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Final
Master Work Plan
Atlantic Fleet Weapons Training Facility
Vieques Island, Puerto Rico

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the
LANTDIV CLEAN II Program
Contract No. N62470-95-D-6007
CTO-031

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Prepared by

CH2MHILL

Tampa, Florida

June 12, 2003

Master Work Plan

Master Work Plan Contents

Project Management Plan

Master Sampling and Analysis Plan

- Master Field Sampling Plan
- Master Quality Assurance Project Plan
- Master Data Management Plan
- Master Investigation-Derived Waste Management Plan

Community Relations Plan

Master Health and Safety Plan

Attachments:

Checklists for Site-Specific Plans

Standard Operating Procedures

Introduction and Work Plan Contents

The U. S. Environmental Protection Agency (EPA) and the U.S. Navy (Navy) entered into a Consent Order on January 20, 2000, to address potential environmental contamination at the Atlantic Fleet Weapons Training Facility (AFWTF) on Vieques Island, Puerto Rico. As part of the Consent Order, the Navy is required to perform a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) to fully determine the nature and extent of any releases of hazardous wastes, solid wastes, and/or hazardous constituents from or at AFWTF.

In response to the requirements of Contract Task Order (CTO)-031, CH2M HILL has prepared a work plan for the RFI at AFWTF. The RFI addresses potential soil and groundwater contamination for nine of 12 identified Solid Waste Management Units (SWMUs) and three identified Areas of Concern (AOCs) at AFWTF. The remaining three identified SWMUs at AFWFT not addressed in this work plan are excluded from the corrective action requirements at AFWFT per section IV.7(d) of the Consent Order.

The work plan provides for submission of a draft, draft final, and final work plan; and consists of the following six plans:

- Project Management Plan, which contains a discussion of the project background, technical approach (including monitoring rationale), schedules, budget, personnel, and the overall management approach to the RFI
- Master Quality Assurance Project Plan, which documents the procedures to ensure that all information, data, and resulting decisions are technically sound, statistically valid, and properly documented
- Data Management Plan, which documents and tracks investigation data and results
- Health and Safety Plan, which discusses the health and safety requirements for performing fieldwork at the sites
- Master Investigation-Derived Waste Management Plan, which provides guidance on handling and disposing of investigation-derived waste (IDW)
- Community Relations Plan, which outlines the public outreach activities planned for the project

FINAL

Project Management Plan

Atlantic Fleet Weapons Training Facility
Vieques Island, Puerto Rico

Contract Task Order 031

Prepared for:

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command
Under the

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

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List of Acronyms

AFWTF	Atlantic Fleet Weapons Training Facility
AOCs	Areas of Concern
ASTs	Aboveground fuel storage tanks
bls	Below land surface
CMS	Corrective Measures Study
CLP	Contract laboratory program
DOH	Department of Health
EDMS	Environmental data management system
EMA	Eastern Maneuver Area
EPA	U.S. Environmental Protection Agency
GIS	Geographic information system
HSWA	Hazardous and Solid Waste Amendments
IAS	Initial Assessment Study
IDW	Investigation-Derived Waste
IDWMP	IDW Management Plan
IM	Interim Measure
LANTDIV	Atlantic Division
MPRs	Monthly progress reports
msl	Mean sea level
NACIP	Navy Assessment and Control of Installation Pollutants
NASD	Naval Ammunition Support Detachment
NATO	North Atlantic Treaty Organization
NAVFACENGCOM	Naval Facilities Engineering Command
Navy	Department of the Navy
NFA	No Further Action
NFESC	Naval Facilities Engineering Services Center
NGFS	Naval gunfire support
NSRR	Naval Station Roosevelt Roads
OB	Open burn
OD	Open detonation
OP	Observation Post
PMP	Project management plan
PRASA	Puerto Rico Aqueduct and Sewer Authority
PREQB	Puerto Rico Environmental Quality Board
RCRA	Resource Conservation and Recovery Act of 1976
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SAP	Sampling and Analysis Plan
SMP	Site Management Plan
SWMUs	Solid Waste Management Units
TC	Toxicity Characteristics
TCLP	Toxicity Characteristics Leaching Procedure
USGS	U.S. Geological Survey
UST	Underground storage tank
VSI	Visual site inspection

SECTION 1

Project Background

The project management plan (PMP) provides an overview and overall management approach to this Atlantic Fleet Weapons Training Facility (AFWTF) Phase I Resource Conservation and Recovery Act of 1976 (RCRA) Facility Investigation (RFI) project. The project management plan contains a discussion of the project background, facility description, project objectives, technical approach (including sampling rationale), personnel, and schedule.

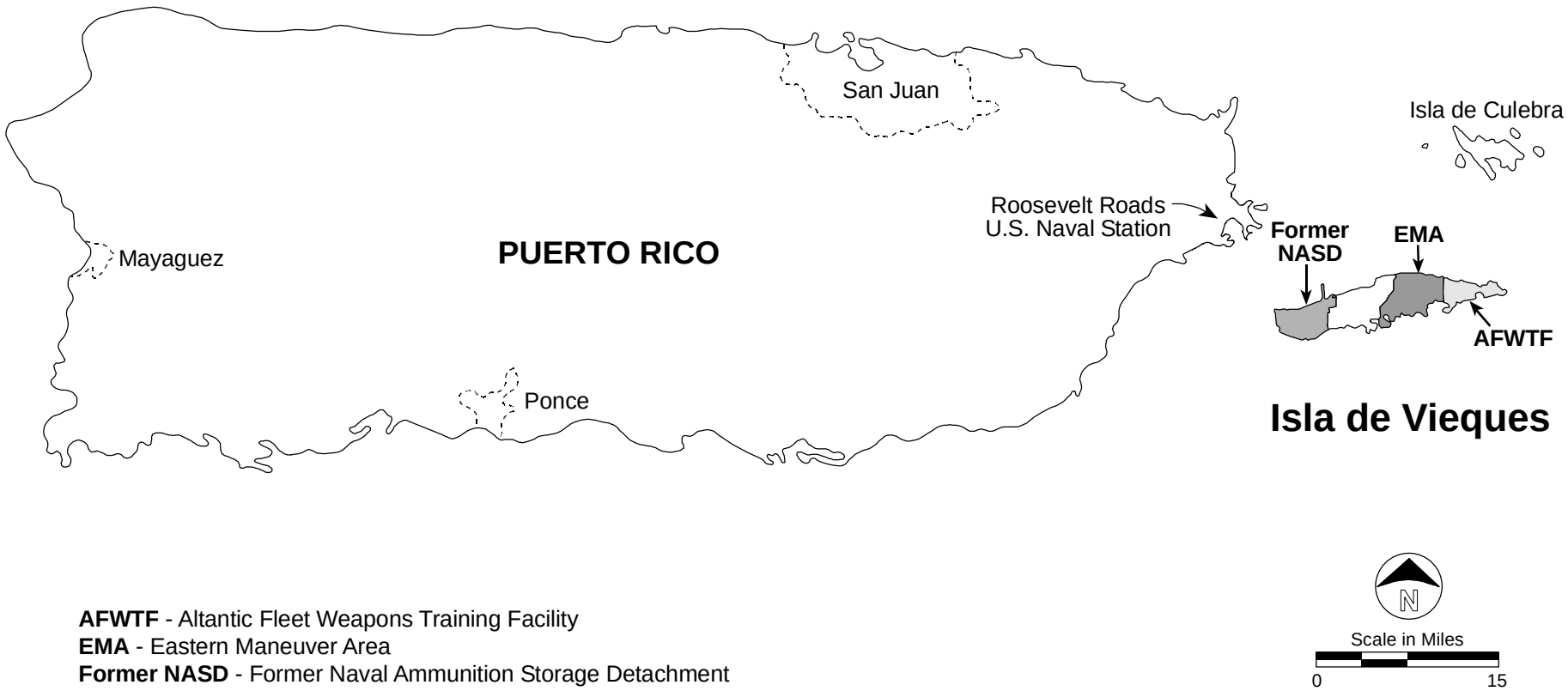
1.1 RFI Background

On January 20, 2000, the U.S. Environmental Protection Agency (EPA) and the U.S. Department of the Navy (Navy) entered into a Consent Order to perform an RFI at the AFWTF on Vieques Island, Puerto Rico. The purpose of the RFI is to determine the nature and extent of potential releases of hazardous wastes, solid wastes, and/or hazardous constituents at or from the facility. The Consent Order was issued based on information gathered during a RCRA Facility Assessment (RFA) completed by A.T. Kearney, Inc., on October 13, 1988, and an updated RFA completed by the Puerto Rico Environmental Quality Board (PREQB) on September 27, 1995.

EPA's jurisdiction to issue the Consent Order derives from authority vested in EPA by Section 7003 of the RCRA, as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, which also mandate compliance by generators of solid and/or hazardous waste.

1.2 Facility Background

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 island of Puerto Rico (Figure 1-1). The Navy's facility is located on the eastern one-third of the island. For the purposes of the EPA Consent Order and this Work Plan, the Facility includes both the AFWTF (comprised of 3,600 acres) and the adjacent and wholly contiguous Eastern Maneuver Area (EMA), comprised of 11,000 acres. Both are under the command of U.S. Naval Station Roosevelt Roads (NSRR). A third Navy activity, Naval Ammunition Support Detachment (NASD), is located on Vieques Island, but under RCRA is not part of the Facility because it is not contiguous and therefore is not subject to the terms and conditions of the EPA Consent Order. In total, the Navy owns approximately 68 percent (22,600 acres) of the land area of Vieques Island.



AFWTF - Altantic Fleet Weapons Training Facility
EMA - Eastern Maneuver Area
Former NASD - Former Naval Ammunition Storage Detachment

Figure 1-1
SITE LOCATION MAP
Vieques Island, Puerto Rico

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1.3 Site and Environmental Setting Characteristics

This section describes the characteristics of the site and environment, including land topography and use, climate, geology, hydrogeology, and hydrology.

1.3.1 Topography

The 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, which is more exposed rugged terrain. The highest point on the western side is approximately 1,000 feet above mean sea level (msl) at Monte Pirate. The highest point on the eastern side is approximately 420 feet above msl at Cerro Matias. The coastal areas contain level terrain primarily made up of lagoons and mangrove swamps. The open burn (OB) and open detonation (OD) locations are relatively level areas containing irregular drainage patterns as a result of continuous bombing exercises (PREQB, 1995). The site topography of the AFWTF and EMA areas, focal points for this Phase I RFI investigation, is shown in Figure 1-2.

1.3.2 Land Use

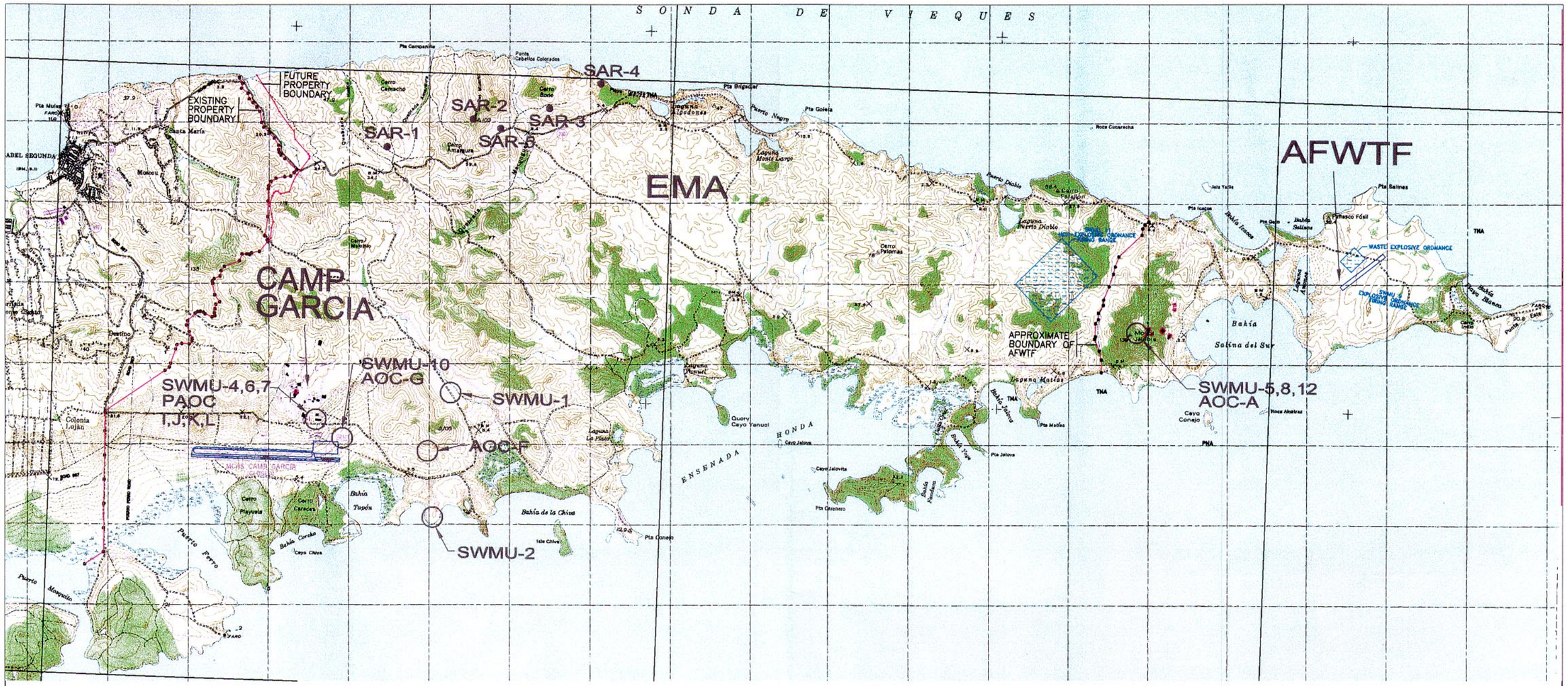
In general, the AFWTF (3,600 acres) and EMA (11,000 acres) land areas remain undeveloped. The Navy land use comprises only a fraction of these two respective land areas.

The AFWTF provides facilities and schedules naval gunfire support (NGFS) and air-to-ground (ATG) ordnance delivery training for Atlantic Fleet ships, North Atlantic Treaty Organization (NATO) ships, air wings, and smaller air units from other allied nations and the Puerto Rican National Guard. The Fleet Marine Force, Atlantic, conducts training for Marine amphibious units, battalion landing teams and combat engineering units in the EMA. Occasionally, naval units of allied nations with a presence in the Caribbean and the Puerto Rican National Guard also utilize the EMA.

The training areas have been in continuous use since World War II when the Navy acquired title to the land. Within the Inner Range, the Atlantic Fleet's ships, aircraft and marine forces carry out training in all aspects of NGFS, ATG ordnance delivery, air-to-surface mine delivery, amphibious landings, small arms, artillery and tank fire, and combat engineering. As part of its normal operations, unexploded ordnance are periodically cleared from the AFWTF's Inner Range and destroyed by open burning/open detonation (OB/OD) at the Facility. In addition, unserviceable military munitions are periodically received from NASD and/or NSRR for OB/OD at AFWTF.

1.3.3 Climate

The climate of Vieques is characterized as warm and humid (tropical-marine), with frequent showers occurring throughout the year. A major factor affecting the temperature on Vieques is the easterly trade winds blowing across the island year-round. This wind moderates the temperature throughout the year, causing an annual mean temperature of 79 F to 80 F and range of 15 F to 25 F. The average rainfall is approximately 36 inches, with extremes of 25 inches in the east and 45 to 50 inches in the west (PREQB, 1995).



Legend:
EMA – Eastern Maneuver Area.
AFWTF – Atlantic Fleet Weapons Training Facility.
SWMU – SOLID WASTE MANAGEMENT UNIT
AOC – AREA OF CONCERN
PAOC – POTENTIAL AREA OF CONCERN
SAR – SMALL ARMS RANGE
NOTE:
SITES I,J,K, AND L ARE POTENTIAL AREAS OF CONCERN. THESE SITES WILL REQUIRE FURTHER INVESTIGATION TO DETERMINE WHETHER RELEASE OF HAZARDOUS MATERIAL. HAS OCCURRED AT EACH RESPECTIVE SITE.

SWMU'S 3,9, AND 11 ARE ILLUSTRATED TO PROVIDE THE LOCATION RELATIVE TO OTHER SWMUS. THESE SITES ARE LOCATED WITHIN THE LIVE IMPACT AREA AND WILL NOT BE INVESTIGATED DURING THE PHASE IRF I.

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Figure 1-2
SITE LOCATION MAP
Atlantic Fleet Weapons Training Facility, Vieques Island

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1.3.4 Geology

The underlying geology of Vieques is divided into rock and sediment deposits. The upland areas contain three rock types: Upper Cretaceous volcanic rocks, Upper Cretaceous or Lower Tertiary intrusive rocks, and Upper Tertiary and Quaternary sedimentary rocks. The lowland areas are unconsolidated sediments of Quaternary age, consisting of alluvial deposits, beach and dune deposits, and swamp and marsh deposits.

The Upper Cretaceous rocks in the upland areas appear to be the oldest exposed rocks on Vieques. These rocks are believed to have been deposited in a marine environment, as was the case with rocks of the same age on the island of Puerto Rico.

Limestone of the upper Tertiary age is found in peninsulas extending into the sea from the southern and eastern coasts of Vieques. Limestone of the Tertiary-Miocene age is also found along these coasts, and is commonly referred to as Puerto Ferro limestone. Quaternary age deposits are typically found in the valleys and coastal areas. These deposits include beach, swamp, and alluvial deposits. The deposits of sand, swamp, and salt mud occur in the coastal areas.

Although sand and crushed quarried stone are typically geologic resources, the limestone on Vieques is too soft and not of the right purity for use as crushed stone or in cement. Quartz diorite, however, has served as a source of crushed rock for military construction. The sand on the island can be divided into two major types: alluvial and marine-deposited calcareous sand. The alluvial sand is used in construction materials such as mortars (PREQB, 1995).

1.3.5 Soils

Soils on Vieques Island are primarily residual, because of both climatic and subsurface rock conditions. The eastern side of the island has poorly developed soil due to the impermeable volcanic rock and the nature of the climate.

Soils on Vieques are typically classified into one of five groups. The first group is referred to as the Descalabrado series. This group accounts for 30 percent of the total land surface area on the island. This soil is shallow and well-drained, and typically very dark brown to dark grayish-brown. Grasses and shrubs are the only types of vegetation able to grow in this particular type of soil. Grazing, wildlife, and woodland are the only other uses for this soil. The second group is the Vieques series, which accounts for approximately 26 percent of the total land surface area on the island. This series is typically shallow, and is found in the upland regions of the island. The soil is dark brown in color, and has good drainage with moderate permeability. The third group is the Coamo series. This soil makes up approximately 16 percent of the total land surface area on the island. This soil is typically deep and well-drained in nature. The surface layer is very dark and slightly acidic to neutral. Agriculture can be maintained here along with xeric trees and brush. The fourth group is the Rock Land area. This area accounts for approximately 8 percent of the total land area on the island. This area is labeled Rock Land because either rock outcrops occur, or loose stones and boulders are common. Volcanic rock and limestone are the principal constituents of this area, and brush and shrubs are the only vegetation visible. The fifth group is divided into eleven additional categories which account for the remaining 20

percent of the land surface area: Ametia, Cartagena, Catano, Coastal Beaches, Descalabrado, Fraternidad, Jacana, Pandura, Paso Seco, Pancena and Pozo Blanco.

Although ATG ordnance delivery and NGFS exercises are conducted on Vieques, soil conditions have not been severely altered on the island, because of the vegetation, soil, and surface drainage characteristics.

1.3.6 Surface Water

The streambeds found on Vieques Island flow either to the north or to the south until they reach the sea. Vieques does not have any perennial surface drainage, and has an average of 36 inches of annual rainfall. Of the 36 inches of annual rainfall, approximately 90 percent is lost to evaporation, based on statistics from the U.S. Virgin Islands. Of the remaining 10 percent, approximately 5 percent infiltrates into the ground recharging the groundwater aquifer, and 5 percent becomes surface runoff.

1.3.7 Groundwater

The groundwater on the island occurs in two aquifers: the Valle de Resolucion located beneath the western portion of the island, and the Valle de Esperanza located beneath the southern portion of the island near Camp Garcia. As discussed previously, approximately 5 percent of the annual precipitation infiltrates through the ground and supplies the aquifers. The Valle de Esperanza is the more productive of the two aquifers, and has been used as a source of drinking water. The Valle de Esperanza aquifer previously supplied water to Camp Garcia and Observation Post-1 (OP-1). The Puerto Rico Aqueduct and Sewer Authority (PRASA) was in charge of a series of 16 wells that pumped approximately 450,000 gallons of water per day. These wells are no longer active, however, because of the installation of a water line from the island of Puerto Rico to Vieques Island in 1978. Camp Garcia and OP-1 are now supplied by surface water from the main island of Puerto Rico.

The U.S. Geological Survey (USGS) has performed a groundwater study on Vieques, including tests on the wells near Esperanza. The results indicate that the groundwater contains high concentrations of sodium bicarbonate. Because of its high sodium content, the groundwater on Vieques is not suitable for extended irrigation use. The high levels of sodium result from sea spray infiltrating into the ground, and saltwater entering the groundwater supply as a result of excessive groundwater withdrawal (USGS, 1989).

