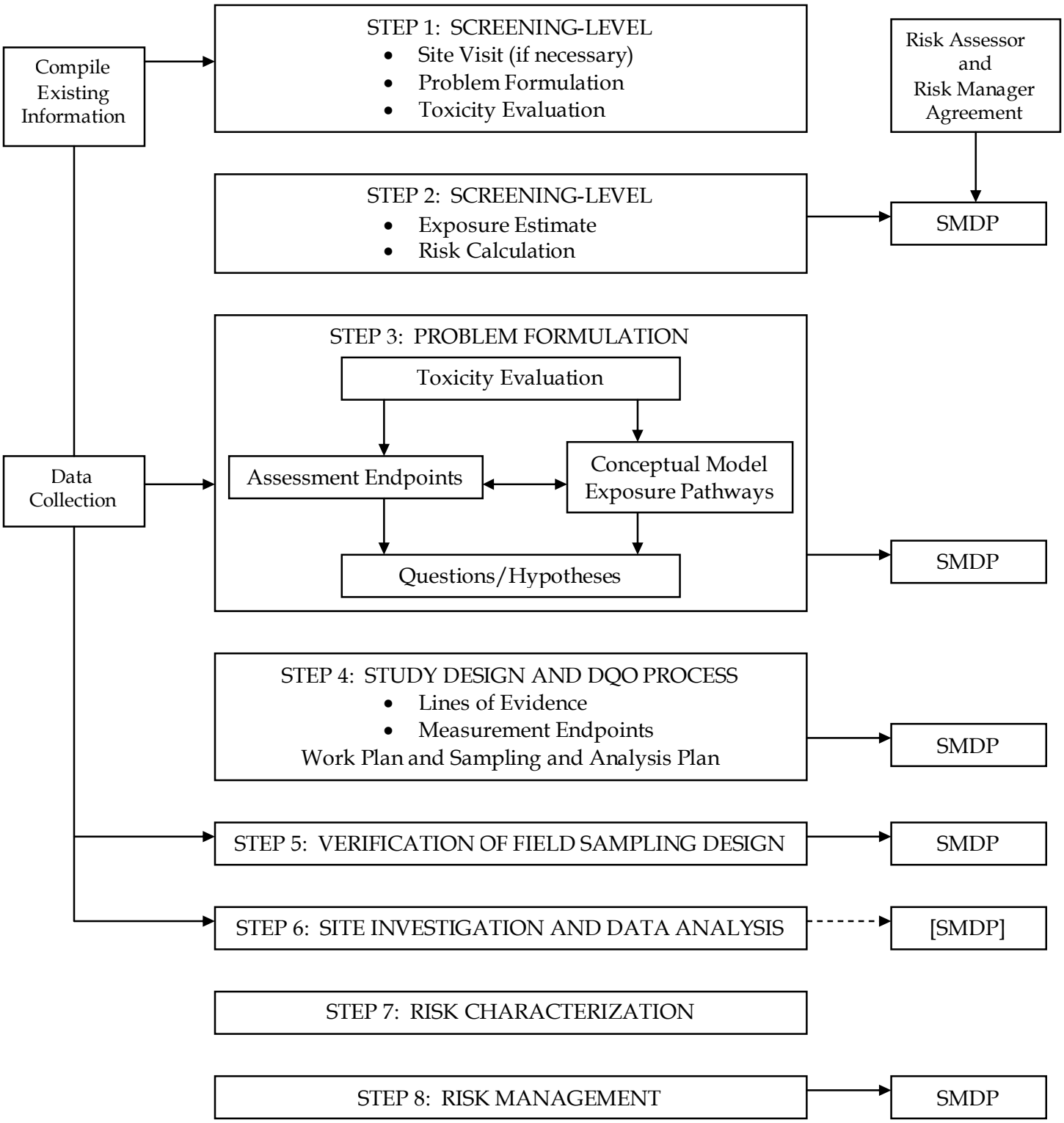