1.4 Identification of Potential Receptors

Under normal circumstances, groundwater and surface waters are not utilized for municipal drinking water supply on Vieques Island. Based on information from the Puerto Rico Department of Health (DOH), the existing water supply wells on Vieques are used for emergency municipal water supply when drinking water supplies are not available via the normal source. Since the late 1970s, this source has been an undersea pipeline from the island of Puerto Rico. The most recent usage of public back-up wells on Vieques for obtaining municipal water supplies occurred in 1998 after Hurricane Georges. In addition, private non-permitted wells may exist; groundwater from such wells may be utilized for human consumption, but no cases of this are currently documented. Therefore, a potential exposure pathway, resulting in unacceptable human health threats, may be present as a

result of human consumption of Vieques Island groundwater impacted by releases of hazardous wastes and/or constituents from AFWTF.

Although the Facility has restricted access, the Navy also allows routine access by the public for recreational swimming, picnicking, and possible recreational fishing and crabbing, at certain beaches within the facility's boundaries. Therefore, other possible exposure pathways for adverse human health impacts (in addition to possible human consumption of groundwater from non-authorized wells) include:

1. Human consumption of faunal species that bio-accumulate released hazardous constituents, which may occur as a result of either onsite recreational fishing, crabbing, etc., by public citizens visiting the Navy's facility or by onsite Navy personnel, or via offsite recreational and/or possibly commercial fishing, crabbing, etc. in the surface waters surrounding the facility
2. Accidental ingestion of, or dermal contact with, contaminated surface waters and/or contaminated soils, either by onsite workers or by public citizens visiting the Navy's Facility for onsite recreational swimming and picnicking at beaches within the facility limits
3. Possible inhalation of contaminated fugitive dust by onsite workers, recreational users visiting onsite, or offsite residents in communities adjoining the western portion of the facility

Pathways for adverse impacts to the environment include:

- Discharge of contaminated groundwater to the surface waters of the surrounding Caribbean Sea and the associated bays
- Direct transport via stormwater run-off of hazardous waste and/or constituents and/or contaminated soils, to the surface waters of the surrounding Caribbean Sea and the associated bays
- Fugitive-dust transport of hazardous waste and/or constituents and/or contaminated soils, to the surface waters of the surrounding Caribbean Sea and the associated bays

1.5 Contaminant Source Characterization (Nature and Extent of Contamination)

1.5.1 Solid Waste Management Units and Areas of Concern

Previous investigations of the areas covered by this work plan consist of an Initial Assessment Study by Greenleaf/Telesca in 1984, an RFA completed by A.T. Kearney, Inc., on October 13, 1988, and an updated RFA completed by the PREQB on September 27, 1995. The two RFAs both identified 11 Solid Waste Management Units (SWMUs) and eight Areas of Concern (AOCs); the designations of certain AOCs in the Updated RFA are different, however, than those used in the 1988 RFA. For the purposes of the EPA Consent Order and this Work Plan, 12 SWMUs and three AOCs have been defined, as presented in Tables 1-1 and 1-2.

TABLE 1-1
List of Solid Waste Management Units (SWMUs)

SWMU #	Description
1	Camp Garcia Landfill (Eastern Maneuver Area)
2***	Fuels Off-Loading Site
3**	Waste Explosive Ordnance Detonation Area
4 */***	Waste Areas of Building 303 (Camp Garcia), including:
	- Spent Battery Accumulation Area
	- Catch Basin for Hydraulic Oil (ex, “AOC C”)
	- Cleaning/Degreasing Basin (ex, “AOC D”)
	- Rags, absorbent and grease storage area (ex, “AOC E”)
5***	Spent Battery Accumulation Area (Inner Range)
6***	Waste Oil and Paint Accumulation Area (Seabees Area at Camp Garcia). To include any releases from the adjacent “Lubricating Oil Storage Area“ (formerly part of “AOC H”)
7***	Waste Oil Accumulation Area (outside building 303 at Camp Garcia). To include releases from the adjacent “Lubricating Oil Storage Area” (formerly part of “AOC H”).
8***	Waste Oil Accumulation Area (Inner Range)
9**	Explosive Ordnance Firing Range
10	Sewage Treatment Lagoons (Camp Garcia)
11**	Non-Explosive Ordnance Firing Range
12 */***	Solid Waste Collection Unit Area (ex, “AOC B”)

* “AOC B” as listed in the 1988 RFA and the 1995 updated RFA, has been determined to be a waste management unit which constitutes a SWMU, and is identified in this Work Plan as SWMU 12. “AOC C,” “AOC D”, and “AOC E” as listed in the 1988 RFA and 1995 Updated RFA, have also been determined to be SWMUs, and because they are all located inside Building 303 at Camp Garcia, which also contains SWMU 4, they have been included as part of SWMU 4, which for the purposes of this Work Plan includes all four waste management areas. Also, “AOC H” as described in the 1988 RFA and 1995 Updated RFA, consists of two areas essentially contiguous with SWMUs 6 and 7 respectively; therefore, areas described as “AOC H” have been included with those two SWMUs.

** Active military range area, excluded from any corrective action requirements under the terms and conditions of the EPA Consent Order, pursuant to Section IV.7.(d).

*** Although the 1988 RFA and 1995 Updated RFA recommended no environmental sampling, EPA has subsequently determined that based on unit design and/or past operational practices, past releases of hazardous wastes and/or solid wastes and hazardous constituents are possible, and Phase 1 RFIs (Release Assessments) are warranted.

TABLE 1-2
List of Areas of Concern (AOCs)

AOC	Description
A */**	Diesel Fuel Fill Pipe Area (Observation Post 1)
F */**	Rock Quarry (Camp Garcia)
G */**	Pump Station and Chlorination Building at Sewage Lagoons (Camp Garcia)

* As discussed previously, "AOC B" as listed in the 1988 RFA and 1995 Updated RFA, has been determined to be a SWMU, and is identified in this Work Plan as SWMU 12. AOCs "C", "D", and "E", as listed in the 1988 RFA and 1995 Updated RFA, have also been determined to be SWMUs, and because they are all located inside Building 303 at Camp Garcia, along with SWMU 4, they have been included in this Work Plan as part of SWMU 4. Also, "AOC H" as described in the 1988 RFA and 1995 Updated RFA, consists of two areas essentially contiguous with SWMUs 6 and 7 respectively; therefore, any releases from areas described as "AOC H" have been included with those two SWMUs. To be consistent with the AOC terminology utilized in the 1988 RFA and 1995 Updated RFA, the designation of other AOCs has remained as in those two documents.

** Although the 1988 RFA and 1995 Updated RFA recommended no environmental sampling, EPA has subsequently determined that based on unit design and/or past operational practices, past releases of hazardous wastes and/or solid wastes and hazardous constituents are possible, and that Phase 1 RFIs (Release Assessments) are warranted.

Three of the SWMUs listed in Table 1-1 (SWMU 3 - Waste Explosive Ordnance Detonation Area, SWMU 9 - Explosive Ordnance Firing Range, and SWMU 11 - Non-Explosive Ordnance Firing Range) are within active military ranges, and are expressly excluded from any corrective action requirements under the terms and conditions of the EPA Consent Order (EPA, 2000). EPA has stated in its Consent Order, however, that "releases of hazardous waste(s) and hazardous constituents from those three SWMUs are considered highly probable, based on the design and operating practices at those SWMUs, and any releases at those three SWMUs are subject to RCRA corrective action authority pursuant to 40 CFR § 264.101, and/or closure requirements of 40 CFR Part 264. Accordingly, EPA reserves its rights to require corrective action at those three SWMUs, which shall be investigated and remediated as necessary under the requirements of a RCRA Subpart X open burning/open detonation permit, when issued, which the facility has applied for. That permit application is currently under review by EPA."

1.5.2 Documentation of Release

Based on visible evidence such as the presence of staining, releases of hazardous or solid wastes and/or hazardous constituents to the environment may have occurred at certain non-range SWMUs and AOCs that are addressed in this Work Plan and which are subject to the EPA Consent Order. At SWMU 2 (Fuels Off-Loading Site), the 1988 RFA and 1995 updated RFA both infer that approximately 100,000 gallons of fuel were likely to have been released to the land and sea over the 25-year period during which this site was utilized. At SWMU 6 (Waste Oil and Paint Accumulation Area), the 1988 RFA and 1995 updated RFA both reported that spills of oil to the soil were observed at this SWMU, indicating potential releases. At SWMU 7 (Waste Oil Accumulation Area), the 1988 RFA and 1995 updated RFA

reported that the soils at that SWMU were severely stained, and described past practices which included digging up visibly stained soil at the SWMU, further indicating that releases occurred. Similarly, staining is reported in the 1988 RFA and 1995 updated RFA for the "Lubricating Oil Storage Area," which is classified as part of SWMU 7 for the purposes of this Work Plan. Likewise, at AOC "A" (Diesel Fuel Fill Pipe), the 1988 RFA and 1995 updated RFA described soils surrounding the fuel fill pipe as being severely stained, indicating a potential release.

Because only limited environmental sampling has been conducted at the SWMUs and AOCs addressed by this Work Plan, no definitive releases have been confirmed at those SWMUs or AOCs. Soil sampling has been conducted at some of the active military range areas (SWMUs 3 and 9) of the facility, which are excluded from the corrective action requirements of the EPA Consent Order under Section IV.7.D. Soil samples were collected in 1991 by the Navy in areas of SWMU 3 (Waste Explosive Ordnance Detonation Area) and SWMU 9 (Explosive Ordnance Firing Range), and analyzed for the Toxicity Characteristics (TC) of 40 CFR § 261.24 utilizing the Toxicity Characteristics Leaching Procedure (TCLP). Results of that sampling were included in the June 28, 1993, RCRA Part B Hazardous Waste Permit Application submitted for the facility by the Navy.

Surface soil sampling was conducted in June 2000 at SWMU 4, SWMU 6, SWMU 7, SWMU 10, and AOC F because of increased activities around these sites related to the Navy's transfer of vehicle maintenance activities from NASD to Camp Garcia, located in the EMA. Additionally, subsurface soil samples and wastewater samples were collected at SWMU 10. Preliminary results of unvalidated data were presented in the August 1, 2000, Quarterly Report for AFWTF. No releases were confirmed at these sites. Several metals were detected, however, in surface soil samples. These metal detections will be addressed by a background study. A separate work plan will be prepared to address background concentrations of metals in soil and groundwater at the AFWTF and EMA. Sampling results for these five sites will be presented in the Phase I RFI report.

SECTION 2

Technical Approach

The information in Section 1 on the project and facility background provides the basis for developing the technical approach to the Phase I RFI that is summarized in this section. In particular, Section 2 details the objectives and technical approach for the field activities of the Phase I RFI. This section also includes brief descriptions of the other tasks that will be performed to meet the objectives of the project. Table 2-1 summarizes all RFI field activities, their objectives, and the technical approaches employed to conduct the activities.

Following execution of the onsite Phase I RFI investigation, a report will be prepared that will make recommendations of either No Further Action (NFA) or a full RFI for each site investigated. At this time, it is assumed that a full RFI will be recommended for selected sites. Following execution of a full RFI, a report will be prepared detailing the findings of the RFI. The RFI report will recommend either a Corrective Measures Study (CMS) or NFA.

2.1 Task FI—Field Investigation

The field investigation includes a number of tasks: surface geophysical surveys, surface soil sampling, soil borings, monitoring well installation, water level measurements, groundwater sampling, chemical analyses in fixed laboratories, well testing, and soil sampling. This section describes the rationale for collecting the data in each step of the investigation and for assuring that the data accurately and precisely represent conditions at the facility.

For each site included in this Phase I RFI, the number and approximate locations of sampling points are defined based on available information. The number and locations of these samples are subject to change and will be finalized in the Site-Specific Work Plan.

Details of the actual field methodologies to be used in the investigations are provided in the Sampling and Analysis Plan (SAP).

2.1.1 Historical Aerial Photograph Analysis

Prior to conducting additional site investigations at the identified SWMUs, a historical aerial photograph analysis will be completed for the EMA and AFWTF. The assessment will be conducted to assess whether any other potential sources of soil and groundwater contamination might exist that were not identified in the RCRA RFA or the Consent Order. The analysis will include the following components:

- A review of historical environmental information, including permits, spill reports, previous investigations, and analytical data
- Interview with site personnel to identify potential areas of concern
- Historical aerial photograph analysis to identify areas of disturbed vegetation, cleared areas, and waste disposal areas

TABLE 2-1
Summary of Objectives and Technical Approaches of Phase I RFI Activities

RFI Activity	Objective(s) of Activity	SWMU/AOC/ PAOC/PI #	Technical Approach to Fulfill Objectives
a) Surface Soil Sampling	Evaluate surface soil quality around potential source areas to determine if a release of hazardous materials has occurred.	01, 02, 05, 08, 10, 12, AOC G	Clean surface area (1 to 2 inches) to remove grass and other vegetation as required. Collect sample using stainless steel trowel, spoon, or hand auger.
b) Soil Borings and Well Installation	Identify and evaluate the stratigraphy beneath and adjacent to each particular site, especially as it relates to influencing the movement of groundwater through the shall water bearing units potentially impacted by hazardous releases; provide permanent points for measuring hydraulic properties and groundwater quality at and adjacent to the facility	01, 02, 04, 10	Use rotary drilling to collect samples of the stratigraphy beneath each site. Characterize lithology and select samples for both chemical and physical analyses. Install wells at strategic locations to be used to sample groundwater, measure water levels, and estimate hydraulic characteristics. Several soil borings and wells will be installed off the site to characterize background conditions.
c) Monitoring Well Groundwater Sampling and Analysis	Evaluate the facility-wide groundwater quality, especially as it relates to potential risks to human health and the environment	01, 10	Analyze groundwater samples for a broad range of chemical constituents, including those related to potential human health and environmental risk and those related to characterizing the origin of the groundwater an the fate and transport of its constituents.
d) Water Level Measurements	Determine horizontal and vertical hydraulic gradients in water-bearing units so that directions(s) and rates of groundwater movement can be evaluated	01, 10	Collect synoptic and continuous water level measurements from monitoring wells.
e) Well Testing	Estimate the hydraulic properties of the significant water-bearing units to determine potential contaminant migration	01, 10	Conduct slug testing on the shallow water-bearing units.
f) Surface Geophysical Surveys	Map the aerial extent of disposal cells and trenches in the land fill area. Map the location of buried utilities.	01	Collect magnetic and/or electromagnetic data along transect lines using a digital data logger and Global Positioning System. Analyze data by contouring and profiling to detect anomalous areas. Use results to locate groundwater and soil sampling points.
g) Visual Site Inspections	Evaluate photo-identified sites to determine potential release locations	PIs 1-23, 11 PAOCs	Perform visual site inspections to evaluate current conditions and locations of potential past releases to the environment.

2.1.2 Initial Site Visit

Before beginning the sampling investigation, CH2M HILL will visit each proposed site included in the Phase I RFI. Numbers of samples to be taken and sample locations that were estimated based only on literature or aerial photograph review will be verified or altered in the field based on site layout and conditions. Only after the initial site visit will mobilization for monitoring well installation and soil sample collection begin.

2.1.3 SWMU 1—Camp Garcia Landfill

According to the RFA, the Camp Garcia Landfill is located in the EMA approximately 4,000 feet north-northwest of Blue Beach. The actual landfill is located approximately 3,000 feet east of Camp Garcia (PREQB, 1995).

According to the Navy Assessment and Control of Installation Pollutants (NACIP) Initial Assessment Study (IAS) report (Greenleaf/Telesca, 1984), this SWMU was in operation from approximately 1954 to 1978, when it became inactive. When this SWMU was operational, this landfill handled paper, corrugated containers, cans and food packaging material, rags, scrap metal, and yard waste. The municipal waste from both Camp Garcia and the Inner Range was handled here. This particular landfill was not lined; it serviced approximately 150 individuals, depending on military exercises. One 5-ton dump truck was used every day, 5 days per week, to dispose waste to this site. According to PREQB (1995), approximately 1,800 to 3,120 tons of waste were distributed over the 100 to 200-acre area. An aerial photo analysis of the landfill, however, indicated that the fill area extended over an area of approximately 50 to 55 acres (Lockheed Martin, 1999, and ERI, 2000). When this SWMU became inactive, a cap was installed. The landfill today is vegetated with dense grasses, and a gravel road constructed in the mid-1980s runs down its center. During the visual site inspection (VSI), no signs of erosion or stresses on vegetation were observed. No documentation was discovered regarding releases at this SWMU (PREQB, 1995). During a February 2000 CH2M HILL site visit, no signs of previous landfill activities were visible at SWMU 1.

Based on the review of the limited information available for the site, the Phase I RCRA Facility Investigation (RFI) is assumed to include the following:

- A detailed aerial photograph analysis
- A geophysical survey using magnetometer and/or EM methods
- Installation of five groundwater monitoring wells
- Collection of five groundwater samples
- Collection of approximately 50 surface soil samples
- Analysis of these samples for Appendix IX constituents and explosives

Institutional controls that preclude intrusive activities at the landfill will be installed and will negate the need for subsurface soil samples at the site.

One monitoring well will be located upgradient of disposal areas and four wells will be located downgradient of disposal cells and trenches. Exact locations will be shown in the

Site-Specific Work Plan. These estimations will be verified or altered upon the initial site visit.

2.1.4 SWMU 2—Fuels Off-Loading Site

SWMU 2 is located at Camp Garcia, and is the former location of four aboveground fuel storage tanks (ASTs). 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 a barge pumping fuel through an 8-inch submarine line to each tank. Before beginning this refueling process, seawater had to be flushed from the submarine line. During this process, approximately 1,000 gallons of fuel were discharged into the ocean and onto the land. According to the NACIP IAS study, this refueling process took place for approximately 25 years; therefore, approximately 100,000 gallons of fuel may potentially have been discharged during this period of time.

The following fuels were stored at this site during the operational period: diesel fuel, leaded gasoline, AVGAS, and JP-5 fuel. The sludge that developed in these tanks was removed by a private contractor and was disposed of on the main island of Puerto Rico.

The site today is overgrown with grass and small shrubs, with only minimal signs of previous activity. During the VSI, no signs of previous releases to either the soil or the water were apparent, and no release controls were identified (PREQB, 1995). These same conditions were observed during the CH2M HILL February 2000 site visit.

Based on the review of the limited information available for the site, the Phase I RFI is assumed to include collection of 12 surface soil samples and analysis of samples for Appendix IX constituents and explosives. Two soil borings, one in the area of the former fuel tanks and one in the area of the former discharge pipeline downgradient from the southern most tank, will be installed to depths of 15 feet below land surface (bls). Exact locations will be illustrated in the Site-Specific Work Plan. These estimations will be verified or altered upon the initial site visit. Detailed locations of sampling sites are presented in the Site-Specific Work Plan.

2.1.5 SWMU 4—Waste Areas of Building 303 (Camp Garcia)

According to the RFA, the waste areas located in Building 303 at Camp Garcia include a spent battery accumulation area; a catch basin for hydraulic oil; a cleaning/decreasing basin; and a rags, absorbent, and grease storage area. The last three areas listed were once individual AOCs, but were changed to waste management units in the Administrative Order On Consent (EPA, 2000).

The battery accumulation area contains spent batteries and battery acid to be disposed of offsite on NSRR. Once at NSRR, the batteries and acid will then be removed by a contractor. According to the RFA, this area in Building 303 was established as a storage area for batteries when the building was erected in the 1960s. This unit is still considered active, and continues to house spent batteries and battery acid. During the VSI, no batteries or acid were present at this location. 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 which may drip from the tanks. During the VSI, no signs of leakage were visible on the cement floor under the basin.

The rags, adsorbent, and grease storage area is also found in Building 303, and contains barrels of grease, rags, and other materials used when a spill develops. According to the RFA, this was also the area where spent batteries were once stored. During the VSI, no signs of spills were visible. These same conditions were observed during the CH2M HILL February 2000 site visit.

No information was available in the RFA to describe the cleaning / degreasing basin (PREQB, 1995).

Initial surface sampling was conducted in June 2000. The initial sampling included the collection of 12 surface soil samples and analysis of samples for Appendix IX constituents and explosives. Results will be presented in the Phase I RFI report along with the analytical results of the proposed background study. The Phase I RFI will include the installation of one soil boring outside the catch basin for hydraulic oil. One soil sample will be analyzed for Appendix IX constituents and explosives. If the degreasing basin can be located, one soil boring will be installed in the basin and four soil samples will be analyzed for Appendix IX constituents and explosives. If a dry well is located at SWMU 04, one soil boring will be installed in the dry well and four soil samples will be analyzed for Appendix IX constituents and explosives.

2.1.6 SWMU 5—Spent Battery Accumulation Area (Inner Range)

This SWMU is located in the Inner Range portion of this installation and is similar to SWMU 4. The batteries and battery acid stored here, however, are outside on a gravel driveway. According to the RFA, the acid from these batteries typically is emptied into plastic containers and shipped to NSRR.

Although the start-up date for this SWMU is unknown, it remains active. During the VSI, a total of nine batteries were stored on the gravel driveway at this site. No signs of any spills or leaks from these batteries were visible. No release controls were identified at this SWMU (PREQB, 1995). During the CH2M HILL February 2000 site visit, release controls (plastic storage trays) for battery storage were present, but no batteries were stored at the site. No signs of releases of battery acid were observed.

Based on the review of the limited information available for the site, the Phase I RFI is assumed to include the collection of four surface soil samples and analysis of these samples for Appendix IX constituents and explosives. These estimations will be verified or altered upon the initial site visit. Sample locations are shown in the Site-Specific Work Plan.

2.1.7 SWMU 6—Waste Oil and Paint Accumulation Area (Seabees Area at Camp Garcia)

According to the RFA, this area is used by the Seabees as a storage area for waste oil and paint.