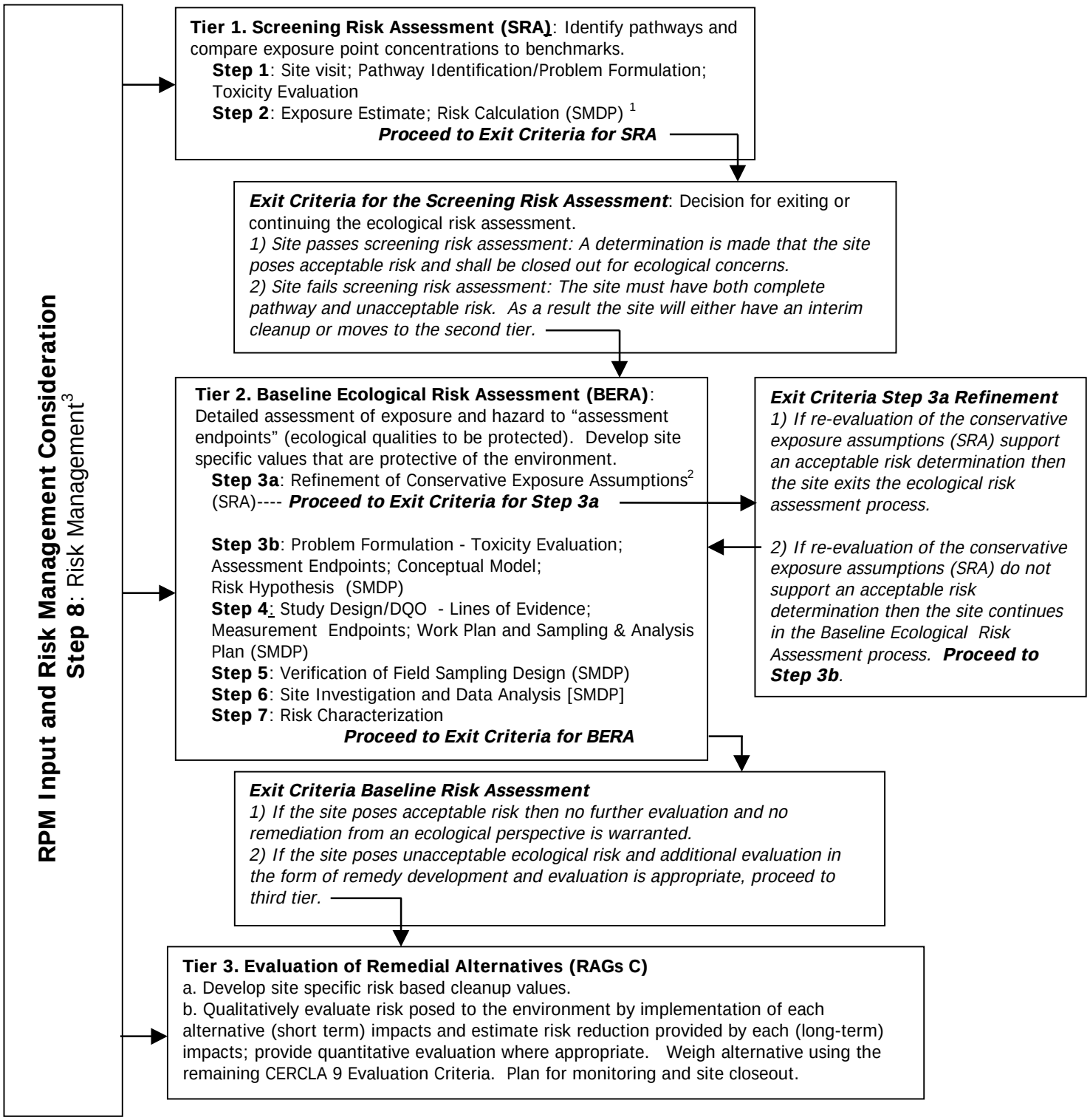