The waste oil at this location is containerized in 55-gallon drums, and the paint is housed in small containers. Tires and two drums of lubricating oil are also present at this site. The waste oil and tires are stored on a grassy area until they are shipped offsite to NSRR. The

RFA states that this area became active approximately 10 years ago, and remains active. During the VSI, signs of oil leakage from the drums into the ground were visible. No release controls are present at this site (PREQB, 1995). During the CH2M HILL February 2000 site visit, no drums or waste materials were present at the site. During an interview with site personnel in June 2000, it was determined that SWMU 6 was located adjacent to SWMU 7 and that the two SWMUs can be investigated at the same time. Initial Phase I RFI sampling was conducted in June 2000. Ten surface soil samples were collected and analyzed for Appendix IX constituents and explosives. Results will be presented in the Phase I RFI report along with the analytical results of the proposed background study.

2.1.8 SWMU 7—Waste Oil Accumulation Area (outside Building 303 at Camp Garcia)

According to the RFA, this area is located outside Building 303 at Camp Garcia. This area is used by the Marines for 3 months per year. During these 3 months, Marines practice their exercises at the EMA, and need a place to dispose of waste oil from the maintenance of their vehicles. This area includes an open-top 55-gallon drum, 25-gallon trash can, and two drums cut in half. According to the RFA, the soil in this area is typically stained with waste oil after maintenance procedures on Marine vehicles. Once the Marines complete their training, they reportedly excavate the soil under the waste oil storage area and mix it with sand. The excavated soil is reportedly then containerized in 55-gallon drums and shipped to NSRR. Although the start date for this site is unknown, the Marines continue to use this area for training. During the VSI, the drums appeared to be full, and signs of waste oil were visible in the soil at this site. No release controls were identified at this SWMU (PREQB, 1995). During the CH2M HILL February 2000 site inspection, no drums of waste oil or other material were present in the area.

This site was investigated along with SWMU 6 in June 2000. The sites are adjacent and were investigated as one large unit (for both SWMU 6 and SWMU 7). Ten soil samples were collected and analyzed for Appendix IX constituents and explosives. Results will be presented in the Phase I RFI report along with the analytical results of the proposed background study.

2.1.9 SWMU 8—Waste Oil Accumulation Area (Inner Range)

This accumulation area is located outside the generator building at the observation post on Cerro Matias.

According to the RFA, this area contains drums that store both waste lubricants and oils. These drums are stored on bare soil prior to being shipped offsite to NSRR. This accumulation area started approximately 10 years ago, and remain active. During the VSI, minimal spills of lubricating oil were present in the area of the drums. No release controls were visible at this site (PREQB, 1995). During the CH2M HILL February 2000 site inspection, no soil straining was evident in the accumulation area, and the drums were stored in plastic secondary containment trays for release control.

Based on the review of the limited information available for the site, the Phase I RFI is assumed to include the collection of five surface soil samples and analysis of samples for

Appendix IX constituents and explosives. Sample locations are shown in the Site-Specific Work Plan.

2.1.10 SWMU 10—Sewage Treatment Lagoons

According to the RFA, the sewage treatment lagoons for Camp Garcia went into service when the adjacent pump station was installed in the early 1950s. This SWMU is still considered active.

These lagoons are divided into two stages for the treatment of domestic waste. Four unlined lagoons are utilized in this process; two received the waste, and two were considered polishing lagoons. Following waste treatment in the polishing lagoons, the remaining liquid was land applied. Because only a small number of Navy Seabees and civilians (45 people) use the sanitary facilities daily, the amount of domestic waste generated was small. Although unlikely, the presence or absence of hazardous constituents in the waste has not been determined. No signs of release are visible at this SWMU, although sampling has not been conducted here (PREQB, 1995). Inspection of the sewage lagoon system during the CH2M HILL February 2000 site visit revealed that the lagoon system was overgrown with vegetation and did not appear to be active.

An initial investigation including the collection of four surface and subsurface samples and one wastewater sample was conducted in June 2000. Results will be presented in the Phase I RFI report. Additional investigations will include the installation of four monitoring wells, collection of 16 surface soil samples, collection of 16 subsurface samples, and analysis of samples for Appendix IX constituents and explosives. Sample locations are shown in the Site-Specific Work Plan.

2.1.11 SWMU 12—Solid Waste Collection Unit Area

This area was formerly referred to as AOC B, but in accordance with the Administrative Order of Consent (EPA, 2000), it was decided that this area should be a waste management unit identified as SWMU 12.

The collection area contains storage devices used to containerize garbage prior to its disposal at the Vieques Island landfill. The containers used to store this garbage include wooden boxes, wooden trailers, and metal dumpsters and cans. During the VSI, only a wooden trailer was visible at this site (PREQB, 1995).

Based on the review of the limited information available for the site, the Phase I RFI is assumed to include the collection of five surface soil samples, and analysis of samples for Appendix IX constituents and explosives. Sample locations are shown in the Site-Specific Work Plan.

2.1.12 AOC A—Diesel Fuel Fill Pipe Area (Observation Post I)

According to the RFA, this area contains a pipe used to fill the underground storage tank (UST) located at OP-I in the Cerro Matias.

The UST and the fill pipe were first put into service approximately 10 years ago. This site contains a 6-foot by 6-foot area of soil in the area of the fill pipe which was found to be stained with fuel from spills during previous refueling procedures. Because the tank is located 25 feet southwest and downgradient of the fill pipe, this staining does not appear to come from the tank. No release controls were found at this site (PREQB, 1995).

The UST, associated piping including the fill pipe, and surrounding soil were excavated and removed for disposal in 1997. The UST was replaced with a new UST. Four confirmation soil samples (sample numbers 23 through 26) were collected from the excavation and analyzed for petroleum-related constituents. No petroleum-related constituents were detected in any of the four soil samples as documented in Table 3-1, Appendix A, of the Site-Specific Work Plan.

Because the soil surrounding the UST and associated piping, including the fill pipe, was excavated and removed for disposal during the 1997 tank replacement, and because the confirmation soil sampling conducted during the tank replacement did not indicate the presence of petroleum-related constituents, no further action is proposed for this site.

2.1.13 AOC F—Rock Quarry (Camp Garcia)

According to the RFA, this site is located southwest of the former Camp Garcia landfill.

This site contains the gravel that the Navy uses for roads and other construction purposes. During the VSI, however, more than just rocks were present in this quarry. Used tires and some paper waste were also visible at this location (PREQB, 1995). During the CH2M HILL February 2000 site inspection, no waste tires or other waste materials were observed at the quarry, and the quarry did not appear to be active.

The preliminary Phase I RFI in June 2000 included the collection of five surface soil samples and the analysis of samples for Appendix IX constituents and explosives. Results will be included in the Phase I RFI report along with the analytical results from the proposed background study.

2.1.14 AOC G—Pump Station and Chlorination Building at Sewage Lagoons (Camp Garcia)

This site, which is located at Camp Garcia, became active in the 1950s. After approximately 30 years of service, this building was shut down because of decreased activity at the facility.

The main purpose of this building was to pump and chlorinate domestic waste water. This building was constructed using concrete, and built partially below grade. During the VSI, stains were visible on the concrete unit because of previous overflowing of the unit. No signs of damage to the grassy area in the general vicinity were apparent (PREQB, 1995). During the CH2M HILL February 2000 site inspection, no staining was observed in the chlorination building, and the site was overgrown with vegetation.

Based on the review of the limited information available for the site, the Phase I RFI is assumed to include the collection of five surface soil samples and analysis of samples for Appendix IX constituents and explosives. Sample locations are shown in the Site-Specific Work Plan.

2.1.15 Future Steps in the RCRA Process

The Phase I RFI is limited in scope and is intended to gather sufficient data to confirm the presence of absence of contamination at a SWMU or AOC, and to provide the information necessary to develop the scope of work for a full RFI or to support an NFA decision. The RCRA process, descried in the Consent Order, includes the following steps: Description of

Current Conditions Report, Phase I RFI, Full RFI, CMS, CMI and an IM at any time. Sites that are determined to be contaminated as a result of this Phase I RFI will be involved in one or various combinations of the following specific activities.

2.1.15.1 Full RCRA Facility Investigation

The full RFI is appropriate when the preceding Phase I RFI has characterized or identified a release of contaminants. This additional study of the facility is typically required either under a schedule of compliance designated in the Site Management Plan (SMP) or under an enforcement order. For AFWTF, the enforcement order will be the compliance schedule.

The purpose of the full RFI is to characterize the nature and extent of the contamination at the facility and to gather sufficient data to support a risk assessment, CMS, NFA decision, or an Interim Measure (IM). The objective of the investigation is to characterize the SWMU or AOC, define potential release locations, define the degree and extent of contamination, and identify actual and potential receptors.

If the full RFI reveals a release that poses a threat of immediate harm to human health and the environment, an IM may be required. If there is no immediate threat to human health or the environment, the existence of contamination above acceptable levels will require an CMS to evaluate potential corrective action alternatives. If the contaminants detected do not exceed the screening criteria, or if the risk assessment indicates that no unacceptable risks to human health or the environment exist, the RFI will recommend NFA for the facility.

2.1.15.2 Corrective Measures Study

A CMS may be required when the Full RFI findings show that conditions at the SWMU or AOC pose unacceptable current or future risks to human health or ecological receptors. The CMS process involves several technical actions to develop feasible corrective measures to remediate the site. The primary objective of the CMS process is to identify, evaluate and recommend remedial technologies that are applicable to the site conditions and the nature and extent of the release.

2.1.15.3 Interim Measure

At any time during the RCRA process, an IM may be conducted if it is determined that an imminent threat exists to human health or the environment. An IM is intended to prevent or minimize the further spread of contamination while long-term remedies are pursued. Additionally, an IM may be performed in order to obtain approval of an NFA recommendation. IMs will be conducted, if applicable, during the investigation process.

2.1.16 Subcontractor Procurement

A number of subcontractors will be procured for the Phase I RFI. All subcontractors will be procured through a precise bid or proposal procedure. Below is a list of potential subcontractors and their anticipated use.

- Surveyor—survey existing and newly installed wells
- Utility search—survey intrusive sampling locations where clearance of buried utilities cannot be confirmed
- Rotary drilling service—soil boring and well installation

- Analytical laboratory—analyze soil, sediment, and groundwater samples for chemical constituents
- Geophysical surveys—map locations of landfill trenches
- Data validation—validate all samples collected for chemical analysis
- Investigation-Derived Waste (IDW) disposal service—hauling and disposal of all soil and groundwater IDW

2.1.17 Investigation-Derived Waste Management and Demobilization

Demobilization activities include general site restoration and handling and disposal of IDW. IDW handling and disposal procedures are discussed in the IDW Management Plan (IDWMP).

2.2 Task DM—Data Management

Analytical results to be used for human health or ecological risk assessment will need the highest level of data quality, and samples will be analyzed in a Navy-approved and contract laboratory program (CLP)-certified fixed laboratory with full documentation using EPA-approved methods. Analyses will include the proper ratio of field QC samples (e.g., one duplicate sample per 10 regular samples) recommended by Naval Facilities Engineering Command (NAVFACENGCOM) guidance (Navy Installation Restoration Laboratory Quality Assurance Guide, Naval Facilities Engineering Services Center [NFESC], February 1996).

For certain chemicals, EPA Region IX has calculated screening level criteria for potential risk to human health and the environment. To detect some of the chemicals at levels as low as the screening level criteria, special analytical methods will be required. Full documentation of these analytical methods will be provided with the sample analyses.

Analytical results will be validated by CH2M HILL subcontractors approved by the Navy. Data validators will use EPA Region II guidance.

Field analyses used to assess hydrogeologic conditions will be performed according to standard operating procedures and results recorded in the field logbook. Results of field analyses will be evaluated by the field team leader.

During the RFI, CH2M HILL will collect a variety of environmental information which will support data analysis, reporting, and presentation activities. Environmental analytical samples and various types of field data will be collected during the investigation. These data will support subsequent data analysis for site characterization and reporting. The data will also support any subsequent remedial action decisions and the presentation of investigation results to the Navy, regulatory agencies, and the public. To meet quality assurance provisions of current regulatory requirements, a complete audit trail of the information flow will be established. Each step in the data management process (data collection, handling, control, storage, access, and analysis) will be adequately planned, executed, and documented. To meet this requirement, CH2M HILL will employ an environmental data management system (EDMS) that manages mission-critical information throughout the RFI process.

The EDMS will broadly support the collection and storage of analytical and field environmental data and project documentation in hard copy and electronic format; the analysis of data and the presentation of investigation findings using geographic information system (GIS) technology; and the access to environmental data and mapping through Web-based interactive viewer tools that facilitate management review and decision-making processes.

2.3 Task AR—Assessment of Risks

Risk assessments will be conducted following all applicable guidance documents from EPA (federal and Region III). The following guidelines are a partial list of those to be used for the human health risk assessment:

- Risk Assessment Guidance for Superfund, Volume 1, Human-Health Evaluation Manual, Part A, Interim Final (EPA, 1989).
- Risk Assessment Guidance for Superfund, Volume 1, Human-Health Evaluation Manual, Part D, Interim Final (EPA, 1998).
- Exposure Factors Handbook (EPA, 1995).
- Human-Health Evaluation Manual Supplemental Guidance: Standard Default Exposure Factors (EPA, 1991).
- Risk-Assessment Guidance for Superfund, Volume 1, Human-Health Evaluation Manual, Part B (EPA, 1991).
- Dermal Exposure Assessment: Principles and Applications (EPA, 1992).
- Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening (EPA Region III, 1993).

The ecological risk assessment will be performed according to the Ecological Risk Assessment Guidance for Superfund (EPA, 1997). The Tri-Service Procedural Guidelines for Ecological Risk Assessments (Wentsall, et al., 1996) also will be followed as appropriate. Quantitative assessments will be calculated for chemicals for which accepted toxicologic values exist. Other chemicals will be evaluated qualitatively.

2.4 Task RF—Phase I RCRA Facility Investigation Report

The results of the Phase I RFI will be documented in a report that will include, at a minimum, the following information:

- History and background of the area, including previous investigations
- Features and environmental setting
- RFI activities
- Sampling and analytical methods
- Presentation and evaluation of the analytical data
- Discussion of the nature and extent of contamination
- Results of the baseline human health and ecological risk assessments

In addition, the RFI report will include, as appropriate, site maps with sampling and monitoring locations, boring logs, geologic cross sections, validated analytical data, and figures depicting the nature and extent of contaminants at individual sites and the facility as a whole. In the event that a full RFI is deemed necessary, the full RFI will include the above referenced information with additional sampling data.

The RFI report will make recommendations concerning additional work and provide necessary support to justify the recommendations. The information collected and presented in the Phase I RFI report will be used in future studies that may include a full RFI and CMS. The Phase I RFI will follow EPA guidance titled Interim Final RCRA Facility Investigation Guidance (EPA 530/SW-89-031, May 1989).

A draft, draft final, and final RFI report will be prepared as part of this task. The draft final report will address any comments on the draft version and the final RFI report will address the regulators' and other relevant parties' comments on the draft final version.

2.5 Task CM—Corrective Measures Report

If a CMS is performed on a particular site, the results of the CMS will be documented in a corrective measures report. The report will include, at a minimum, the following information:

- Description and history
- Summary of the RFI and the impact on the selected corrective measure(s), including relevant field and laboratory studies
- Summary of corrective measure(s), including description; rationale; performance expectations; preliminary design criteria and rationale; general operation and maintenance requirements; and long-term monitoring requirements
- Design and implementation precautions of the corrective measure(s), including special technical problems; additional engineering data required; permits and regulatory requirements; access, easements, and rights-of-way; health and safety requirements; and community relations activities
- Cost estimates, including a capital cost estimate; operation and maintenance cost estimate; and present-worth analysis

Draft, draft final, and final versions of the corrective measures report will be prepared as part of this task. The draft final corrective measures report will address comments on the draft version, and the final corrective measures report will address the regulators' and other relevant parties' comments on the draft final version.

2.6 Task PP—Project Planning

Project management involves such activities as daily technical support and guidance; budget and schedule review and tracking; review of subcontractor invoices and client billings; personnel resources planning and allocation; subcontractor coordination; preparation for and attending meetings; preparation of monthly progress reports (MPRs);

and communication and coordination of events. The project manager is responsible for all of these tasks. The project manager will review subcontractor invoices monthly and prepare MPRs monthly. The project manager will attend all key project meetings and prepare meeting summaries. The project manager will notify the EPA of any key technical changes or deviations from the work plan and any changes in key management staff assigned to the project.

SECTION 3

Schedule

Table 3-1 presents the schedule to perform the tasks for the Phase I RFI.

TABLE 3-1
Proposed Project Milestones

Phase I RCRA Facility Investigation, AFTWF
Vieques Island, Puerto Rico
2001

Key Project Milestones	End	Duration
Draft Site-Specific Work Plan		28 days
EPA Review		90 days
Final Site-Specific Work Plan		30 days
Conduct Field Investigation		30 days
Laboratory Analyses		30 days
Data Validation/Management		30 days
Data Evaluation		30 days
Draft Phase I RFI Report		30 days
Navy Review		90 days
Draft Final Phase I RFI Report		30 days
EPA Review		90 days
Final Phase I RFI Report		30 days

SECTION 4

Project Team

Project organization is depicted graphically in Figure 4-1. The CH2M HILL Project Manager designated for the oversight of this CTO is Mr. Marty Clasen. Mr. Clasen will have overall responsibility for such activities as technical support and oversight, budget and schedule review and tracking, review of invoices, personnel resources planning and allocation, and coordination. Mr. Erik Isern will serve as the field team leader for all work on the Phase I RFI. Mr. Isern will be responsible for providing technical support and oversight, personnel resources planning and allocation, and (in coordination with LANTDIV) he will assist the Project Manager in tracking the budget and schedule for the RFI activities and in preparing MPRs and reviewing invoices. In addition, Mr. Russ Bowen, Mr. David Lane, and Mr. John Tomik will provide senior review. Mr. Kevin Sanders will provide senior project chemistry support.

The RFI field program (soil sampling, well installation, etc.) will be performed by qualified CH2M HILL staff members. CH2M HILL will notify LANTDIV which CH2M HILL personnel will mobilize to the site prior to initiating field activities.

Resumes for the following individuals are included at the end of this plan:

- Mr. Russ Bowen
- Mr. Marty Clasen
- Mr. David Lane
- Mr. Eric Isern
- Mr. Kevin Sanders
- Mr. John Tomik

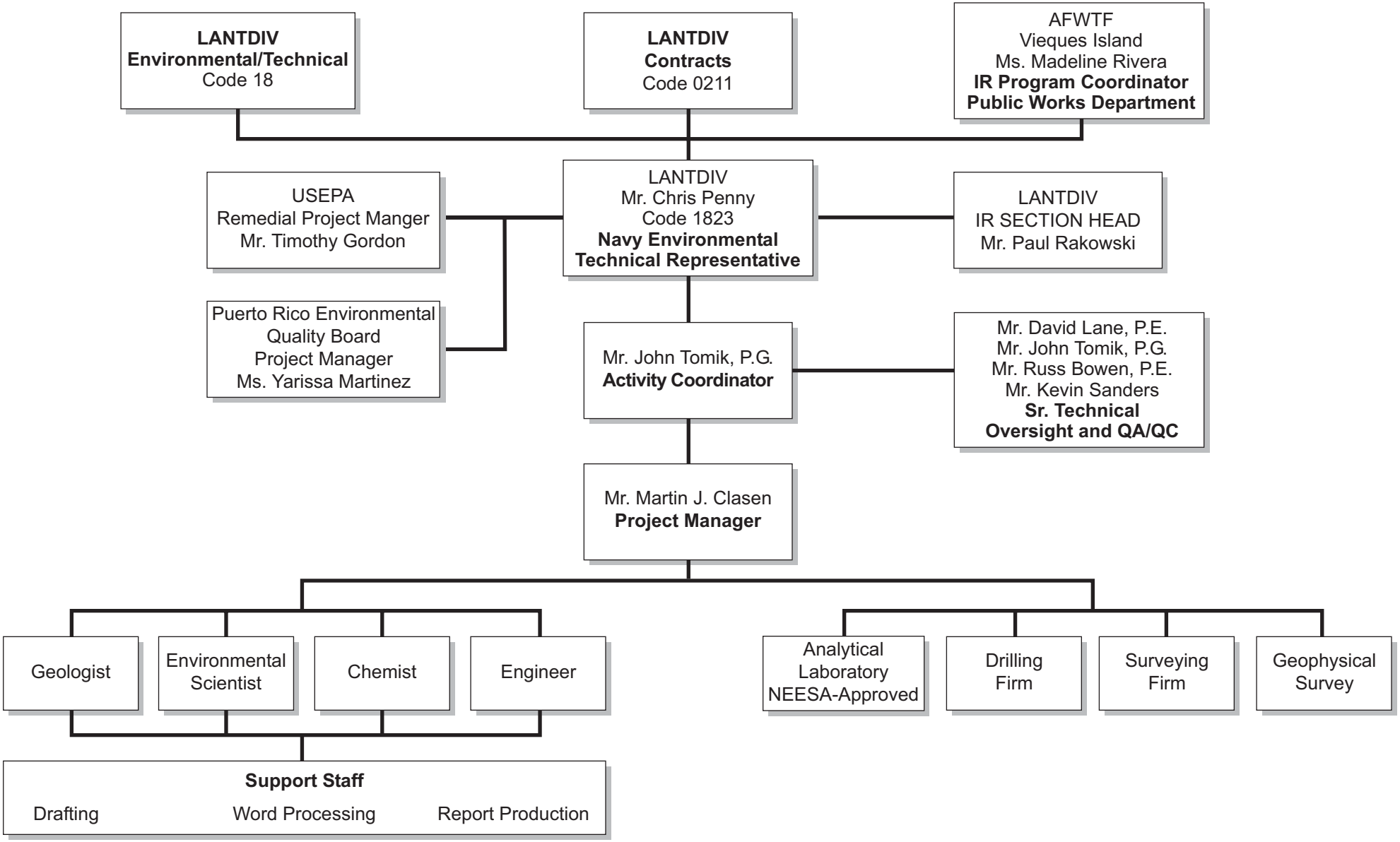

FIGURE 4-1
Project Organization
AFWTF Vieques Island, Puerto Rico

CH2MHILL

SECTION 5

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I certify that the information contained in or accompanying this Final Work Plan for the RCRA Facility Investigation, Vieques Island, dated February 2001, is true, accurate, and complete.

As to the QAPP and SAP portions of this work plan for which I cannot personally verify accuracy, I certify under penalty of law that this work plan and all attachments were prepared in accordance with procedures designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, or the immediate supervisor of such person(s), the information submitted is, to the best of my knowledge and belief, true, accurate, and complete.

I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

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RESUMES

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Master Sampling and Analysis Plan

Master Field Sampling Plan

FINAL

Master Field Sampling Plan

Atlantic Fleet Weapons Training Facility
Vieques Island, Puerto Rico

Contract Task Order 031

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

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List of Acronyms

AFWTF	Atlantic Fleet Weapons Training Facility
ASTM	American Society for Testing and Materials
ATV	All-terrain vehicle
BGS	Below ground surface
°C	Degrees Centigrade
CLP	Contract laboratory program
COC	Chain-of-custody
D.O.	Dissolved oxygen
EPA	Environmental Protection Agency
EM	Electromagnetic induction
FID	Flame ionization detector
FSP	Field Sampling Plan
GPS	Geographic Positioning System
GPR	Ground penetrating radar
HCl	Hydrochloric acid
HNO_3	Nitric acid
HSP	Health and Safety Plan
IDW	Investigation-derived waste
IDWMP	Investigation-derived waste management plan
LANTDIV	Atlantic Division
MHZ	Megahertz
MP	Master Plan
MS/MSD	Matrix spike, matrix spike duplicate
MSL	Mean sea level
NaOH	Sodium hydroxide
NAS	Naval Air Station
NAVFACENGCOM	Naval Facilities Engineering Command
NTR	Navy Technical Representative
NTU	Nephelometric turbidity unit
OVM	Organic vapor monitor
PAH	Polycyclic Aromatic Hydrocarbon
PC	Personal computer
PCB	Polychlorinated biphenyl
PID	Photoionization detector

PVC	Polyvinyl chloride
QAPP	Quality Assurance Project Plan
QC	Quality control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
SOP	Standard operating procedures
SSP	Site screening process
SVOC	Semivolatile organic compound
TAL	Target Analyte List
TCL	Target Compound List
USCS	Unified soil classification system
USGS	United States Geological Society
VOC	Volatile organic compound
XRF	X-Ray Fluorescence

SECTION 1

Introduction

This Master Field Sampling Plan (FSP) is a compilation of the anticipated field activities that may be performed to support Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) activities at the Atlantic Fleet Weapons Training Facility (AFWTF) on Vieques Island, Puerto Rico. The purpose of the Master FSP is to describe the types of field procedures which may be performed during the course of field activities, and how these procedures will be completed. This Master FSP does not include site-specific information regarding past activities, nor does it include potential sample locations or the number of samples to be collected. Site-specific field activities will be described in separate Site-Specific Work Plans. These work plans will reference this Master FSP, rather than repeat the information contained in this plan. Information to be provided in each site-specific FSP is outlined on the FSP site-specific checklist, located in Attachment 1 of the Master WP.

This Master FSP describes field investigation procedures and practices to be followed at AFWTF and is organized in three sections. Section 1 is a general introduction. Section 2 addresses analytical services and describes the different field activities which may be performed. Section 3 provides protocol for sample documentation and custody. All analyses will be performed in accordance with standard EPA Contract Laboratory Program (CLP) protocol or EPA Test Methods for Evaluating Solid Waste (SW-846) Third Edition. Tests conducted in the field, such as water quality measurements and tests for soil characteristics, will be performed according to the Standard Operating Procedures (SOPs), located in Attachment 2 of the Master WP. The potential field activities that may be conducted at the base include:

- Geophysical surveys
- Soil gas surveys
- Surface water and sediment sampling
- Surface soil sampling
- Soil boring installation
- Subsurface soil sampling
- Monitoring well installation and development
- Monitoring well abandonment
- Groundwater sampling
- Direct-Push groundwater sampling
- Aquifer testing
- Hydrologic measurements
- Sewer Sampling
- Biota sampling
- Trenching
- Land surveying
- Investigation derived waste sampling

- Decontamination
- Health and Safety Monitoring

The background and setting for AFWTF is described in the Master WP and is not repeated here. Site-specific information regarding individual sites will be included in Site-Specific Work Plans.

SECTION 2

Field Activities

This section describes analytical field sampling analytical/quality control protocol and field activities which may be performed at AFWTF. Not all of these activities will be conducted at all sites. The field activities discussion is general; details of the procedures are provided in the SOPs included as Appendix A of the Master WP.

The sampling activities at AFWTF conform to U.S. Navy specifications and guidelines.

2.1 Analytical Services

Analytical services include the measurement of field parameters, routine analyses of environmental samples, and data validation.

2.1.1 Field Measurements

The field parameters temperature, pH, dissolved oxygen (DO), turbidity, oxidation reduction potential (ORP), and specific conductance are measured as screening tools. These parameters will be used to evaluate groundwater and surface water conditions prior to sample collection. These parameters will also be used to estimate the effectiveness of well development activities.

Field screening also includes the use of an organic vapor monitoring instrument to measure organic vapors in air and an explosimeter to measure the vapors associated with combustible gasses. These data will be used for the following:

- Evaluation of ambient air conditions during field activities to meet the requirements of the HSP
- Assist in the gross screening of soil samples

Field screening procedures are discussed in more detail in the SOPs included in Attachment 2 of the Master WP.

2.1.2 Routine Sample Analysis

The routine analysis of environmental samples will be requested for Appendix IX constituents and explosives.

These data will be used for the following:

- Risk assessment
- Characterization of the native soil and fill
- Characterization of groundwater, sediment, and surface water

The methods and procedures to be followed during routine sample analyses are discussed in more detail in Section 8 of the Master QAPPs.

2.1.3 Data Validation

Data validation requirements are discussed in more detail in Section 9 of the Master QAPP.

2.2 Field Quality Control (QC) Procedures

QC duplicate samples and blanks are used to provide a measure of the internal consistency of the samples and to provide an estimate of the components of variance and the bias in the analytical process. Table 10-1 in the QAPP is a summary of the collection frequencies of the field QC samples.

2.2.1 Blanks

Blanks provide a measure of cross-contamination sources, decontamination efficiency, and other potential errors that can be introduced from sources other than the sample. American Society for Testing and Materials (ASTM) Type II water will be used for blanks. Four types of blanks will be generated during sampling activities: trip blanks, field blanks, equipment blanks, and temperature blanks.

One trip blank will be included each day for each cooler containing samples for volatile organic compound (VOC) analysis. The trip blanks will be prepared before each sampling event, shipped or transported to the field with the sampling bottles, and sent to the laboratory unopened for analysis. Trip blanks will not be prepared or handled in the field. Trip blanks will indicate whether contamination is introduced during shipment to the field, storage in the field, or shipment from the field to the analytical laboratory.

One field blank will be collected each week of sampling. The field blanks will indicate whether contamination has been introduced by ambient air conditions in the field or by handling the sample bottle in the field or in the laboratory. The pre-preserved sample container will be filled with ASTM Type II water in the field at the time of sampling.

One equipment blank will be collected each day during sampling. The equipment blanks will indicate the completeness of equipment decontamination procedures.

A temperature blank will be included in each cooler containing samples requiring preservation so that the laboratory can record the temperature without disturbing the samples. The temperature blank will not be given a sample number nor listed as a sample on the chain-of-custody (COC).

2.2.2 Duplicates

Field duplicate samples will be collected in accordance with procedures described in Sections 3.2.3 and 3.2.4 of the Site-Specific Work Plan at a frequency of 1 per 10 field samples per matrix. The locations from which the duplicates are taken will be selected with a bias for locations where contamination is expected. The duplicate sample will be submitted for analysis as two independent samples with different sample numbers. Data validators will use these results to evaluate the precision of the analytical data.

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

Matrix spike / matrix spike duplicate (MS / MSD) samples will be collected at a frequency of 1 per 20 field samples. For the MS / MSD measurement, three aliquots of a single sample are analyzed. The matrix spike is an aliquot of sample spiked with a known concentration of target analyte(s). The matrix spike duplicate is an intra-laboratory split sample spiked with identical concentrations of a target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike is used to document accuracy in a given sample matrix. The MSD is used to document the precision in a given sample matrix. Thus, the matrix accuracy is evaluated from spike recoveries, while the precision is evaluated from comparison of the spike concentrations (SW846) of the MS and MSD. Data validators will use the results to evaluate the accuracy of the analytical data and precision through comparison of the duplicate spike results.

2.3 Geophysical Surveys

Geophysical survey methods that may be used include electromagnetic induction (EM), ground penetrating radar (GPR), magnetometry, and downhole geophysical surveys. Appropriate survey methods will be selected to delineate potential areas of buried wastes and utilities at the areas under investigation. Utility clearance will be performed by AFWTF and / or its subcontractors prior to any soil disturbance. The results from these surveys will be used to determine the locations of subsequent soil borings and monitoring wells and to characterize the condition of the subsurface.

In general, grids will be established in the field at areas to be evaluated at an appropriate spacing (e.g., 15 to 20 feet), depending on the geophysical method being used and the size of the site. Smaller grid spacings may be used in areas where greater subsurface definition is required (e.g., locating an underground storage tank). The grid spacings will be tied to existing permanent structures (e.g., buildings, monitoring wells) so they can be referenced to later land surveys. In some areas, brush and tree clearing may be required for the geophysical surveying operations. The criteria used to determine grid spacing will be further defined in the Site-Specific Work Plans.

2.3.1 Electromagnetic Induction

EM terrain conductivity profiling is a non-invasive method used to identify lateral changes in subsurface conductivity through inductive electric measurements made at the ground surface. The EM survey is a rapid, cost effective reconnaissance tool. Areas of higher-than-background conductivity may be associated with surficial and buried wastes, contaminants, or metal objects (i.e., buried drums and storage tanks, product lines, utility lines). EM may also be used for contaminant plume mapping, locating abandoned trenches and lagoons, and locating lateral anomalies such as pockets or pits of different materials.

EM data will be digitally recorded and downloaded to a personal computer (PC) for processing and analysis. Data will be profiled and contoured over the area of investigation to determine inordinately high and low conductivity values. Areas interpreted to represent buried waste, contaminants, or metals will be delineated.

2.3.2 Ground Penetrating Radar (GPR)

GPR is an active geophysical system which transmits high frequency EM waves into the ground and detects the energy reflected back to the surface. The GPR transmits electromagnetic waves of radio and microwave frequencies (e.g., 80 megahertz [MHz] to 1,000 MHz). Reflections typically occur at lithologic changes, subsurface discontinuities, and internal soil structures. GPR is useful for determining the presence of underground utilities and buried metallic objects, and for further characterizing buried wastes by producing a graphic cross section of the subsurface. Other applications include locating concrete foundations, buried archaeological artifacts, excavations, filled pits, and lagoons.

2.3.3 Magnetometry

Magnetometry measures local perturbations in the earth's magnetic field. Both naturally-occurring and man-made magnetic materials can modify the ambient field. Buried ferrous objects, such as drums, tanks, and product lines, usually produce a detectable magnetic anomaly.

Magnetic data will be digitally recorded and downloaded to a PC for processing and analysis. Data will be profiled and contoured over the area of investigation to facilitate identification of anomalous magnetic intensities. Areas interpreted to represent buried waste, contaminants, or metals will be delineated.

2.3.4 Downhole Geophysics

Downhole geophysical methods are used to characterize or log the stratigraphy, geology, morphology, and hydrology of a well or open bore hole. Methods that are commonly utilized and what is recorded are summarized below:

- Caliper log – measures changes in the diameter of the borehole
- Fluid resistivity log – records natural variations in electrical resistivity (resistance) of borehole and interstitial fluids
- Electrical resistivity log – records natural variations in electrical resistivity (resistance) between contrasting lithologic types and interstitial fluids
- Spontaneous potential log – records natural variations in electrical potential (voltages) between contrasting lithologic types
- Gamma log – records natural variations in gamma radiation between contrasting lithologic types
- Acoustic (sonic) log – records natural variations in density (porosity) between contrasting lithologic types
- Neutron logs – records natural variations in neutron emission between contrasting lithologic types
- Temperature log – records variations in water temperature within a borehole
- Fluid movement (flow) log – records variations in borehole groundwater flow-through

2.4 Soil Gas Survey

Soil gas surveys are expected to be used in areas where materials containing petroleum-based compounds, VOCs, or other hydrocarbon compounds were used, spilled, or stored. Soil gas survey results will be used to help delineate the extent and concentration of organic vapors in the vadose zone which may be indications of soil and/or groundwater contamination. The results may also be used to determine the need for and locations of confirmatory soil borings and monitoring wells.

Soil gas samples will be collected in-situ and analyzed onsite. Samples may be analyzed for hydrocarbon compounds and/or selected chlorinated compounds (i.e., trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane) using gas chromatographic techniques. Samples can also be analyzed for combustible gases using a portable combustible gas indicator.

2.5 Surface Water and Sediment Sampling

Surface water and/or sediment samples will be collected from the Caribbean Sea sewers, sumps, and other structures across the site. For the sewers, sampling will proceed from downstream to upstream locations to reduce the amount of turbidity and potential cross-contamination of downstream samples. Sampling will be conducted at low tides, where appropriate, and low flow to minimize dilution of possible contaminants. Sampling activities will not occur after periods of heavy rainfall.

2.5.1 Surface Water Sampling

Field parameters (e.g., DO, temperature, specific conductance, pH, and ORP) will be measured prior to sample collection. Surface water samples will then be collected by submersing the sampling container directly into the surface water body or by using a “thief” type sampler and then transferring the sample to the sample container. The body of the immersed sampling container will face downstream so that any sediment disturbed during the immersion of the container does not enter the sampling vessel. If the volume of surface water encountered is insufficient to allow the direct submersion of the sampling containers, a glass interim vessel will be used to transfer the surface water sample to the sample containers. The glass interim vessel will be laboratory cleaned to the same specifications as the sample containers.

Table 2-1 presents the required containers, preservatives, and holding times for water samples. All appropriate preservatives will be added to the sample containers by the contracted laboratory before shipment to the environmental contractor’s field team. All samples will be kept cool in the field at 4 degrees Celsius (ºC), using bagged ice.

For VOC samples, the bottles will be filled so as to minimize aeration of the samples. During the collection of surface water samples, care will be taken to ensure that any pre-added preservative is not rinsed from the sampling container during sample collection. Sample vials will be filled completely and capped to prevent the entrapment of any air bubbles in the vial.

TABLE 2-1
Required Containers, Preservatives, and Holding Times for Water Samples

Analysis	Analytical Preparation/ Method Number	No. of Containers	Sample Container	Preservative	Holding Time	Volume of Sample Collected
VOCs	SW-846 Method 5030B/8260B, 8015	3	Three 40-ml glass vials w/Teflon-lined cap	HCl to pH <2; Cool to 4ºC	14 days	Fill completely; no air bubbles
SVOCs	SW-846 Method 3510C/8270C	2	Two 1-liter bottles	Cool to 4ºC	7 days extraction/40 days to analysis	Fill to shoulder
Pesticides/PCBs	SW-846 Methods 3510C/8081A and 3510C/8082	2	Two 1-liter bottles	Cool to 4ºC	7 days extraction/40 days to analysis	Fill to shoulder
Metals	SW-846 Methods 3010A/6010B and 3010A/7000 series	1	1-liter polyethylene bottle	HNO_3 to pH <2; Cool to 4ºC	6 months (28 days for mercury)	Fill to shoulder
Cyanide	SW-846 Methods 9010B and 9012A series	1	1-liter polyethylene bottle	NaOH to pH >12; Cool to 4ºC	14 days	Fill to shoulder
Lead and Arsenic	SW-846 Methods 3010A/7421 and 3010A/7061A	1	1-liter polyethylene bottle	HNO_3 to pH <2; Cool to 4ºC	6 months	Fill to shoulder
Explosives	SW-846 Method 8330	1	1-Liter Amber	Cool to 4ºC	14 days/ extraction/40 days to analysis	Fill to shoulder
Total Organic Carbon	EPA Method 9060	1	500-ml amber glass	H_2SO_4 or HNO_3 to pH<2; Cool to 4ºC	28 Days	Fill completely, no air bubbles
TCLP VOCs	SW-1311/5030B/ 8260B	3	40-ml glass vials w/Teflon-lined cap	Cool to 4ºC	14 days to filter/14 days to analysis	Fill completely; no air bubbles
TCLP SVOCs, Pesticides, Metals	SW-1311 SW-3510C/ 8270C/8081A SW-3010A/6010B SW-7470A for mercury	2	1-liter bottles	Cool to 4ºC	14 days to extraction /7 days to SVOC and Pest analysis; 28 days to mercury analysis; 180 days to metals analysis	Fill to shoulder
Total Suspended Solids (TSS)	EPA Method 160.2	1	500 ml bottle	Cool to 4ºC	7 days	Fill to shoulder
Total Dissolved Solids (TDS)	EPA Method 160.1	1	250 ml bottle	Cool to 4ºC	7 days	Fill to shoulder
Alkalinity	EPA Method 310.1	1	250 ml bottle	Cool to 4ºC	14 days	Fill to shoulder
Hardness	EPA Method130.2	1	250 ml bottle	HNO_3 to pH <2; Cool to 4ºC	6 months	Fill to shoulder
Acrolein/ Acrylonitrile	SW846 5030B/8260B/8015	1	40 ml glass vial w/Teflon lined cap	HCL to pH 4-5 cool to 4ºC or unpreserved	14 days preserved or 7 days unpreserved	Fill completely no air bubbles
Reactivity	SW7.3.3.2	1	1-liter polyethylene bottle	Cool to 4ºC NaOH	48 hours	Fill to shoulder

TABLE 2-1a

Required QA/QC Samples

Parameters[1]	SWMU 1	SWMU 2	SWMU 4	SWMU 5	SWMU 8	SWMU 10	SWMU 12	AOC G	Total	FD	MS/ MSD	AB	EB	TB
Surface Soil Samples														
Appendix IX VOCs	50	24	NA	4	5	16	5	5	109	11	6	1	12	12
Appendix IX SVOCs	50	24	NA	4	5	16	5	5	109	11	6	1	12	
Appendix IX Metals	50	24	NA	4	5	16	5	5	109	11	6	1	12	
Appendix IX Herbicides	50	24	NA	4	5	16	5	5	109	11	6	1	12	
Appendix IX Pesticides/PCBs	50	24	NA	4	5	16	5	5	109	11	6	1	12	
Explosives	50	24	NA	4	5	16	5	5	109	11	6	1	12	
Subsurface Soil Samples (at 5' Depth)														
Appendix IX VOCs	N/A	N/A	1	N/A	N/A	16	N/A	N/A	17	2	1	1	2	2
Appendix IX SVOCs	N/A	N/A	1	N/A	N/A	16	N/A	N/A	17	2	1	1	2	
Appendix IX Metals	N/A	N/A	NA	N/A	N/A	16	N/A	N/A	16	2	1	1	2	
Appendix IX Herbicides	N/A	N/A	NA	N/A	N/A	16	N/A	N/A	16	2	1	1	2	
Appendix IX Pesticides/PCBs	N/A	N/A	NA	N/A	N/A	16	N/A	N/A	16	2	1	1	2	
Explosives	N/A	N/A	NA	N/A	N/A	16	N/A	N/A	16	2	1	1	2	
Groundwater Samples														
Appendix IX VOCs	5	N/A	NA	N/A	N/A	5	N/A	N/A	10	1	1	1	2	2
Appendix IX SVOCs	5	N/A	NA	N/A	N/A	5	N/A	N/A	10	1	1	1	2	
Appendix IX Metals	5	N/A	NA	N/A	N/A	5	N/A	N/A	10	1	1	1	2	
Appendix IX Herbicides	5	N/A	NA	N/A	N/A	5	N/A	N/A	10	1	1	1	2	
Appendix IX Pesticides/PCBs	5	N/A	NA	N/A	N/A	5	N/A	N/A	10	1	1	1	2	
Explosives	5	N/A	NA	N/A	N/A	5	N/A	N/A	10	1	1	1	2	
Subsurface Soils (at 15' Depth)														
Appendix IX VOCs	NA	3	8 [2)]	NA	NA	NA	NA	NA	11	1	1	1	1	1
Appendix IX SVOCs	NA	3	8	NA	NA	NA	NA	NA	11	1	1	1	1	
Appendix IX Metals	NA	NA	NA	NA	NA	NA	NA	NA	NA					
Appendix IX Herbicides	NA	NA	NA	NA	NA	NA	NA	NA	NA					
Appendix IX Pesticides/PCBs	NA	NA	NA	NA	NA	NA	NA	NA	NA					
Explosives	NA	NA	NA	NA	NA	NA	NA	NA	NA					

1) refer to Table 8-2 of the Master QAPP for a detailed list of constituents.
2) Contingent on finding degreasing basin and dry wall

NOTE: Field QC estimates are based on 12 field sampling days; same source water (thus 1 AB per method, per matrix) throughout the field effort for blanks; 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 piece of equipment; trip blanks at 1 per cooler (assume 1 cooler of VOC's per sampling day)

2.5.2 Sediment Sampling

Sediment samples will typically be collected with surface water samples. At locations where both sediment and surface water samples are being collected, the surface water sample will be collected first. This will ensure that any sediment disturbed during the sediment sampling does not enter the surface water sampling container.