FIGURE 1 USEPA EIGHT-STEP ECOLOGICAL RISK ASSESSMENT PROCESS FOR SUPERFUND

Figure 2. Navy Ecological Risk Assessment Tiered Approach



Notes: 1) See EPA's 8 Step ERA Process for requirements for each Scientific Management Decision Point (SMDP).
2) Refinement includes but is not limited to background, bioavailability, detection frequency, etc.
3) Risk Management is incorporated throughout the tiered approach.

ERAs are conducted using a tiered, step-wise approach and are punctuated with Scientific Management Decision Points (SMDPs). SMDPs represent points in the ERA process where agreement on conclusions, actions, or methodologies is needed so that the ERA process can continue (or terminate) in a technically defensible manner. The results of the ERA at a particular SMDP are used to determine how the ERA process should proceed, for example, to the next step in the process or directly to a later step. The process continues until a final decision has been reached (i.e., remedial action or controls if unacceptable risks are identified, or no further action if risks are acceptable). The process can also be iterative if data needs are identified at any step; the needed data are collected and the process starts again at the point appropriate to the type of data collected.

The screening (preliminary) problem formulation is the first step of an ERA and establishes the goals, scope, and focus of the SERA. As part of problem formulation, the environmental setting of the site is characterized in terms of the habitats and biota known or likely to be present. The types and concentrations of chemicals that are present in ecologically relevant media (such as surface water, sediment, and surface soil) are also described. A preliminary conceptual model is developed that describes potential sources, potential transport pathways (the mechanisms whereby chemicals may be transported from a source of contamination to ecologically relevant media), potential exposure pathways (an exposure pathway links a potential source of contamination with one or more receptors through exposure via one or more media and exposure routes), potential exposure routes, and potential receptors. Assessment endpoints, measurement endpoints, and risk hypotheses are then selected to evaluate those receptors for which complete and potentially significant exposure pathways are likely to exist[1]. The fate, transport, and toxicological properties of the chemicals present at the site, particularly the potential for bioaccumulation, are also considered during the problem formulation process.

Step 1 of the ERA process is intended to answer two main questions:

1) Do complete exposure pathways exist?

2) Are sufficient data available to conduct the SERA?

If no complete exposure pathways exist, the ERA process terminates at Step 1 with a conclusion of negligible (acceptable) risk because exposure, and thus potential risk, can only occur if complete exposure pathways exist. If one or more complete exposure pathways are known to exist, or are likely to exist, the ERA process continues to Step 2 but only evaluates those pathways that have been determined to be "critical" (ecologically important), that is, represent exposures to sensitive receptors that are associated with the predominant fate and transport mechanisms at the site (EPA, 1997). An evaluation of the available data is then conducted to determine if they are adequate to support the SERA. When both normal and duplicate samples are available from a specific sample location the normal sample (as opposed to the duplicate QA/QC sample) will be used in the ERA. If not, additional data are collected before the ERA process continues. The second step of the ERA process involves conducting a screening exposure assessment, a screening effects assessment, and a screening risk calculation (risk characterization) based upon very conservative assumptions.

[1] An assessment endpoint is an explicit expression of the environmental component or value that is to be protected. A measurement endpoint is a measurable ecological characteristic that is related to the component or value chosen as the assessment endpoint. Risk hypotheses are testable hypotheses about the relationship among the assessment endpoints and their predicted responses when exposed to contaminants or other stressors.

Sources for ecological soil screening values will include, in general order of preference, the following:

- Ecological Soil Screening Levels (Eco-SSLs) (EPA, 2005)
- Toxicological benchmarks for screening contaminants of potential concern for effects on soil and litter invertebrates and heterotrophic process: 1997 revision. (Efroymson et al., 1997a)
- Toxicological benchmarks for screening contaminants of potential concern for effects on terrestrial plants: 1997 revision. (Efroymson et al., 1997b)
- Intervention Values and Target Values - Soil Quality Standards (Ministry of Housing, Spatial Planning, and Environment [MHSPE], 2001)
- U.S. Fish and Wildlife soil screening values (Beyer, 1990)
- Other relevant studies/sources from the literature

Sources for ecological sediment screening values will include, in general order of preference (which will vary depending upon the salinity of the water body [i.e., freshwater versus marine]), the following:

- Freshwater sediment consensus values (MacDonald et al., 2000)
- Ecotox Thresholds, ECO Update (EPA, 1996)
- National Oceanic and Atmospheric Administration (NOAA) Effects Range-Low (ER-L) values (Long et al., 1995)
- Ontario freshwater sediment values (MOE, 1993)
- NOAA Squirts (Buchman, 1999)
- Toxicological benchmarks for screening contaminants of potential concern for effects on sediment-associated biota: 1997 revision (Jones et al., 1997)
- Interim Sediment Quality Guidelines (Environment Canada, 1995)
- Other relevant studies/sources from the literature

Sources for ecological surface water screening values will include, in general order of preference (which will vary depending upon the salinity of the water body [i.e., freshwater versus marine]), the following:

- Puerto Rico's Water Quality Standards (PREQB, 2003)
- National Recommended Water Quality Criteria (EPA, 2002f)
- Ecotox Thresholds, ECO Update (EPA, 1996)
- NOAA Squirts (Buchman, 1999)
- Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 revision (Suter and Tsao, 1996)

- Other relevant studies/sources from the literature

The screening values from these sources are included in the attached QAPP Worksheet 15.

The results of the SERA are used to evaluate the potential for unacceptable ecological risks based upon very conservative assumptions. If the results of the SERA suggest that further ecological risk evaluation is warranted, the ERA process proceeds to the BERA (Steps 3 through 7), which is a more detailed phase of the ERA process, for the pathways, chemicals, receptors, and areas identified in the SERA. As indicated above, the first step of the BERA (Step 3) is divided into two distinct sub-steps in Navy ERA guidance.

Step 3 of the EPA ERA guidance consists of the following activities (EPA, 1997):

1. Refinement of the Chemicals of Potential Concern (COPCs) from the SERA
2. Further characterizing the potential ecological effects of contaminants
3. Refining information on contaminant fate and transport, complete exposure pathways, and receptors potentially at risk
4. Selecting assessment endpoints
5. Refining the conceptual model and risk hypotheses from the SERA

Step 3A of the Navy policy/guidance (refinement of conservative exposure assumptions) corresponds to the first activity listed above for the EPA ERA guidance. In Step 3A, a refined evaluation of exposure estimates is conducted using more realistic assumptions and additional methodologies relative to those used in the SERA, which is intended to be a very conservative assessment. Examples of more realistic exposure assumptions include using central tendency (e.g., mean) estimates (rather than maximums) for media concentrations, bioaccumulation factors, and exposure parameters. Examples of additional methodologies include consideration of background and upgradient concentrations, bioavailability, and detection frequency (CNO, 1999; NAVFAC, 2003).

If risk estimates (and their associated uncertainty) are acceptable following Step 3A, the site will meet the conditions of the exit criterion specified in the Navy guidance. If the Step 3A evaluation does not support a determination of acceptable risk within acceptable uncertainty, the site continues to Step 3B.

Step 3B of the Navy policy/guidance (problem formulation) corresponds conceptually to the last four activities listed above for the EPA ERA guidance. In Step 3B, the preliminary conceptual model from the SERA is refined based upon the results of the Step 3A evaluation to develop a revised list of key receptors, critical exposure pathways, key COPCs, assessment endpoints, measurement endpoints, and risk hypotheses. Based upon the refined conceptual model, the lines of evidence to be used in characterizing risk are determined. Agreement on the refined conceptual model, COPCs, exposure pathways, endpoints, and risk hypotheses constitutes the SMDP at the end of Step 3 in both Navy and EPA ERA guidance.

Following the completion of Step 3, a decision point is reached with two potential outcomes. If the refined risk estimates are acceptable for each selected assessment endpoint, the investigation proceeds to risk characterization (Step 7) to document this conclusion, and the ERA process terminates. If the uncertainties associated with the refined risk estimates are unacceptable

and/or the risk estimates indicate that unacceptable risks may exist, site-specific studies might be required and the ERA process continues (Steps 4 through 6). The scope (e.g., spatial extent of sampling) and components (e.g., collection of biological data, such as tissue samples, toxicity testing, etc.) of any site-specific studies is determined by the conclusions of Step 3 and the pathways/endpoints associated with the potential unacceptable risks.