Several different techniques may be used to collect sediment samples, including stainless steel trowel sampling, stainless steel hand auger sampling, and grab sampling with a Ponar Dredge. The method selected will typically depend on the flow and depth of water at the sampling location. Sewers will be sampled only at manholes. Brief descriptions of these sampling techniques and their applicability are provided in Section 2.5.2.3 of the Master Field Sampling Plan. Table 2-2 lists required containers, preservatives, and holding times for sediment samples.

During sediment sample collection, the VOC sample containers will be filled first. The sample will be placed directly into the VOC sample container to minimize the volatilization of organic compounds. The remaining sample volume will be placed into a stainless steel bowl and mixed thoroughly. After mixing, all other sample containers will be filled.

2.5.2.1 Stainless-Steel Trowel

A stainless steel trowel will be used to collect sediment samples in areas where there is minimal water flow across the sampling location and depth specific characterization is not required. The trowel will be used to transfer the sediment from the sampling location into the sample containers.

2.5.2.2 Stainless-Steel Hand Auger

For depth-discrete sediment sampling, a clean stainless steel, hand-held coring instrument with a disposable plastic liner tube, fitted with an eggshell catcher to prevent sample loss, will be used. The coring device will be pushed through the thickness of the sediments. The core will either be extruded into a stainless steel bowl or directly into the appropriate sample bottles. The sample recovery will be noted, and the discrete interval (e.g., 0 to 4 inches, 4 to 8 inches, 8 to 12 inches, or deeper if needed) will be placed in a stainless steel mixing bowl.

2.5.2.3 Ponar Dredge Sampling

A Ponar Dredge will be used to collect sediment samples from beneath any surface water greater than 1 foot in depth. The ponar dredge is a “clamshell” type sampling device consisting of the bucket/jaws and the sampler arms. During sampling activities, a length of rope is attached to a ring on the top of the sampler arms. The sampler arms are then pushed toward the bucket to open the sampler jaws. The jaws are locked in the open position by inserting a spring-loaded steel pin through a small hole in the arms. The sampler is lifted by the rope, with the sampler’s weight creating the tension that holds the locking pin in place. The sampler is lowered until the sediments are encountered, pulled up approximately 6 inches, and allowed to free fall. With the tension relieved, the spring on the locking pin forces the pin out of the hole in the arms. As the sampler is retrieved the jaws close, trapping the sediment sample inside. Any surface water entrapped in the sampler is slowly decanted through a screened port on the top of the ponar.

TABLE 2-2
Required Containers, Preservatives, and Holding Times for Soil and Sediment

Analysis	Analytical Preparation/ Method Number	No. of Containers	Sample Container	Preservative	Holding Time	Volume of Sample
VOCs	SW-846 Method 5035/8260B	3 to 4	3-4 each 5-g En Core™ sampler	4°C	48 hours to extraction and 14 days from extraction to analysis	Fill completely with no air bubbles
SVOCs	SW-846 Method 3550B/8270C	1	8-oz. Glass jar [1]	4°C	14 days to extraction and 40 days from extraction to analysis	Fill completely
Pest/PCBs	SW-846 Methods 3550B/8081A/ and 3550B/8082	1	8-oz. Glass jar [1]	4°C	14 days to extraction and 40 days from extraction to analysis	Fill completely
Pesticides	SW-846 Method 3550B/8081A	1	8-oz. Glass jar [1]	4°C	14 days to extraction and 40 days from extraction to analysis	Fill completely
Metals	SW-846 Methods 3050B/6010B 7000 series	1	4-oz. Glass jar [1]	4°C	6 months, 28 days for mercury	Fill to shoulder
Cyanide	SW-846 Methods 9010B and 9012A series	1	8-oz plastic or glass bottle	Cool to 4ºC	14 days	Fill completely
Lead/Arsenic/ Explosives	SW-846 Methods 3050B/7421 and 3050B/7061 A	1	8-oz plastic or glass bottle	Cool to 4ºC	6 months	Fill to shoulder
Explosives	SW-846 Methods 8330	1	4-oz. Glass jar [1]	4°C	7 days to extraction and 14 days from extraction to analysis	Fill completely
Total Organic Carbon	EPA Method 9060	1	8-oz plastic or glass bottle	Cool to 4ºC	28 days	Fill completely
Grain Size	ASTM 0421-58/0422-63	1	Quart size plastic bag	Cool to 4ºC	--	Approximately 1/3rd full
TCLP VOCs	SW846 Method 1311 SW-5030B/8260B	2	2 each 25 gram En Core™ sampler	Cool to 4ºC	14 days to extraction/14 days to analysis	Fill completely
TCLP SVOCs, Pesticides, Metals	SW846 Method 1311 SW-3510C/8270C/ 8081A SW-3010A/6010B SW-7471A for mercury	1	8-oz glass bottle with Teflon-lined cap	Cool to 4ºC	14 days to extraction/40 to SVOC and Pest analysis; 28 days to mercury analysis; 180 days to metals analysis, 7 days extraction	Fill completely
Reactivity	SW-846 Sections 7.3, 3.2/7.3, 4.2	1	8-oz plastic or glass bottle	Cool to 4ºC	48 hours	Fill completely
Corrosivity	SW-846 Section 7.2	1	8-oz plastic or glass bottle	Cool to 4ºC	28 days	Fill completely
Ignitability	SW 846 Method 1010/1020A	1	8-oz plastic or glass bottle	Cool to 4ºC	ASAP	Fill completely

1- Teflon lined cap

2.6 Surface Soil Sampling

Sampling techniques that may be employed for surface soil sampling include stainless steel trowel sampling and stainless steel hand auger sampling, depending on the nature of the material to be sampled. A stainless steel trowel will typically be used to collect samples of loosely packed materials and a stainless steel hand auger for densely packed materials. Surface soil samples will be obtained from a depth of 0 to 6 inches below ground surface (bgs) and typically be used to investigate leaks and spills on the ground surface. Samples collected from beneath paved or gravel surfaces are not considered surface samples. Table 2-2 lists the required containers, preservatives, and holding times for soil samples.

2.7 Soil Borings

Before soil borings (or well borings) are initiated, utility clearances will be obtained from the Navy. Borings will be advanced by a tripod, van-mounted probe, truck-mounted drill rig, or all-terrain vehicle (ATV) drill rig, using a split-spoon sampler. The sampler is driven into unconsolidated materials using a falling weight connected to the drill rig. Alternatively, soil samples will be collected using thin-walled tubes for geophysical analysis.

If physical access to areas is restricted, soil borings may also be advanced using a hand auger or a tripod-mounted sampling device. The locations and total depth of hand-augered boreholes will be determined in the field based upon subsurface soil conditions and site-specific sampling objectives.

The soil borings performed under these investigations will typically be sampled continuously (every 2 feet) or periodically (every 5 feet) to depth, as necessary, for lithologic and/or chemical characterization. Soil samples obtained by probe using direct-push methods will be collected either intermittently or continuously at intervals predicated by the equipment used. A geologist will observe the drilling and sampling operations. The soil will be classified according to the Unified Soil Classification System (USCS). Field observations of lithology, moisture content, discoloration, odors, and other visible features will be described and recorded in the field logbook and on to a soil boring log provided in the Field Sampling Plan. During advancement of the boring, a photoionization detector (PID) will be used to measure volatile organic contamination in the soil cuttings and split spoon samples. Subsurface soil samples may be analyzed from all or selected boreholes.

Upon completion, each boring will be backfilled with a bentonite-cement grout mixture. A labeled stake will be placed at the ground surface near the borehole for future reference for soil borings on unpaved areas. Asphalt or other surface material will be patched and the boring location will be identified with spray paint. Auger cuttings will be containerized in a roll-off, or drums. If significant contamination is present, either visually or by measurement from a PID, the soil will be drummed separately from the roll-off box, labeled with the appropriate boring number, and placed on a wooden pallet at the site. Soil cuttings from background locations will be spread on the ground (if the area is unpaved) near the borehole and not containerized; if the area is paved, the soil cuttings will be drummed.

2.8 Subsurface Soil Sampling

Subsurface soil densities vary from site to site across Vieques and will dictate subsurface soil sampling methodologies. Split spoon sampling techniques will typically be used at locations where samples are being collected from depths greater than 3 to 5 feet, discreet sampling intervals, from beneath asphalt, or where compaction of the soil has made sample collection using manual augers or trowels impossible. Alternatively, soil will be sampled using direct-push methods and sampling tubes where soil densities are low enough.

A drill rig will be used to advance 3-¼-inch to 6-¼-inch hollow stem augers to the top of the desired sampling interval. A stainless steel split-spoon sampler will be attached to the proper length of drilling rod and inserted through the hollow stem augers. A 150-pound hammer will be used to advance the split-spoon sampler up to 2 feet below the auger or until refusal, as required for sample collection. The split-spoon sampler will then be retrieved and the sample handled in accordance with site-specific SAPs. Direct-push methods will obtain the sample from the desired depth by pushing the sampling tube directly to that depth.

2.9 Monitoring Well Installation

Monitoring wells will be installed in selected boreholes. Boreholes drilled for monitoring well installation will be lithologically logged by the Field Geologist as described in Section 2.7. Well locations will be determined based upon previous analytical results, or other pertinent field data, as described in the site-specific work plans.

Monitoring well borings will usually be installed using hollow stem augers, unless field conditions require the use of a rotary or sonic method. The rotary method will utilize the addition of drilling water, not drilling mud. Well screens will be placed within the zone of interest. Specific well screen placement will be discussed in the Site-Specific Work Plans.

At locations where permanent wells are not required or well installation cannot be completed using a truck-mounted or ATV drilling rig, drive points may be installed. Drive points are 2-inch-diameter, stainless steel monitoring wells with short screens, and are installed by driving the well point into the ground. These will be installed in wet areas where the weight of a drilling rig cannot be supported, or because of steep slopes or dense forest. Drive points may also be installed in an open borehole.

2.9.1 Monitoring Well Construction

Monitoring wells will be constructed of 2-inch inside diameter (I.D.), Schedule 40 polyvinyl chloride (PVC) risers and screen, with flush joint threads. Wells will be completed with 10-foot-long No. 10 slot size screens. A typical well construction diagram is provided with this FSP. Well construction may differ at locations that warrant larger size diameter wells such as potential free phase product accumulation areas. At these locations, screen lengths may be increased to 15 feet and slot sizes increased to No. 20. Samples of aquifer material for grain size analysis may be collected from selected well borings if unusual size materials are observed; from this information, screen slot size and sand pack particle size will be determined for these wells. Wells also may be constructed of stainless steel rather than PVC

in areas where high concentrations of solvents are present in the groundwater that could degrade a PVC well. Permanent water level measurement notches will be made on the northern side of the riser casing to keep water level gauging events consistent.

A sand pack will be placed around the screened interval to 1 to 2 feet above the top of the screen. A minimum of 2 feet of bentonite will be placed above the sand pack. If above the water table, bentonite will be hydrated with potable water prior to grouting. Grout will be placed via a side-discharging tremie pipe above the bentonite pellets to within 1 foot of the ground surface.

Drive points may be constructed in one of two ways. If the drive point is hammered into place, no other well construction will be necessary, and the well assembly is fabricated from 2-inch-diameter stainless steel and includes a screen (anticipated to be 2 to 3 feet in length), casing, and a hardened point. If a hand-augered borehole is used, the procedure will consist of:

- Advancing a 4-inch-diameter hand auger to the desired depth below the water table
- Installing a temporary casing if the borehole collapses using PVC pipe hammered into the collapsing borehole and reaugered to clean out the soils until final depth is achieved
- Placing a 2-inch-diameter drive point in the open borehole
- Placing sand pack around the drive point to a depth that is approximately 1 foot above the screened interval
- Placing a bentonite seal above the sand pack to the top of the borehole
- Grouting will not be used in drive points

In high traffic areas, wells will be completed with a flush mounted protective casing with locking cap. A 2-foot x 2-foot x 4-inch concrete pad will be installed in the asphalt or concrete to reinforce the shallow wells. This will be sloped away from the well to prevent surface water infiltration. Monitoring well numbers and other pertinent information will be marked either on the concrete pads or on stainless steel well tags attached to the concrete pads.

Wells completed where there is no vehicular traffic will have 2 to 3 feet of “stickup” above ground surface. A steel protective casing will be placed over the riser and cemented into a 4-foot x 4-foot x 4-inch concrete pad. Steel guard posts will be placed around the protective casing to prevent accidental damage. The pad will be sloped away from the well to prevent surface water infiltration.

Piezometers may be installed to be used to measure water levels. These piezometers are not expected to be sampled but will be constructed in the same manner as wells are.

Some wells may require that a surface casing be installed to prevent potential contamination from migrating between water-bearing units separated by low-permeability materials. Surface casings will consist of either PVC or steel. The casings will be set into low-permeability material separating the water-bearing units and will be grouted in place.

2.9.2 Monitoring Well Development

Monitoring wells will be developed prior to groundwater sampling by removing water from each well using a peristaltic pump or submersible pump. The development water will be discharged into 55-gallon drums or other storage containers (e.g., tankers). A surge block also will be used to aid in development. If dedicated sampling equipment is not used, equipment will be decontaminated between wells.

Well development will be performed after the grout used to construct the well has been allowed to adequately set at least 24 hours. The groundwater levels will be measured to the nearest 0.01 foot from the top of the PVC casing. Development will consist of removing at least three borehole volumes of water, plus the amount of water added during the drilling or installation process. Development will continue until groundwater turbidity levels reach 50 nephelometric turbidity units (NTUs), or until 6 hours of development has passed, whichever comes first. The goal of 50 NTUs was developed due to the nature of geology on Vieques and the persistence of wells going dry during purging activities. Water clarity will be measured with a Hach™ NTU meter or equivalent. Development information, including water clarity, pH, specific conductivity, and temperature, will be recorded in the field logbook.

Wells installed as part of previous investigations will be evaluated in the field to determine if redevelopment is required. Redevelopment will be considered necessary if 10 percent or more of the screen length has been “silted in” (i.e., filled in by soil particles; this soil matter leads to turbid samples and possibly incorrect conclusions about groundwater analytical results). Redevelopment will also be conducted at wells where high turbidity levels are exhibited and water yields are sufficient to warrant redevelopment efforts. If redevelopment is necessary, it will follow similar procedures as for newly installed wells; however, additional time and volume of water removed may be needed to remove the fine sediment from the well.

After installation of drive points, the inside of each drive point screen will be scrubbed with a 2-inch-diameter round steel brush to clean out any mud or sediment that might clog the screen slots. The water in the drive point will then be bailed out. If necessary, certified laboratory grade distilled water may be added and the screens scrubbed again to facilitate water flow through the screen. This procedure may be repeated two or three times to clean the screen.

2.10 Monitoring Well Abandonment

Well abandonment will be performed on monitoring wells which are no longer in use or which are improperly constructed. The well abandonment procedures will be in accordance with Navy requirements. The objective of this procedure is to prevent contamination from reaching groundwater through the well. Abandonment will consist of over-drilling the well using hollow stem augers and, if possible, removing the screen and riser pipe. The riser and screen will be decontaminated, cut into small sections approximately 3 feet long, and disposed of as regular trash. The well borehole will then be filled with cement grout by a tremie pipe, which will extend to the bottom of the well borehole. As the grout fills the well borehole, the pipe will be raised until a return of grout is noted at the surface.

2.11 Groundwater Sampling from Monitoring Wells

Monitoring wells will not be sampled for at least 2 weeks after the well has been developed. This will allow an adequate amount of time for the well to recover. Prior to sampling, groundwater will purged from each well. Purging will be performed until at least three borehole volumes have been removed and the temperature, specific conductance, and pH have stabilized to within 10 percent for three consecutive readings. The borehole volume will be calculated using values for the depth of the well, the depth to water, and the well diameter. Purging will be accomplished using low flow pumps or bailers. Well purging data will be recorded in the field logbook. The Investigation-Derived Waste Management Plan (IDWMP) discusses treatment and disposal of purge water.

Samples will be collected after the field parameter measurements have stabilized. Wells that are pumped dry during purging will be allowed to recover before sampling; the sample will be obtained as soon as a sufficient volume of groundwater to fill all sample containers has entered the well.

Purging activities will be conducted in a manner which minimizes agitation of groundwater in the wells, and at a pumping rate not to exceed one liter per minute. Purging will be conducted using low flow peristaltic pumps when the depth to water will allow the use of these pumps. Peristaltic pumps, however, can only pull water from a depth of approximately 25 feet. Therefore, in instances where groundwater is greater than approximately 25 feet below grade, variable speed submersible environmental pumps (Grundfos or equivalent) will be utilized for purging. Bladder pumps were ruled out for use at ATWTF for purging because of the difficulty in obtaining compressed gasses on the island. All down-hole and effluent tubing will be Teflon® lined or Teflon®.

Groundwater samples will be collected from the discharge hose of the purge pump into properly-labeled, laboratory-prepared sampling containers filled and/or preserved as appropriate; cooled to approximately 4 °C; and shipped to the analytical laboratory under appropriate COC documentation procedures. The pump rate shall be reduced to below one liter per minute, for all samples to reduce the potential for collecting turbid groundwater samples. Clean, double check valve bailers may be used for sampling as a last resort in wells in which the depth to water or other extenuating circumstances preclude the collection of non-turbid samples through the pump. In this case, care will be taken when lowering the bailer not to agitate the water surface. Table 2-1 shows the required containers, preservatives, and holding times for water samples.

2.12 Direct-Push Groundwater Sampling

Groundwater samples may be collected using a direct-push (e.g., Geoprobe® or HydroPunch®) hydraulic sampler mounted on a 4-wheel-drive truck where permanent wells are not installed and the extent of groundwater contamination needs to be defined. Prior to sampling activities, utility clearances will be performed. The direct-push probe will be advanced to the desired depth and the sample will be collected. Alternatively, the borehole will be advanced using a drill rig and hollow stem auger techniques to reach the depth of interest in the aquifer. At that depth, the drill rods will be removed and the direct-push samplers hydraulically pushed to the zone of interest. The cover will then be retracted,

allowing water to flow into the device. Groundwater samples will either be retrieved using a double check valve sampling tool or a “mini” bailer. Samples will be collected directly into sample containers that have been precleaned and preserved by the analytical laboratory to EPA specifications.

Table 2-1 shows the required containers, preservatives, and holding times for groundwater samples.

2.13 Aquifer Testing

Aquifer testing that might be completed include slug tests, step-drawdown pumping tests, and constant-rate pumping tests.

2.13.1 Slug Tests

Rising and falling head slug tests may be performed in monitoring wells to evaluate aquifer hydraulic conductivity in the vicinity of the well. Slug tests will be performed after groundwater sampling using solid PVC slugs with clean bailer rope. A pressure transducer attached to an electronic recording device, such as an In-Situ Hermit™, will be used to record changes in pressure associated with water level recovery. Tests will be repeated three times to verify reproducibility. Alternatively, tests will be performed by sealing the top of the well riser, forcing the water level in the well down with nitrogen, releasing the nitrogen pressure, and recording the water level recovery.

The *Bower & Rice* method for unconsolidated aquifers will be used to evaluate the hydraulic conductivity’s of the aquifer.

2.13.2 Step-Drawdown Pumping Tests

Step-drawdown pumping tests might be performed to ascertain the efficiency (specific capacity) of a well and to determine an appropriate pumping rate for conducting a constant-rate pumping test. Methodology will be described in site-specific WPs and FSPs.

2.13.3 Constant-rate Pumping Tests

A constant-rate pumping test might be performed on a well to ascertain the transmissivity and storage coefficient or storativity of the aquifer for use in modeling and capture zone analyses. Methodology will be described in site-specific WPs and FSPs.

2.14 Hydrologic Measurements

Groundwater or surface water hydrologic measurements may be collected at AFWTF. Measurement procedures are described below.

2.14.1 Groundwater Level Measurements

Groundwater level measurements will be measured in monitoring wells, piezometers, and drive points. Fluid level measurements will be used to evaluate the movement of groundwater, the horizontal hydraulic gradient, the vertical hydraulic gradient, and the thickness of any free product, if present. This information, when combined with other site-

specific information such as hydraulic conductivity, extent of contamination, and product density, may be used to estimate contaminant movement or source areas. Fluid levels will be measured with a water level indicator or oil/water interface probe, as appropriate. The depth from the top of casing to fluid level will be recorded to the nearest 0.01 foot.

2.14.2 Surface Water Level Measurements

Surface water level measurements may be read from surveyed staff gauges placed in surface water bodies. Surface water level measurements will be used with groundwater measurements to help determine communication between surface water and groundwater. Depth of surface water bodies may be measured using a graduated weighted tape or similar device.

2.15 Sewer Sampling

Samples of surface water and/or sediment may be collected from storm sewers on the site to determine if contaminants are being transported in the sewers. All samples will be collected from manholes that provide access to the sewers. Manholes are confined-space entry areas and samples will be collected from the surface, if possible, to avoid the need of staff to enter manholes. Weighted bottles and samplers attached to poles will be used to avoid confined-space entries.

2.16 Biota Sampling

Aquatic biota sampling for surface water and sediment may include collecting aquatic macroinvertebrate and fish. The biota samples will be located to represent upstream, adjacent, and downstream conditions when possible. Sample locations selection will be based on migration pathways. In tidal areas, the presence of a salt wedge and the magnitude of tidal influence upstream will be evaluated by collection of physical field measurements including salinity and conductivity. The degree of tidal influence will provide important information about the flushing of contaminants. Upstream samples collected in fresh water will provide background data from true upstream conditions not impacted by tidal fluctuations in streamflow. Site-specific conditions, such as headwater systems, may preclude the establishment of an upstream station.

Qualitative terrestrial vegetation sampling, qualitative mammalian species surveying, qualitative herpetofauna community surveying, and avian community surveying may be performed.

2.16.1 Aquatic Macroinvertebrate Sampling

Benthic macroinvertebrates may be collected using a Ponar bottom grab sampler or hand-held coring device. A minimum of three replicate grab samples will be collected at each sampling location because of the precision of macroinvertabrate sampling. Sampling precision is affected by the substrate area encompassed by the sampling device and the distribution of the organisms. Three replicate random sampling units at each sampling location generally are considered a minimum based on guidance in *Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters* (EPA, 1990). The

invertebrate taxa will be identified to genus and species level with the exception of fragmented and juvenile specimens and for those species with known taxonomic difficulties.

2.16.2 Fish Sampling

Fish may be collected from surface water bodies using electrofishing, gill nets, seining, trot lines, or other fish collection techniques. The fish collection method used will depend on whether freshwater or estuarine systems are being evaluated. Electrofishing will be used in freshwater systems. Gill nets, trap nets, and trot lines will be used in estuarine and large stream and riverine systems. Seines will be deployed in small stream systems and from the shore of large estuarine and riverine systems.

Sampling will be conducted in areas within the designated reach that will ensure adequate representation of the fish community. Fish will be held in fish boxes with an adequate air supply until taxonomic identification and field processing. Species will be identified, measured, and weighed. Fish with disease, tumors, fin damage, and skeletal anomalies will be noted. One representative fish from each species will be preserved for taxonomic verification. All remaining fish will be returned to the surface water body.

In addition to fish community sampling, fish tissue sampling may be conducted to determine bioconcentration of selected contaminants in fish.

2.17 Test Pits/Trenching

Test pits or trenches may be completed in areas where characterization of fill or other waste materials is required or the extent of contamination needs to be determined. Test pits and trenches may be excavated up to 15 feet in length and to a maximum depth of 10 feet. Samples of materials excavated from the trench will be collected from the bucket of the backhoe or the pile of excavated material using a stainless steel trowel or spoon. Test pits and trenches will not be entered by any member of the sampling team.

The position of the test pit or trench will be determined in the field by the Project Geologist/Scientist. Utility clearance will be obtained from the Navy prior to excavation. Excavation equipment will be decontaminated prior to and after each test pit or trench excavation. Excavation will proceed by removing lifts of no more than about 6 to 12 inches, until an assessment of the material can be made. The material removed from the trench will be placed on plastic sheeting. A geologist will log the test pit materials. The cross section will be sketched or described and notable features will be identified in the field log book. Depths will be measured from the ground surface. The length and width of the test pit will also be measured. The test pits and trenches will be backfilled with the material removed from the excavation immediately after being completed to reduce site hazards and minimize the potential for rainwater accumulation and subsequent contaminant migration.

2.18 Surveying

Surveying activities will be necessary to establish northing and easting data for subsequent transfer to site maps and for development of groundwater flow maps. Surveying efforts will

be completed by a qualified surveying subcontractor utilizing the Puerto Rico coordinate system, NAD 1983 Vertical Datum Grid System as the reference datum. The following land surveying activities may be conducted at the Base:

- Obtaining elevations of groundwater monitoring wells, piezometers, soil borings, and drive points, to an accuracy of 0.01 feet, referenced to mean sea level (MSL). Elevations will be determined from a United States Geological Survey (USGS) benchmark located at the facility. Benchmarks may not be readily accessible to the survey sites.
- Establishing the elevation reference point for wells at the top of the inner PVC well casing, and a permanent mark designating the elevation point. The ground surface elevation for each well and boring will be established to an accuracy of 0.01 feet. Horizontal control shall be established to the 0.1 foot.
- The location of each well, boring, and test pit will be tied into permanent land monuments (e.g., building corners). Horizontal control shall be established to the 0.1 foot.
- Grid intersections (for soil gas or geotechnical surveys) will be marked with wooden stakes or spray paint and will be numbered by the surveyor with a unique location number.
- Surveying of surface water/sediment sampling stations will be performed using geographic positioning system (GPS) equipment.

Portable GPS systems may also be used to determine horizontal coordinates for points, such as sampling locations and grid points. Horizontal control varies with different GPS systems.

2.19 Investigation-Derived Waste Sampling

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. Base-wide IDW management is addressed in the Master IDWMP.

2.20 Decontamination

Temporary decontamination pads will be placed at strategic locations throughout AFWTF prior to field activities generating large quantities of water. The decontamination pads will be constructed of high density polyethylene and wood with elevated sides and a sump to collect fluids. These fluids will be pumped into a tank designated for that site. The location of the decontamination pads will be finalized during mobilization, as directed by AFWTF, and will be based upon areas or sites that are under investigation. Specific elements of decontamination are described below.

2.20.1 Sampling Equipment Decontamination

Sampling equipment (e.g., split-spoons, sampling trowels, bucket augers, bailers, etc.) will be decontaminated prior to sampling and between samples. Waters generated during decontamination of sampling equipment at each site will be contained in 55-gallon drums, pending receipt of analytical results and final disposition recommended to the facility. Decontamination water will be segregated from all other water because of solvents and acids introduced into the water.

All heavy equipment, including the drilling rig, rods and augers, and other downhole equipment used during site investigation activities will be decontaminated prior to use and between locations using a high-pressure steam wash at a decontamination pad located on or near the site. The steam-cleaning water will be from a potable source. The decontamination water will be pumped into drums with a sump pump and the drums will be emptied immediately into a tank that is centrally located at each site. Monitoring well casings and screens will also be steam-cleaned using the same procedure, unless they are certified by the manufacturer as clean, and plastic seals are intact.

2.20.2 Personnel Decontamination

Personnel decontamination is discussed in the Master HSP.

2.21 Health and Safety Monitoring

The ambient air will be monitored during most field activities to determine the presence of organic and/or explosive vapors that may pose a health risk. The monitoring activities are discussed in detail in the Master HSP.

2.22 Field Tests

Various field tests may be performed during sampling activities. Field tests are commonly used at AFWTF to measure water quality parameters of groundwater and surface water and to assess the chemical properties of soil.

Water quality parameters that may be measured during field activities include pH, specific conductance, DO, temperature, alkalinity, and turbidity. Measurement of these parameters will be performed in accordance with site-specific WPs and FSPs, and with the SOPs located in Attachment 2 of the MP.

Field tests used to assess the chemical properties of site soils include, but are not limited to, X-ray fluorescence (XRF) field screening (to identify soil containing concentrated amounts of heavy metals); immunoassay screening (to determine the presence of polychlorinated biphenyls [PCBs], polycyclic aromatic hydrocarbons [PAHs], benzene, or trinitrotoluene [TNT] above certain concentrations); flame ionization detector (FID) and PID headspace screening (to detect the presence of organic and inorganic vapors being emitted from soil). All soil field tests will be performed in accordance with site-specific WPs, FSPs, and SOPs.

SECTION 3

Documentation

3.1 Sample Designation

Each sample will be designated by an alphanumeric code that identifies the site and matrix sampled and contains a sequential sample number. Site-specific procedures are elaborated below.

Location types will be identified by a two-letter code. Each sampling location will be identified with a two-digit number corresponding to the well or sampling location.

The following is a general guide for sample identification:

First Segment of Sample Number	Second Segment of Sample Number	Third Segment of Sample Number	
Naval Installation Abbreviation	**Site Number**	**Sample Type**	**Sample Location**
AA	AAA	AA	AAAAA

Symbol Definition:

A = Alphanumeric

Site Abbreviation:

AA = Two letter abbreviation identifying the Naval Installation where the sample was collected. Vieques Island = VI.

Site Number:

AAA = One letter and two numbers or three numbers identifying the site on the facility where the sample was collected (i.e., S01 = Site 1 and 201 = AOC 201)

Sample Type:

SS = Soil Sample
SB = Soil Boring (subsurface soil) Sample
SD = Sediment Sample
SW = Surface Water Sample
GP = Direct-Push Groundwater Sample
GW = Groundwater Sample
DR = Drum Sample
PZ = Piezometer Sample
SG = Soil Gas Sample
TR = Trench Sample

IS = IDW Soil Sample

IW = IDW Water Sample

Sample Location

AAAAA = Unique sample number and qualifiers

Qualifiers

P = Duplicate Sample

L = Diluted for laboratory analysis

R = Rerun of laboratory analysis

Numbering Format for QA/QC Samples

QA/QC samples will follow the following pattern:

AA-DDMMYY

where the two digits before the hyphen will be alphabetic, by QA/QC type, and the six digits after the hyphen will designate the date on which the samples were collected. Eligible QA/QC sample types are:

FB Field blank

TB Trip blank

EQ Equipment blank

The date designation will always have six digits in a DDMMYY format. Examples of this numbering approach for QA/QC samples are:

FB-100196 Field blank collected on October 1, 1996

TB-072997 Trip blank collected on July 29, 1997

EQ-080198 Equipment blank collected on August 1, 1998

3.2 Sample Shipping Procedures

All field sampling activities will be documented through the use of field logs and COC procedures. Sample containers will be provided by the laboratory as certified clean. An identification label, indicating the sample number, station number, analysis to be performed, preservative used, date and time of sample collection, and the name of the responsible sampling team member, will be attached to each sample container.

After being collected, samples will be packed in coolers with vermiculite and ice for delivery to the laboratory. COC forms will be taped to the inside of the lid of each cooler. COC forms contain general information about the location of the activity and the members of the sampling team, as well as specific information about type of sample, sample location, number of sample containers from each station, and analyses to be performed. Each time the sample is relinquished or received, the party involved signs the form and notes the time and date.

The coolers used to deliver the samples will be sealed with strapping tape. Evidence tape will be placed across the front and back of each lid to control tampering. The samples will be delivered to the laboratory at the end of each day of sampling to ensure that holding times are not exceeded.

SECTION 4

References

U.S. Environmental Protection Agency. *Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters*. 1990.

ATTACHMENT A

Typical Soil Boring Log

CH2MHILL

PROJECT NUMBER	BORING NUMBER SHEET 1 OF 1

SOIL BORING LOG

PROJECT : LOCATION :

ELEVATION : 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
5						
10						
15						
20						
25						

ATTACHMENT B

Typical Well Construction Diagram

CH2MHILL

PROJECT NUMBER	WELL NUMBER SHEET 1 OF 1

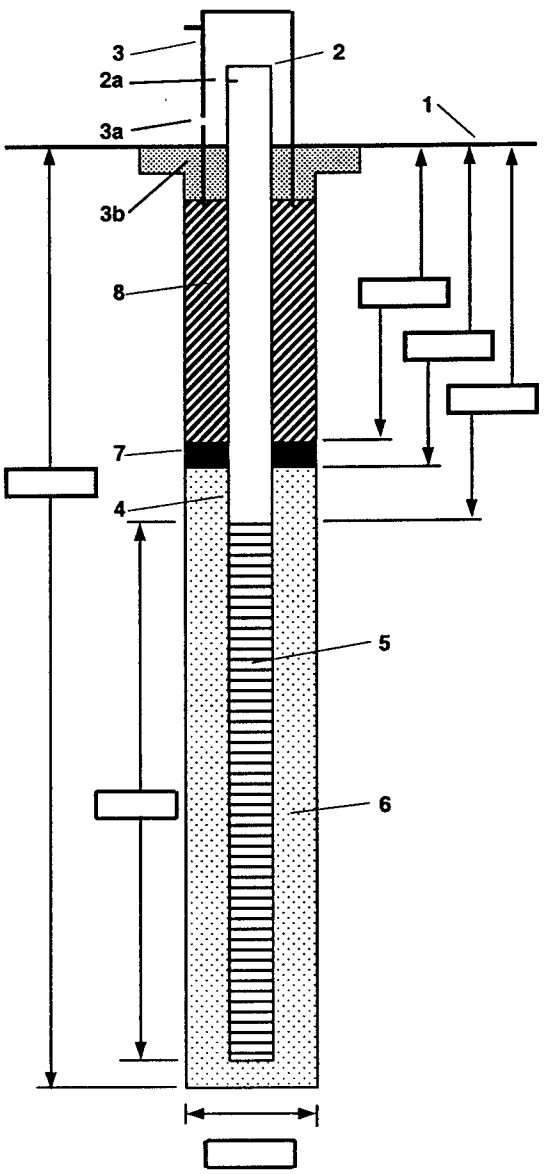
WELL COMPLETION DIAGRAM

PROJECT : LOCATION :

DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

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- Type/slot size of screen _____

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 _____

Development time _____

Estimated purge volume _____

Comments _____

Master Quality Assurance Project Plan

FINAL
Master Quality Assurance Project Plan

Atlantic Fleet Weapons Training Facility
Vieques Island, Puerto Rico

Contract Task Order 031

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

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June 12, 2003

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List of Acronyms

AFWTF	Atlantic Fleet Weapons Training Facility
ARAR	Applicable or Relevant and Appropriate Requirement
ASTM	American Society for Testing and Materials
BOA	Basic ordering agreement
BTAG	Biological Technical Assistance Group
CLP	Contract Laboratory Program
COC	Chain-of-custody
CTO	Contract task order
DO	Dissolved Oxygen
DQOs	Data quality objectives
EFA	Engineering Field Activity
EPA	Environmental Protection Agency
FS	Feasibility Study
FSP	Field Sampling Plan
GC/MS	Gas chromatograph/mass spectrometer
HASP	Health and Safety Plan
IDWMP	Investigation derived waste management plan
ILM03	EPA CLP SOW for multimedia, multi-concentration inorganic analysis
LANTDIV	Atlantic Division
LQAP	Laboratory Quality Assurance Plan
MCL	Maximum contaminant level
MS	Matrix spike
MSD	Matrix spike duplicate
µg/L	Micrograms per liter
µg/mg	Micrograms per milligram
NAVFACENGCOM	Naval Facilities Engineering Command
NFEC	Naval Facilities Engineering Command
NFESC	Naval Facilities Engineering Service Center
OLC02	EPA analytical method for organic low-concentration water
OLM03	EPA CLP SOW for multimedia, multi-concentration organic analysis
OVA	Organic vapor analyzer
OVM	Organic vapor meter

PA	Preliminary Assessment
PARCC	Precision, accuracy, representativeness, completeness, and comparability
%R	Percent recovery
PCB	Polychlorinated biphenyl
PQL	Practical quantitation limit
QA	Quality assurance
QAPP	Quality assurance project plan
QC	Quality control
RCRA	Resource Conservation and Recovery Act
RF	Response factor
RFI	RCRA Facility Investigation
RI	Remedial Investigation
RPD	Relative percent difference
RPM	Remedial project manager
RSD	Relative standard deviation
SAP	Sampling and analysis plan
SMC	System monitoring compound
SOP	Standard operating procedure
SOW	Statement of work
SSAs	Site screening areas
SVOC	Semivolatile organic compound
SWMU	Solid waste management unit
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity characteristic leaching procedure
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TSS	Total Suspended Solids
VOA	Volatile organic analysis
VOC	Volatile organic compound
WP	Work Plan

SECTION 1

Introduction

This master quality assurance project plan (QAPP) has been developed for the field investigation activities at the Atlantic Fleet Weapons Training Facility (AFWTF) on Vieques Island, Puerto Rico. This Master QAPP describes the general quality assurance and quality control (QA / QC) procedures used for conducting groundwater, surface water, sediment, soil, waste liquids and solids, and biota sampling at sites under investigation at AFWTF. Investigation sites covered under this QAPP include those that will be part of future preliminary assessment (PA), remedial investigation (RI), or feasibility study (FS) actions as well as initial investigations at site screening areas (SSAs). This QAPP is intended to encompass most analytical methodologies that may be used in investigations at AFWTF. Not all analytical methods will be utilized at all sites; however, this Master QAPP is intended to be comprehensive such that any analyses that might be performed for future investigations are included herein. This document will be reviewed and updated at least once every 3 years as required by the U.S. Environmental Protection Agency (EPA), Region II. Future additions of analytical parameters or changes in methodologies will be provided as addenda to the Master QAPP.

Field investigations and corresponding QA / QC procedures at specific sites, solid waste management units (SWMUs), or SSAs will be described in the site-specific sampling and analysis plans (SAPs) submitted under separate cover. Detailed information regarding sample handling and analytical methods are provided in Sections 4 and 6, respectively. Sample collection procedures are provided in the Master Field Sampling Plan (FSP) or in the standard operating procedures (SOPs) in Appendix A of the Master Work Plan (WP) as summarized in Section 5.

Field sampling and laboratory analyses will be conducted in accordance with Section X of the January 2000 RCRA Order and the Navy Installation Restoration Chemical Data Quality Manual (IR CD QM).

SECTION 2

Project Description

The AFWTF provides facilities and schedules naval gunfire support (NGFS) and air-to-ground (ATG) ordnance delivery training for Atlantic Fleet ships and other allied nations. It is located on the eastern end of Vieques Island, Puerto Rico. A general description of the facility and its environmental history are provided in the Master WP. Site-specific historical information or plans for investigation will be provided in the site-specific work plans, which will be developed as each site or group of sites is investigated.

The Navy CLEAN II contract awarded to CH2M HILL by the Naval Facilities Engineering Command (NAVFACENGCOM), LANTDIV, specifies investigation and study at several sites. Studies at the AFWTF are intended to characterize the potential human and ecological effects associated with past activities at the facility. Goals of the studies include:

- Obtaining data to determine the nature and extent of contamination at each of the sites, SWMUs, and SSAs
- Identifying potential sources, migration pathways, and receiving media
- Obtaining data to assess the potential human health risks and ecological effects associated with contamination
- Obtaining data to support the selection and development of remedial alternatives

The scope and specific objectives of the studies to be conducted at AFWTF are presented in the Master WP and will be updated in each site-specific work plan.

CH2M HILL will use subcontractors to perform laboratory analysis, data validation, drilling, monitoring well construction, investigative-derived waste disposal, and surveying. Specific subcontractors have not yet been identified.

The objectives of the sampling work to be performed are not the same for all the sampling events. Most sampling results are expected to be used for:

- Determining the nature and extent of contamination
- Assessing ecological and human health risks
- Screening
- Assessing engineering and water quality parameters
- Characterizing wastes generated by site activities

The quality of the data must be very high to meet the first two objectives. The EPA SW 846 Statement of Work (SOW) for organic and inorganic analytical methods outlines rigorous quality control with full documentation. The SW 846 methods combined with the highest level of EPA-guided data validation provides the highest level of data quality. The SW 846 methods are to be used when available for risk assessment and evaluation of remedial alternatives.

Data quality does not need to be as stringent for the remaining objectives. Screening provides the lowest data quality but the most rapid results. It is often used for health and safety monitoring at the site, preliminary comparison to Applicable or Relevant and Appropriate Requirements (ARARs), initial site characterization to locate areas for subsequent and more accurate analyses, and for engineering screening of alternatives (bench-scale tests). Such data include those generated onsite through the use of an Organic Vapor Meter (OVM), pH, conductivity, and other real-time monitoring equipment at the site. Results from parameters such as total organic carbon (TOC), total dissolved solids (TDS), and total suspended solids (TSS) will be used to evaluate process options and determine general water quality. Waste products will be analyzed by the toxicity characteristic leaching procedure (TCLP) and for Resource Conservation and Recovery Act (RCRA) characteristics (reactivity, ignitability, and corrosivity) to determine disposal options described in the Master Investigative-Derived Waste Management Plan (IDWMP).

Whenever appropriate, samples will be analyzed for the full Appendix IX list of compounds according to the SW-846 protocols for organic and inorganic compounds. The Appendix IX list for organics includes volatile organic compounds (volatiles or VOCs), semivolatile organic compounds (semivolatiles or SVOCs), pesticides, and polychlorinated biphenyls (PCBs). The individual compounds in each group are listed in Section 8, Table 8-2. The Appendix IX list for inorganic analytes includes 17 metals (see Table 8-2).

Additional analyses will be necessary for some sites. The parameters will be analyzed by EPA SW846 methods.

2.1 Project Schedule

Sample collection events will be planned to maximize efficiency while maintaining field quality control. A detailed schedule will be included in the site-specific work plans.

SECTION 3

Project Organization

The CH2M HILL activity manager will serve as the primary contact and will assume primary responsibility for ensuring that the work is performed in a manner that is acceptable to LANTDIV, Atlantic Division. With the activity manager's oversight, the various project managers will be responsible for activities such as budget and schedule review and tracking, preparation and review of invoices, personnel-resource planning and allocation, and coordination with LANTDIV, AFWTF, and CH2M HILL subcontractors. Senior reviewers and the Quality Control Officer for CH2M HILL will review documents and procedures. Technical performance of the investigations to be conducted at AFWTF and the key personnel responsible for quality assurance throughout its duration are presented in Section 4. of the Master WP. Management personnel will be identified for each site in the site-specific addenda to the Master WP. Figure 3-1 shows the project organization and lines of authority.

The field investigation tasks will be performed by CH2M HILL personnel. CH2M HILL will notify AFWTF and LANTDIV before initiating field activities that require CH2M HILL personnel to mobilize to the site. A field task manager will be assigned to lead field activities. The field task manager will be responsible for maintaining the field log book, ensuring that the SAP is being followed, and monitoring the site for releases. The responsibilities of the field staff will include collecting the samples in accordance with the SAP, supervising subcontractors, completing sample paperwork, and shipping samples.