Step 7 consists of the documentation and synthesis of the information and data identified in Steps 1 through 3 (no additional study) or Steps 1 through 6 (additional study). In this step, risk is evaluated and characterized using both quantitative and qualitative methods. Conclusions are made as to whether there is a reasonable potential for unacceptable ecological risk and, if there is a potential for unacceptable ecological risk, the magnitude of that risk. The results of the completed BERA (Step 7) are used to make necessary risk management decisions (Step 8) related to current or future risks. Possible decisions include:

- Adequate information exists to conclude that no unacceptable ecological risks exist. The assessment should stop at Step 7.
- Adequate information exists to conclude that unacceptable ecological risks exist for which remedial actions or controls are warranted. Whether remedial actions or controls are taken, and the specific actions or controls taken, will depend upon a number of risk management factors such as the results of human health risk assessments (if applicable) and the potential impact of the remedial action or control itself on the habitats and biota present. This analysis would occur as part of Step 8.

References

Chief of Naval Operations (CNO). 1999. *Navy policy for conducting ecological risk assessments.* Memorandum from Chief of Naval Operations to Commander, Naval Facilities Engineering Command. Ser N453E/9U595355.

NAVFAC (Naval Facilities Engineering Command). 2003. *Navy guidance for conducting ecological risk assessments.* http://web.ead.anl.gov/ecorisk/. February.

U.S. Environmental Protection Agency (EPA). 1997. *Ecological risk assessment guidance for Superfund: process for designing and conducting ecological risk assessments.* Interim Final. EPA/540/R-97/006.

ATTACHMENT 7

Soil Sample Depth Selection Criteria

Soil Sample Depth Selection Criteria

This protocol defines the soil sample selection criteria that are used to select soil sampling depths for environmental investigations on Vieques, unless otherwise deemed appropriate and specified in site-specific project plans.

Soil sampling is conducted to provide information for various purposes, such as nature and extent of contamination determination, human health and ecological risk assessments, etc. In addition to general site characterization use (e.g., nature and extent of contamination), surface soil data are used in human health and ecological risk assessments. Subsurface soil data from samples collected to a depth of 6 feet are used in human health risk assessments. The presence or potential presence of basements often is associated with subsurface soil depths of 10 feet for human health risk assessment. The subsurface soil depth for human health risk assessments conducted for Vieques is limited to 6 feet because there are no basements in Puerto Rico.

Surface Soil

In order to provide analytical data from a single depth that can be used for both human health and ecological screening/risk assessments (as well as site characterization), the following are the criteria used to select the surface soil sampling depth at a given site under investigation:

Surface soil samples will be collected from the top 12 inches of soil when:

1. The site is landlocked (i.e., no surface water bodies are within the site boundary, and there is no potential (based on past history and current conditions) for off-site impacts to any surface water bodies, including ephemeral streams).
2. Risk to ecological receptors is a potential concern.

Surface soil samples will be collected from the top 24 inches of soil when:

1. The site is near water and the land crab is a potential receptor of concern.
2. There is limited or no ecological habitat and the main potential concern at the site is for human health.

Subsurface Soil

The following are the general criteria that are used to select subsurface soil sampling depths at environmental sites. It should be noted that subsurface soil sample selection criteria may be modified on a site-specific basis, based on factors such as the depth to groundwater, depth to bedrock, depth of contaminant source, and extent of contamination.

For the purposes of collecting data for site characterization and human health risk assessment, at each subsurface soil sampling location, continuous split-spoon (or direct-

push) samples will be collected from the bottom of the surface soil interval (i.e., 1 foot or 2 feet) to 6 feet (or bedrock or water table if encountered above 6 feet). One subsurface soil sample will be collected for analysis in the 2-ft interval within the 1- or 2-to-6 ft interval (depending on the surface soil depth), based on where visual and/or instrument (e.g., OVA) screening suggests the presence of contamination, to be used for human health risk evaluation (and site characterization). In the absence of potential contamination based on visual and/or instrument screening, the subsurface soil sample will be collected for analysis at the 4-to-6 ft interval (or just above the water table or bedrock, if encountered before this depth).