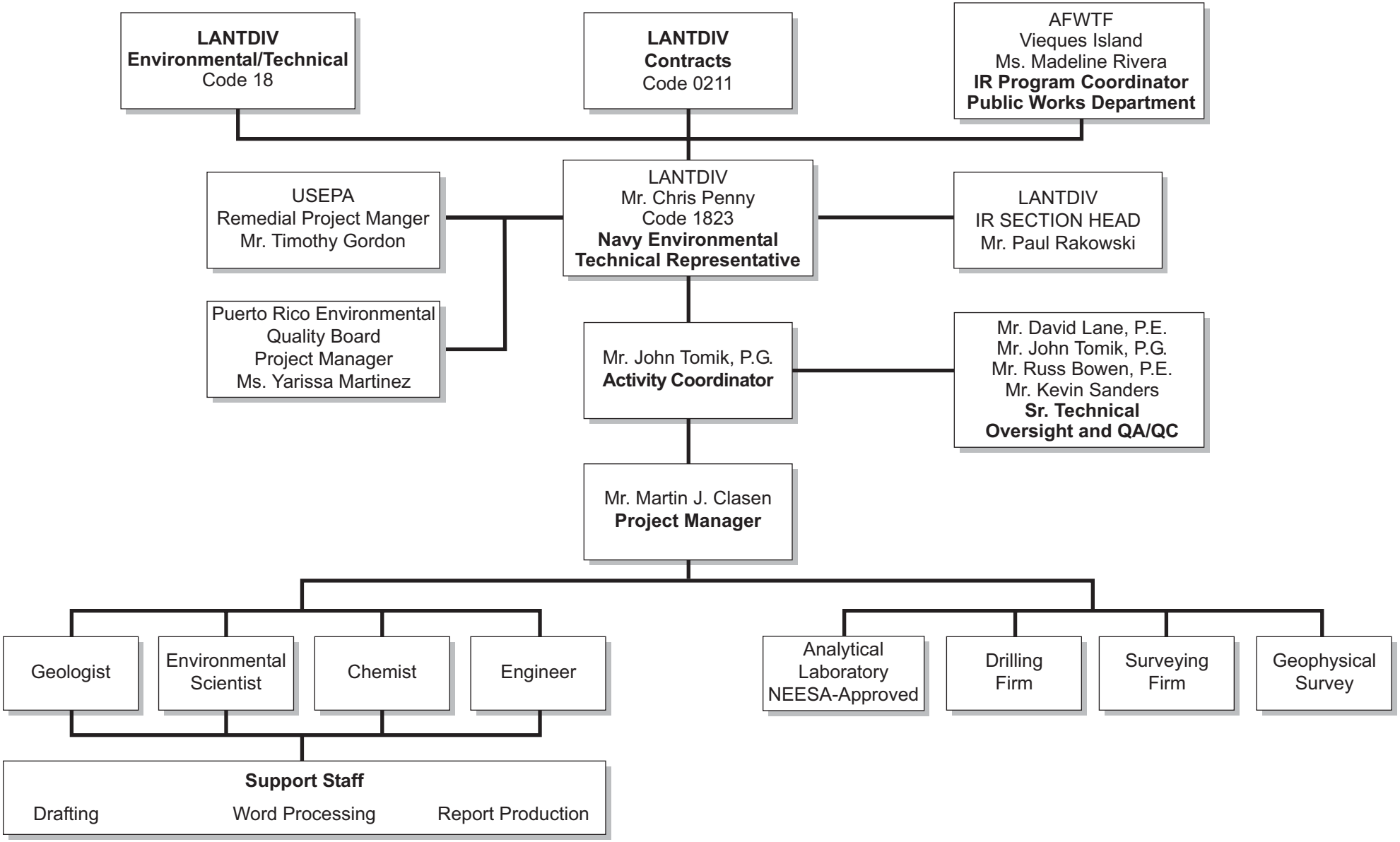

FIGURE 3-1
Project Organization
AFWTF Vieques Island, Puerto Rico

CH2MHILL

SECTION 4

Quality Assurance Objectives

The required quality of the analytical data to be collected is dependent upon the use of the data. Data development during the Installation Restoration (IR) Program activities will be used site-specific and delivery order specific purposes. This QAPP may be used to accomplish program-wide IR activities.

4.1 Data Quality Objectives

Data Quality Objectives (DQOs) will be established for each major sample collection effort as specified in the *Guidance for the Data Quality Objectives Process* (*EPA QA/G4*). DQOs are the quantitative and qualitative descriptions of the data required to support an environmental decision or action. As target values for data quality, they are not necessarily criteria for acceptance or rejection of individual analytical results. DQOs for a site vary according to the end use of the data. Everyone, from the data gatherer to the analytical laboratory, is involved in the DQO development process from the beginning.

The following fundamental mechanisms will be used to achieve quality goals:

- Prevention of errors through planning, documented instructions and procedures, and careful selection and training of personnel
- Assessment of data through field and laboratory audits and data validation of the analytical results
- Correction of errors through a corrective-action program

The DQOs for this project are based on the use of the data, including potential comparisons to concentrations of concern. Analytical data quality levels and concentrations of concern are described in this section.

4.1.1 Analytical Data Quality Levels

Once the DQO process has been completed, the specific QA/QC requirements will be evaluated to determine the type of analytical data that will be collected. Analytical data quality is specified in terms of levels defined in the DQO Guidance Document (*EPA QA/G4*). Two analytical levels are defined below:

High Level DQOs - The higher level DQOs for this project as described in Section 2 are to reliably determine the nature and extent of contamination and to assess the ecological and human health risks. Risk assessments involve comparing detected concentrations of contaminants with standards and toxicological or biological criteria.
Low Level DQOs - Analyses of engineering and water quality parameters or waste disposal characteristics do not require the level of quality control and documentation needed for risk assessment. In the field, all instruments will be calibrated according to the SOPs and site-specific FSPs and documented in the log books. When appropriate, equipment blanks will be collected and analyzed, and matrix influences will be determined. The laboratories will

follow the procedures of the EPA methods selected, and submit documentation to substantiate the analyses.

4.1.2 Concentrations of Concern

In order to define data needs, potential concentrations of concern (screening criteria) must be established. Comparison of analytical results to established screening criteria (i.e., risk-based criteria, etc.) will be conducted to determine if further action is warranted at a particular site. Screening criteria applicable to the Navy sites at AFWTF for each media were derived from the following sources:

- Groundwater - Lowest of the Federal Maximum Contaminant Level (MCL) or EPA Region IX Preliminary Remedial Goals (PRGs)
- Surface Water – USEPA National Recommended Water Quality Criteria (the lower of the human health or ecological criteria)
- Soil – The lower of the EPA Region IX PRG (leachability or direct contact) or EPA Region IV ecological screening criteria
- Sediment – NOAA guidelines for ecological receptors.

These values have been established as the Program Required Quantitation Limits (PRQLs).

Once a laboratory is selected for the project, the laboratory quantitation limits (limits corresponding to the lowest calibration standard) must be developed by considering the screening criteria, the laboratory MDL, and the laboratory standard levels. Laboratory quantitation limits should be selected to meet as many screening criteria as possible while still maintaining acceptable calibration quality control results. In general, the laboratory quantitation limit for a given parameter should be at least two times greater than the laboratory's MDL.

Due to very low concentrations of concern, there may be laboratory quantitation limits that are not low enough to meet some concentrations of PRQLs due to limitations of the analytical methods. The laboratory and Prime Contractor will work together to try to meet the PRQLs for as many compounds as concern as possible. An exception report will be generated which lists all the laboratory quantitation limits which exceed PRQLs, and appropriate actions will be taken to minimize the number of laboratory quantitation limits which exceed the PRQLs. This may involve selection of a different analytical method, performance of calibration studies to lower the laboratory quantitation limit, or other appropriate actions. For all analytes in which the PRQL is not achievable, evidence that the level is technically unachievable will be provided to EPA prior to sampling for EPA approval.

4.2 Project QA Objectives

Once the DQO process has been completed, the specific QA / QC requirements will be evaluated to determine the type of analytical data that will be collected. The overall QA objectives for the Program-Wide IR Program is to develop and implement procedures that will provide data that are of known, documented, and defensible quality. QA / QC is

ensured through appropriate sample collection, preservation and transportation methods combined with an evaluation of analytical performance through analysis of quality control samples.

The three documents in the Master SAP (QAPP, FSP, and IDWMP) contain the plans and procedures for safe, competent sampling and for effective management of the data. Each laboratory providing analytical data for the sampling efforts will developed its own laboratory quality assurance plan (LQAP). The SAP and the LQAP must address the elements of the Navy QA Program. Audits in the field and in the laboratories will determine how the QA/QC procedures are being implemented. Discrepancies, if any, will be addressed through the corrective action programs described in the SAP and the LQAP.

Data evaluation will be conducted by the data management staff of CH2M HILL. The Chain of Custody (COC) forms, laboratory case narratives, and log books will be checked against sample results, blank results, and percent recoveries (where applicable).

The quality of the data generated by sampling, monitoring, and analyses will be evaluated in terms of precision, accuracy, representativeness, completeness, and comparability (PARCC) DQOs are measured by the degree of precision, accuracy, representativeness, completeness, and comparability (PARCC) of the data required for the project. The project's precision and accuracy objectives for laboratory analysis are in Table 4-1. Laboratory specific limits will be generated after a laboratory has been contracted. The quality objectives for field parameters (OVM, conductivity, etc.) are included in SOPs in Appendix A of the Master WP.

TABLE 4-1
Precision, Accuracy, and Completeness of Objectives

Parameter	Precision[1] (Relative Percent Difference)	Accuracy[1] (Percent Spike Recovery)	Analytical Method	Intended Data Use
Groundwater and Surface Water				
Organic Compounds	≤ 20	50 – 150	SW-846 Methods 8260B, 8270C, and 8081A/8082	Determine extent of contamination. Human and ecological risk assessment.
Organophosphorus Pesticides	≤ 20	50 – 150	SW-846 Method 8141A	Determine extent of contamination Human and ecological risk assessment.
Chlorinated Pesticides	≤ 20	50 – 150	SW-846 Method 8151A	Determine extent of contamination Human and ecological risk assessment.
TAL Metals and Cyanide	≤ 20	75-125	SW-846 Methods 6010B and 7000 series	Determine extent of contamination Human and ecological risk assessment.
Low-concentration Metals and Cyanide	≤ 20	75-125	SW-846 Methods 6010B and 7000 series	Determine extent of contamination Human and ecological risk assessment.
Explosives	≤ 20	75-125	SW-846 Methods 8330 and 8332 series	Determine extent of contamination Human and ecological risk assessment.
TOC	≤ 20	75-125	EPA Method 9060	Evaluate process options
TSS, TDS	≤ 20	75-125	EPA Methods 160.1 and 160.2	Evaluate process options
Alkalinity	≤ 20	75-125	EPA Method 310.1	Evaluate process options and determine water quality
Hardness	≤ 20	75-125	EPA Method 130.2	Evaluate process options and determine water quality
Soil and Sediment				
Organics	≤ 35	50 – 150	SW-846 Methods 8260B, 8270C, and 8081A/8082	Determine extent of contamination Human and ecological risk assessment.
Organophosphorus Pesticides	≤ 35	50 – 150	SW-846 Method 8141A	Determine extent of contamination Human and ecological risk assessment.
Chlorinated Pesticides	≤ 35	50 – 150	SW-846 Method 8151A	Determine extent of contamination Human and ecological risk assessment.
TAL Metals and Cyanide	≤ 35	75-125	SW-846 Methods 6010B and 7000 series	Determine extent of contamination Human and ecological risk assessment.
Explosives	≤ 20	75-125	SW-846 Methods 8330 and 8332 series	Determine extent of contamination Human and ecological risk assessment.
Grain Size	--	--	ASTM 0421-58/0422-63	Characterize soil or sediment
TCLP Organics and Inorganics	≤ 35	75-125	SW-846 Method 1311	Determine disposal options
RCRA Parameters (Reactivity, Ignitability, Corrosivity)	≤ 35	--	SW-846 Sections 7.3, 3.2/7.3, 4.2, SW-846 Method 1010/1020A, SW-846 Section 7.2	Determine disposal options

[1]Target QC limits until laboratory specific limits are generated.

4.3 PARCC

4.3.1 Accuracy and Precision

Accuracy is a measure of the agreement between an experimental result and the true value of the parameter. Analytical accuracy can be determined by using known reference materials or matrix spikes (MS). Spiking of reference materials into the actual sample matrix is the preferred technique because it quantifies the effects of the matrix on the analytical accuracy.

Accuracy can be expressed as percent recovery (%R) determined by the following equation:

where: SSR = spiked sample result
SR = sample result (native)
SA = spike added

Precision is the measure of the agreement or repeatability of a set of duplicate results obtained from repeat determinations made under the same conditions. The precision of a duplicate determination can be expressed as the relative percent difference (RPD), which is determined by the following equation:

where: X1 = first duplicate value
X2 = second duplicate value

For a given laboratory analysis, the duplicate RPD values are tabulated, and the mean and standard deviations of the RPD are calculated. Control limits for precision usually are plus or minus two standard deviations from the mean.

Accuracy and precision will be monitored by using field duplicate, MS, and matrix spike duplicate (MSD) samples. These data alone cannot be used to evaluate the accuracy and precision of individual samples, but will be used to assess the long-term accuracy and precision of the analytical method.

4.3.2 Completeness

Completeness will be calculated on an overall basis with data quality evaluations being performed on any data rejections as described in Appendix K of the *NASD Phase I Expanded*

Preliminary Assessment/Site Investigation Report, CH2M HILL, October, 2000. Completeness is defined as the percentage of analytical measurements that are judged to be valid, validity being defined by the DQOs. Percent completeness is calculated as the number of analyses meeting all quality criteria divided by the total number of analyses performed, multiplied by 100. The completeness goal for the project is 85 percent.

4.3.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent parameter variations at a sampling point. Representativeness is a measure of how closely the measured results reflect the actual distribution and concentration of certain chemical compounds in the medium sampled. The Master FSP and the SOPs describe the procedures to be used for collecting samples. This process will generate samples that are as representative as possible. Documentation of laboratory and field procedures, as described in the FSP, will be used to verify that protocols have been followed and that sample identification and integrity have been maintained.

4.3.4 Comparability

"Comparability" is the term that describes the confidence with which one data set can be compared to another. Comparability refers to such issues as using standard field and analytical techniques, following the same QA/QC procedures, and reporting data in the same units. This criterion becomes important if more than one field team is collecting samples or more than one laboratory is analyzing samples. Consistency in sampling and laboratory procedures will be maintained throughout the project. (See the Master FSP and the SOPs in Appendix A of the Master WP for a discussion of sampling procedures.) In addition, accepted methodologies will be used for sample analysis, and these methods will not be changed during the project.

SECTION 5

Sample Collection Procedures

Descriptions of sampling procedures are contained in the attached Master FSP and in the SOPs in Appendix A of the Master WP. Procedures are included that describe the following, at a minimum:

- Sampling methods
- Sample packing, handling, and shipment, including time considerations
- Preparation and use of trip blanks, field blanks, equipment blanks, and duplicate samples
- Documentation of sampling activities

Site-specific sampling procedures, sampling point selection, special conditions for sample container preparation, or special time requirements will be addressed in the site-specific SAPs.

SECTION 6

Sample Custody

Essential to a sampling and analysis program is maintaining the integrity of the sample, from collection to data reporting. This requires tracking the possession and handling of samples from the time of collection, through analysis, to final disposal. This documentation is referred to as chain-of-custody (COC). Figure 6-1 shows an example of a COC form. The essential components of the COC are described in the section 3.2.6 of the Site-Specific Work Plan and section 3.2 of the FSP as summarized below.

6.1 Field Custody

The field team leader is responsible for the care and custody of samples until they are shipped or otherwise delivered to the laboratory custodian in accordance with methods for sample shipment procedures defined in section 3.2 of the FSP.

6.2 Transfer of Custody

The COC form must be completed before samples are shipped. The persons involved in relinquishing and receiving the samples will sign, date, and note the time of sample receipt on the COC form. The first such transfer may occur between the field sampler and the sample carrier. Another transfer may occur between the sample carrier and the laboratory's sample custodian. Each sample shipment will be accompanied by a COC record that identifies the contents of the shipment.

6.3 Laboratory Custody

Laboratory custody procedures are detailed in each laboratory's LQAP. The laboratory custodian will verify that the custody seals on the sample shipment or the containers are intact and that the information on the COC matches the actual contents. The laboratory custodian also will note anomalies, such as broken bottles, elevated temperatures, and missing labels. The project-specific procedures for sample custody are described fully in the FSP. Once a laboratory has been selected, a QAPP Addendum will be developed to provide laboratory specific custody controls.

6.4 Sample Disposal

Unless otherwise instructed, the analytical laboratory will dispose of unused sample portions after 180 days, in accordance with RCRA regulations and the LQAP. Unused samples will be offered to the EPA prior to disposal.

FIGURE 6-1
Sample COC Form

Progress Environmental Laboratories

№ 21359

4420 Pendola Point Road
Tampa, Florida 33619
(813) 247-2805
FAX: (813) 248-1537

Client:	Due Date(TAT):													
Project Mgr:	Fax Reports to:( ) -													
Project :	Bill to:													
Project #:														
PO #:	Sampler's Initials:													
Station ID	Date	Time	PEL Lab #	# of Bttls	Pres									Remarks

Relinquished By:	Received By:	Date	Time	Project Notes
Relinquished By:	Received By:	Date	Time	
Relinquished By:	Received By:	Date	Time	
Relinquished By:	Received By:	Date	Time	

SECTION 7

Equipment Calibration

Various instruments will be used in the field and in the laboratory to collect data and monitor site conditions. Proper calibration, maintenance, and use of the instruments is important for collecting high-quality data. A record of calibration and maintenance activities is as important as the data record itself for verifying the delivery of high-quality data.

7.1 Field Equipment Calibration

The following field equipment to be used during this investigation will require calibration:

- pH meter
- conductivity meter
- organic vapor meter (OVM)
- organic vapor analyzer (OVA)
- explosimeter
- turbidity meter
- dissolved oxygen (DO) meter
- portable gas chromatograph
- x-ray fluorescence

The meters used for field measurement will be calibrated before and during each day's use according to procedures and schedules outlined in the HASP or SOPs. The standards that will be used to calibrate these instruments are shown in Table 7-1. Standards will be purchased as necessary from appropriate vendors.

If an individual suspects an equipment malfunction, the meter will be removed from service and tagged so that it is not used inadvertently, and the equipment manager will be notified so that a substitute piece of equipment can be used. Some backup equipment will be available in the field for use in case of a malfunction.

Equipment that fails calibration or becomes inoperable during use will be removed from service and tagged so that it is not used inadvertently. Such equipment will be repaired and satisfactorily re-calibrated. Equipment that cannot be repaired will be replaced.

The results of activities performed using equipment that has failed re-calibration will be evaluated. If the results are adversely affected, the outcome of the evaluation will be documented and the task manager will be notified.

7.2 Laboratory Equipment Calibration

The laboratory itself is responsible for equipment and instrument calibration and maintenance. Manufacturer's guidance shall be followed for general upkeep. Laboratory

calibration procedures are outlined in the LQAP which will be included as an Addendum to the Master QAPP following laboratory selection.

TABLE 7-1
Calibration Standards

Instrument	Calibration Standard	Span	Reading	Method
OVM (11.7 eV)	100 ppm isobutylene	RF = 0.68	68 ppm	1.5 L/min reg: T-tubing
OVA	100 ppm methane	RF = 1.00	100 ppm	1.5 L/min reg: T-tubing
pH Meter	pH 4 and 7 Buffers	N/A	N/A	N/A
Conductivity Meter	EC 225 and 1,000 µS/cm	N/A	N/A	N/A
Explosimeter	75% LEL Pentane	N/A	50% ±5% LEL Oxygen	1.5 L/min: Direct tubing
Turbidity Meter	Per instrument instructions	N/A	N/A	Per instrument instructions
DO meter	N/A	N/A	> 0.1 ppm	Adjust for temperature, altitude, and salinity

SECTION 8

Analytical Procedures

All laboratory analyses will be performed by a laboratory approved by NFESC. The laboratories will be procured using basic ordering agreements (BOAs). Until the BOAs with CH2M HILL are in place, the BOA laboratories from Baker will be used. Table 8-1 lists analytical procedures that may be used for samples collected at AFWTF. Other analyses may be required and will be discussed in the site-specific SAP. Table 8-2 lists the chemicals analyzed by each method and the reporting limits.