For the purposes of site characterization (not for risk assessment purposes), continuous soil sampling will continue from 6 feet to bedrock or the water table, whichever is shallower. Additional soil sample(s) will be collected for analysis below the 6-foot depth (i.e., between 6 feet and the water table or bedrock, whichever is shallower) if visual or instrument screening suggests the presence of contamination, to assist in delineating the vertical extent of contamination.

ATTACHMENT 8

General Data Flow and Evaluation Schematics

General Data Flow and Evaluation Schematics

Attached are two schematics showing the general flow and evaluation of data collected as part of the Environmental Restoration Program on Vieques. The first schematic shows the flow of data from collection through use in decision making for a particular site. The second schematic provides details regarding how data are used in risk screening and risk assessment, including how background data are incorporated in the evaluation process. It should be noted that these schematics provide a general overview of data flow, evaluation, and use. Site-specific circumstances may require deviation from or modification of this process, which will be documented, as applicable, in site-specific project plans.

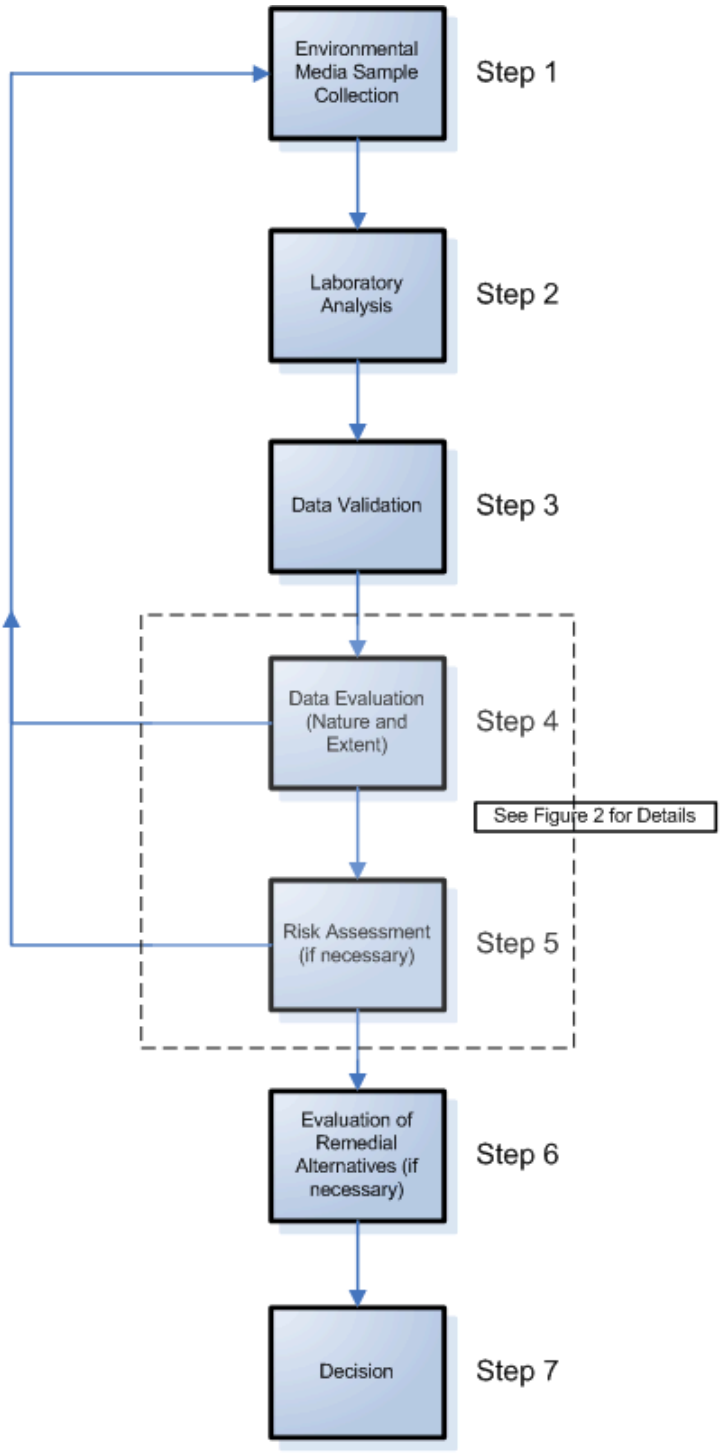


Figure 1
General Schematic of Data Flow Steps

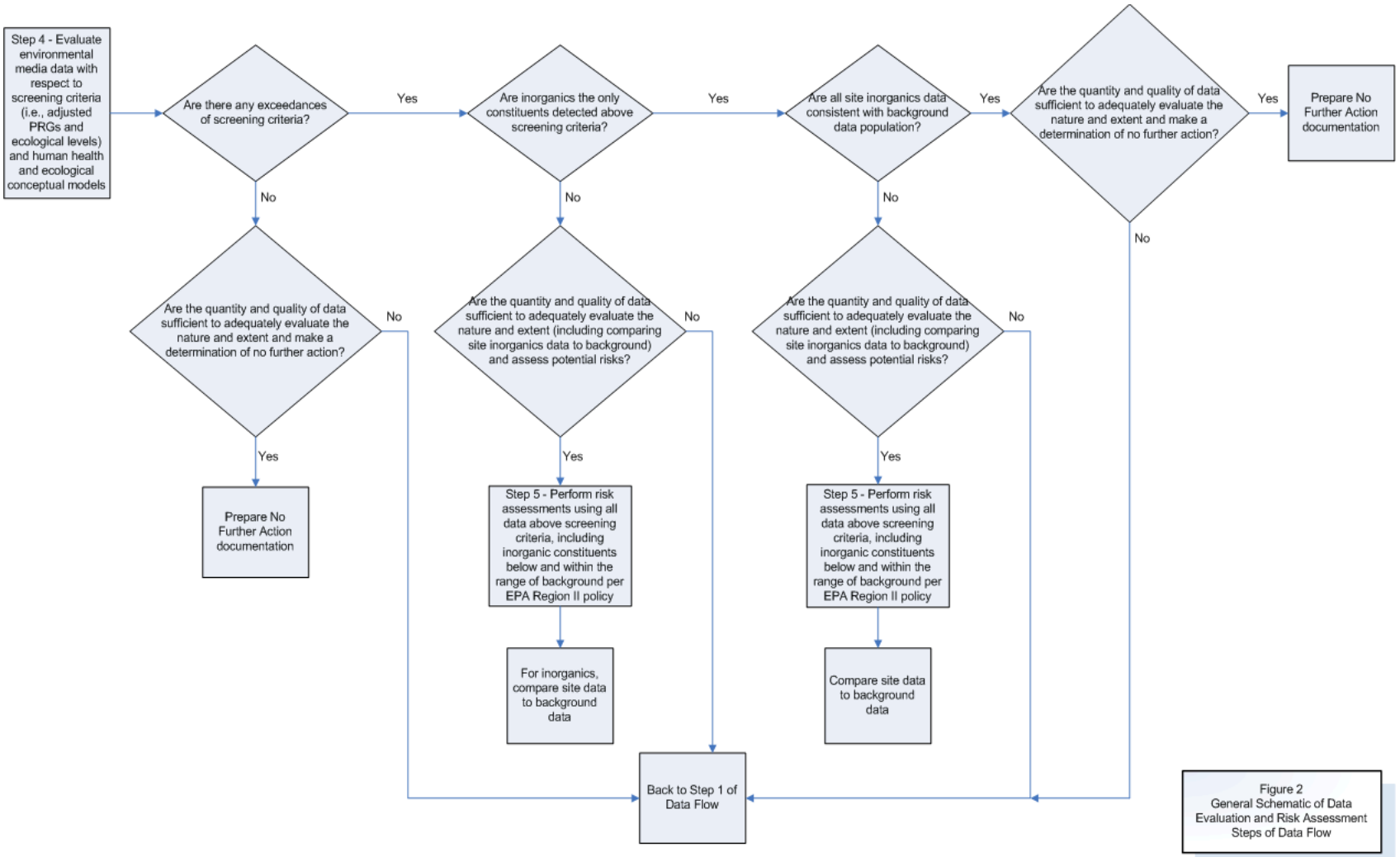


Figure 2
General Schematic of Data Evaluation and Risk Assessment Steps of Data Flow