TABLE 8-1
Analytical Procedures

Analysis	Methodology
TCL VOCs, SVOCs, and Pesticides/PCBs	SW-846 Methods 8260B, 8270C, and 8081A/8082
Organophosphorus pesticides	SW-846 Method 8141A
Chlorinated pesticides	SW-846 Method 8151A
Metals	SW-846 Methods 6010B and 7000 series
TOC	EPA Method 9060
TDS	EPA Method 160.1
TSS	EPA Method 160.2
Hardness	EPA Method 130.2
Alkalinity	EPA Method 310.1
Grain Size	ASTM 0421-58/0422-63
TCLP Extraction	SW-846 Method 1311
Corrosivity	SW-846 Section 7.2
Ignitability	SW-846 Method 1010/1020A
Reactivity	SW-846 Sections 7.3, 3.2/7.3, 4.2
Explosives	SW-846 Method 8330

TABLE 8-2A
RLs for Appendix IX VOCs, SW-846 method 8260B

Compound	Water RL (µg/L)	Soil RL (µg/kg)	Compound	Water RL (µg/L)	Soil RL (µg/kg)
1,1,1,2-Tetrachloroethane	1	5	cis-1,2-Dichloroethylene	0.5	2.5
1,1,1-Trichloroethane	1	5	cis-1,3-Dichloropropene	1	5
1,1,2,2-Tetrachloroethane	1	5	Dibromochloromethane	1	5
1,1,2-Trichloroethane	1	5	Dichlorodifluoromethane	2	10
1,1-Dichloroethane	1	5	Ethyl methacrylate	1	5
1,1-Dichloroethylene	1	5	Ethylbenzene	1	5
1,2,3-Trichloropropane	1	5	Isobutyl alcohol	40	200
1,2-Dibromo-3-chloropropane	2	10	Methacrylonitrile	2	10
1,2-Dibromoethane	1	5	Methyl bromide	2	10
1,2-Dichloroethane	1	5	Methyl chloride	2	10
1,2-Dichloropropane	1	5	Methyl ethyl ketone	10	20
1,4-Dioxane	200	500	Methyl iodide	1	5
2-Hexanone	10	20	Methyl methacrylate	1	5
4-Methyl-2-pentanone	5	20	Methylene bromide	1	5
Acetone	10	20	Methylene chloride	1	5
Acetonitrile	20	100	N-butyl alcohol	50	1000
Acrolein	20	100	Propionitrile	4	20
Acrylonitrile	20	100	Styrene	1	5
Allyl chloride	2	10	Tetrachloroethylene	1	5
Benzene	1	5	Toluene	1	5
Bromodichloromethane	1	5	trans-1,2-Dichloroethylene	0.5	2.5
Bromoform	1	5	trans-1,3-Dichloropropene	1	5
Carbon disulfide	1	5	trans-1,4-Dichloro-2-butene	1	5
Carbon tetrachloride	1	5	Trichloroethylene	1	5
Chlorobenzene	1	5	Trichlorofluoromethane	2	10
Chloroethane	2	10	Vinyl acetate	2	10
Chloroform	1	5	Vinyl chloride	2	10
Chloroprene	1	5	Xylenes, Total	1	5

RLs are estimated reporting limits for the applicable analyte. Laboratory specific reporting limits will be obtained and compared with the screening criteria upon contracting with an analytical laboratory

TABLE 8-2B
RLs for Appendix IX SVOCs SW-846 method 8270C

Compound	Water RL (µg/L)	Soil RL (µg/kg)
1,2,4,5-Tetrachlorobenzene	10	330
1,2,4-Trichlorobenzene	10	330
1,2-Dichlorobenzene	10	330
1,3-Dichlorobenzene	10	330
1,4-Dichlorobenzene	10	330
1,4-Naphthoquinone	50	1600
1-Naphthylamine	10	330
2,3,4,6-Tetrachlorphenol	50	1600
2,4,5-Trichlorophenol	10	330
2,4,6-Trichlorophenol	10	330
2,4-Dichlorophenol	10	330
2,4-Dimethylphenol	10	330
2,4-Dinitrophenol	50	1600
2,4-Dinitrotoluene	10	330
2,6-Dichlorophenol	10	330
2,6-Dinitrotoluene	10	330
2-Acetylaminofluorene	100	3300
2-Chloronaphthalene	10	330
2-Chlorophenol	10	330
2-Naphthylamine	10	330
2-Picoline	20	660
3,3'-Dimethylbenzidine	50	1600
3,3'-Dichlorobenzidine	50	1600
4,6-Dinitro-o-cresol	50	1600
4-Aminobiphenyl	50	1600
4-Bromophenyl phenyl ether	10	330
4-Chlorophenyl phenyl ether	10	330
4-Nitroquinoline 1-oxide	100	3300
5-Nitro-o-toluidine	20	660
Acenaphthene	10	330
Acetophenone	10	330
alpha,alpha-Dimethylphenethylamine	50	1600
Aniline	10	330

TABLE 8-2B
RLs for Appendix IX SVOCs SW-846 method 8270C

Compound	Water RL (µg/L)	Soil RL (µg/kg)
Anthracene	10	330
Aramite	20	660
Benzyl alcohol	10	330
Bis(2-chloro-1-methylethyl)ether	10	330
Bis(2-chloroethoxy)methane	10	330
Bis(2-chloroethyl)ether	10	330
Bis(2-ethylhexyl)phthalate	10	330
Butyl benzyl phthalate	10	330
Chlorobenzilate	10	330
Diallate	20	660
Dibenzofuran	10	330
Diethyl phthalate	10	330
Dimethoate	20	660
Dimethyl phthalate	10	330
Di-n-butyl phthalate	10	330
Di-n-octyl phthalate	10	330
Dinoseb	20	660
Diphenylamine	10	330
Ethyl methanesulfonate	10	330
Fluoranthene	10	330
Fluorene	10	330
Hexachlorobenzene	10	330
Hexachlorobutadiene	10	330
Hexachlorocyclopentadiene	50	1600
Hexachloroethane	10	330
Hexachloropropene	100	3300
Isophorone	10	330
Isosafrole	20	660
m-Cresol	10	330
m-Dinitrobenzene	10	330
Methapyrilene	50	1600
Methyl methanesulfate	10	330
m-Nitroaniline	50	1600

TABLE 8-2B
RLs for Appendix IX SVOCs SW-846 method 8270C

Compound	Water RL (µg/L)	Soil RL (µg/kg)
Nitrobenzene	10	330
N-Nitrosodiethylamine	10	330
N-Nitrosodimethylamine	10	330
N-Nitrosodi-n-butylamine	10	330
N-Nitrosodiphenylamine	10	330
N-Nitrosodipropylamine	10	330
N-Nitrosomethylethylamine	10	330
N-Nitrosomorpholine	10	330
N-Nitrosopiperidine	10	330
N-Nitrosopyrrolidine	10	330
o-Cresol	10	330
o-Nitroaniline	50	1600
o-Nitrophenol	10	330
o-Toluidine	20	660
p-(Dimethylamino)azobenzene	20	660
p-Chloroaniline	10	330
p-Chloro-m-cresol	10	330
p-Cresol	10	330
Pentachlorobenzene	10	330
Pentachloroethane	50	1600
Pentachloronitrobenzene	50	1600
Pentachlorophenol	10	330
Phenacetin	20	660
Phenol	10	330
p-Nitroaniline	50	1600
p-Nitrophenol	50	1600
p-Phenylenediamine	100	3300
Pronamide	20	660
Pyrene	10	330
Pyridine	20	660
Safrole	20	660
sym-Trinitrobenzene	50	1600

RLs are estimated reporting limits for the applicable analyte. Laboratory specific reporting limits will be obtained and compared with the screening criteria upon contracting with an analytical laboratory

TABLE 8-2C
RLs for Appendix IX PAHs, SW-846 method 8310

Analyte	Water RL (µg/L)	Soil RL (µg/kg)	Analyte	Water RL (µg/L)	Soil RL (µg/kg)
2-Methylnaphthalene	0.02	5	Benzo(g,h,i)perylene	0.02	5
3-Methylcholanthrene	0.50	5	Benzo(k)fluoranthene	0.02	5
7,12-Dimethylbenz(a)anthracene	0.50	5	Chrysene	0.02	5
Acenaphthylene	0.02	5	Dibenz(a,h)anthracene	0.02	5
Benzo(a)anthracene	0.02	5	Indeno(1,2,3-cd)pyrene	0.02	5
Benzo(a)pyrene	0.02	5	Naphthalene	0.02	5
Benzo(b)fluoranthene	0.02	5	Phenanthrene	0.02	5

RLs are estimated reporting limits for the applicable analyte. Laboratory specific reporting limits will be obtained and compared with the screening criteria upon contracting with an analytical laboratory

TABLE 8-2D
RLs for Appendix IX Organochlorine Pesticides, SW-846 method 8081A

Analyte	Water RL (µg/L)	Soil RL (µg/kg)	Analyte	Water RL (µg/L)	Soil RL (µg/kg)
4,4'-DDD	0.05	1.7	Endosulfan sulfate	0.05	1.7
4,4'-DDE	0.05	1.7	Endrin	0.05	1.7
4,4'-DDT	0.05	1.7	Endrin aldehyde	0.05	1.7
Aldrin	0.05	1.7	Gamma BHC	0.05	1.7
Alpha BHC	0.05	1.7	Heptachlor	0.05	1.7
Beta BHC	0.05	1.7	Heptachlor epoxide	0.05	1.7
Chlordane	0.5	17	Isodrin	0.1	3.3
Delta BHC	0.05	1.7	Kepone	1.0	33
Dieldrin	0.05	1.7	Methoxychlor	0.1	3.3
Endosulfan I	0.05	1.7	Toxaphene	2.0	67
Endosulfan II	0.05	1.7			

RLs are estimated reporting limits for the applicable analyte. Laboratory specific reporting limits will be obtained and compared with the screening criteria upon contracting with an analytical laboratory

TABLE 8-2E
RLs for Appendix IX Organophosphorous Pesticides, SW-846 method 8141A

Analyte	Water RL (µg/L)	Soil RL(µg/kg)
Disulfoton	1	33
Famphur	1	33
Methyl parathion	1	33
Parathion	1	33
Phorate	1	33
Tetraethyl dithiopyrophosphate	1	33
O,O-Diethyl O-2-pyrazinyl phosphorothioate	1	33
O,O,O-Triethyl phosphorothioate	1	33

RLs are estimated reporting limits for the applicable analyte. Laboratory specific reporting limits will be obtained and compared with the screening criteria upon contracting with an analytical laboratory.

TABLE 8-2F
RLs for Appendix IX PCBs, SW-846 method 8082

Analyte	Water RL (µg/L)	Soil RL (µg/kg)
Aroclor-1016	1	33
Aroclor-1221	1	33
Aroclor-1232	1	33
Aroclor-1242	1	33
Aroclor-1248	1	33
Aroclor-1254	1	33
Aroclor-1260	1	33

RLs are estimated reporting limits for the applicable analyte. Laboratory specific reporting limits will be obtained and compared with the screening criteria upon contracting with an analytical laboratory

TABLE 8-2G
RLs for Appendix IX Herbicides, SW-846 method 8151A

Analyte	Water RL (µg/L)	Soil RL (µg/kg)
2,4-D	4.0	80
2,4,5-T	1.0	20
2,4,5-TP (Silvex)	1.0	20

RLs are estimated reporting limits for the applicable analyte. Laboratory specific reporting limits will be obtained and compared with the screening criteria upon contracting with an analytical laboratory.

TABLE 8-2H
RLs for Appendix IX Dioxins and Furans, SW-846 method 8290

Analyte	Water RL (µg/L)	Soil RL (µg/kg)
2,3,7,8-TCDD	0.0007	0.003
Total HxCDD	NA	NA
Total HxCDF	NA	NA
Total PeCDD	NA	NA
Total PeCDF	NA	NA
Total TCDD	NA	NA
Total TCDF	NA	NA

RLs are estimated reporting limits for the applicable analyte. Laboratory specific reporting limits will be obtained and compared with the screening criteria upon contracting with an analytical laboratory.

NA – Not Available.

TABLE 8-2I
RLs for Appendix IX Inorganics, SW-846 method 6010B, a 9000 series method for cyanide and sulfide, and a 7000 series method for mercury

Analyte	Water RL (µg/L)	Soil RL (µg/kg)	Analyte	Water RL (µg/L)	Soil RL (µg/kg)
Antimony	60	6,000	Mercury	0.2	100
Arsenic	10	1,000	Nickel	40	4,000
Barium	200	20,000	Selenium	5	500
Beryllium	5	500	Silver	10	1,000
Cadmium	5	500	Sulfide	500	50000
Chromium	10	1000	Thallium	10	1,000
Cobalt	50	500	Tin	100	10,000
Copper	25	2,500	Vanadium	50	5,000
Cyanide	10	500	Zinc	20	2,000
Lead	3.0	300			

RLs are estimated reporting limits for the applicable analyte. Laboratory specific reporting limits will be obtained and compared with the screening criteria upon contracting with an analytical laboratory.

TABLE 8-2J
Analytical Parameters and Reporting Limits
Explosives
SW-846 Method 8330 and 8332

Analyte	Water RL (µg/L)	Soil RL (µg/kg)
1,3,5-Trinitrobenzene	0.11	120
1,3-Dinitrobenzene	0.13	64
2,4,6-Trinitrotoluene	0.18	88
4-Amino-2,6-dinitrotoluene	0.29	100
2-Amino-4,6-dinitrotoluene	0.17	370
2,4-Dinitrotoluene	0.59	120
2,6-Dinitrotoluene	0.73	99
Nitrobenzene	0.26	68
2-Nitrotoluene	0.49	110
3-Nitrotoluene	110	71
4-Nitrotoluene	0.56	68
Hexahydro-1,3,5-trinitro-1,3,5-triazine	0.32	58
Octahydro-1,3,5,7-tetranitro-1,3,5,7-	0.69	80
tetrazocine (HMX)		370
Nitroglycerin	0.99	12000
Pentaeythritol tetranitrate (PETN)	2.1	14000
Ammonium Perchlorate	0.002	0.04
Picric Acid	300	300

Method and Target List	Reporting	Limits	Screening Criteria				
Volatiles - SW846 8260B	**Soil ug/kg**	**Water ug/L**	**Soil mg/kg**	**Groundwater ug/L**	**SSL (DAF=20, mg/Kg)**	**Sediment mg/kg**	**Surfacewater ug/l**
1,1-Dichloroethane (1,1-DCA)	10	10	5.06E+01	8.11E+01	2.30E+01		
1,1-Dichloroethylene (1,1-DCE)	10	10	1.24E+01	3.39E+01	6.00E-02		
1,1,1-Trichloroethane (1,1,1-TCA)	10	10	1.20E+02	3.17E+02	2.00E+00		
1,1,2-Trichloroethane (1,1,2-TCA)	10	10	7.29E-01	2.00E-01	2.00E-02		
1,1,2,2-Tetrachloroethane	10	10	4.08E-01	5.53E-02	3.00E-03		
1,2-Dichloroethane (1,2-DCA)	10	10	2.78E-01	1.23E-01	2.00E-02		
1,2-Dichloropropane	10	10	3.42E-01	1.65E-01	3.00E-02		
2-Butanone (MEK)	10	10	7.33E+02	1.90E+02	na		
2-Hexanone	10	10	NA	na	na		
4-Methyl-2-pentanone (MBK)	10	10	7.87E+01	1.58E+01	na		
Acetone	10	10	1.57E+02	6.08E+01	1.60E+01		
Benzene	10	10	6.01E-01	3.36E-01	3.00E-02		
Bromodichloromethane	10	10	8.24E-01	1.81E-01	6.00E-01		
Bromoform	10	10	6.16E+01	8.51E+00	8.00E-01		
Bromomethane	10	10	3.90E-01	8.66E-01	2.00E-01		
Carbon disulfide	10	10	3.55E+01	1.04E+02	3.20E+01		
Carbon tetrachloride	10	10	2.51E-01	1.71E-01	7.00E-02		
Chloroethane	10	10	3.03E+00	4.64E+00	na		
Chlorobenzene	10	10	1.51E+01	1.06E+01	1.00E+00		
Chloroform	10	10	3.56E+00	6.17E+00	6.00E-01		
Chloromethane	10	10	1.23E+00	1.51E+00	na		
cis-1,3-Dichloropropene	10	10	7.77E-01	3.95E-01	4.00E-03		
Dibromochloromethane	10	10	1.11E+00	1.33E-01	4.00E-01		
Ethylbenzene	10	10	8.92E+00	2.91E+00	1.30E+01		
Methylene chloride	10	10	9.11E+00	4.28E+00	2.00E-02		
Styrene	10	10	1.70E+02	1.64E+02	4.00E+00		
Tetrachloroethylene (PCE)	10	10	1.51E+00	6.59E-01	6.00E-02		
Toluene	10	10	5.20E+01	7.23E+01	1.20E+01		
Total xylenes	10	10	2.75E+01	2.10E+01	2.10E+02		
trans-1,3-Dichloropropene	10	10	7.77E-01	3.95E-01	4.00E-03		
Trichloroethene (TCE)	10	10	5.30E-02	2.80E-02	6.00E-02		
Vinyl Chloride	10	10	7.91E-02	1.98E-02	1.00E-02		
Semivolatiles - SW846 8270C			**mg/Kg**	**ug/L**	**mg/Kg**	**mg/Kg**	**mg/Kg**
Acenaphthene	330	10	3.68E+02	3.65E+01	5.70E+02	1.60E-02	
Acenaphthylene	330	10	3.68E+02	3.65E+01	5.70E+02		
Anthracene	330	10	2.19E+03	1.83E+02	1.20E+04		
Benzo(a)anthracene	330	10	6.21E-01	9.21E-02	2.00E+00		
Benzo(b)fluoranthene	330	10	6.21E-01	9.21E-02	5.00E+00		
Benzo(k)fluoranthene	330	10	6.21E+00	9.21E-01	4.90E+01		
Benzo(g,h,i)perylene	330	10	na	na	na		
Benzo(a)pyrene	330	10	6.21E-02	9.21E-03	8.00E+00	4.30E-01	
Butyl benzyl phthalate	330	10	1.22E+03	7.30E+02	9.30E+02		
bis(2-Chloroethoxy) methane	330	10	na	na	na		
bis(2-Chloroethyl)ether	330	10	2.11E-01	9.78E-03	4.00E-04		
bis(2-Chloroisopropyl)ether	330	10	2.88E+00	2.74E-01	na		
bis(2-Ethylhexyl)phthalate	330	10	3.47E+01	4.80E+00	NA		
Bromophenyl phenyl ether, 4-	330	10	na	na	na		
Carbazole	330	10	2.43E+01	3.36E+00	6.00E-01		
Chloroaniline, 4-	330	10	2.44E+01	1.46E+01	7.00E-01		
Chloronaphthalene, 2-	330	10	na	na	na		
Chlorophenyl-phenyl ether, 4-	330	10	na	na	na		
Chrysene	330	10	6.21E+01	9.21E+00	1.60E+02		
Dibenz(a,h)anthracene	330	10	6.21E-02	9.21E-03	2.00E+00		
Dibenzofuran	330	10	2.91E+01	2.43E+00	na		
Di-n-butyl phthalate (Dibutyl phthalate)	330	10	6.11E+02	3.65E+02	2.30E+03		
Dichlorobenzene, 1,2 -	330	10	3.70E+01	3.70E+01	1.70E+01		
Dichlorobenzene, 1,3 -	330	10	1.59E+00	5.48E-01	na		
Dichlorobenzene, 1,4 -	330	10	3.45E+00	5.02E-01	2.00E+00		
Dichlorobenzidine, 3,3'-	670	20	1.08E+00	1.49E-01	7.00E-03		
Diethyl phthalate	330	10	4.89E+03	2.92E+03	na		
Dimethyl phthalate	330	10	1.00E+04	3.65E+04	na		
Dinitrotoluene, 2,4-	330	10	7.15E-01	9.89E-02	8.00E-04		
Dinitrotoluene, 2,6-	330	10	7.15E-01	9.89E-02	8.00E-04		
Di-n-octyl phthalate	330	10	2.44E+02	1.46E+02	1.00E+04		
Fluoranthene	330	10	2.29E+02	1.46E+02	4.30E+03	6.00E-01	
Fluorene	330	10	2.75E+02	2.43E+01	5.60E+02		
Hexachlorobenzene	330	10	3.04E-01	4.20E-02	2.00E+00		
Hexachlorobutadiene	330	10	6.24E+00	8.62E-01	2.00E+00		
Hexachlorocyclopentadiene	330	10	3.65E+01	2.19E+01	4.00E+02		
Hexachloroethane	330	10	3.47E+01	4.80E+00	5.00E-01		
Indeno(1,2,3-cd)pyrene	330	10	6.21E-01	9.21E-02	1.40E+01		
Isophorone	330	10	5.12E+02	7.08E+01	5.00E-01		
Methylnaphthalene, 2-	330	10	na	na	na		
Naphthalene	330	10	5.59E+00	6.20E-01	8.40E+01	1.60E-01	
Nitroaniline, 2- (o-)	990	50	1.75E-01	1.04E-01	na		
Nitroaniline, 3- (m-)	990	50	na	na	na		
Nitroaniline, 4- (p-)	990	50	na	na	na		
Nitrobenzene	330	10	1.96E+00	3.40E-01	1.00E-01		
Nitrosodiphenylamine, n-	330	10	9.93E+01	1.37E+01	1.00E+00		
n-Nitroso-di-n-propylamine	330	10	9.93E+01	1.37E+01	1.00E+00		
Phenanthrene	330	10	na	na	na	2.40E-01	

Pyrene	330	10	2.32E+02	1.83E+01	4.20E+03	6.60E-01	
Trichlorobenzene, 1,2,4-	330	10	6.50E+01	1.94E+01	5.00E+00		
Chloro-3-methylphenol, 4- (p-Chloro-m-cresol)	330	10	na	na	na		
Chlorophenol, 2-	330	10	6.34E+00	3.04E+00	4.00E+00		
Dichlorophenol, 2,4-	330	10	1.83E+01	1.09E+01	1.00E+00		
Dimethylphenol, 2,4-	330	10	1.22E+02	7.30E+01	9.00E+00		
Dinitro-2-methylphenol, 4,6-	990	50	na	na	na		
Dinitrophenol, 2,4-	990	50	1.22E+01	7.30E+00	3.00E-01		
Methylphenol, 2- (o cresol)	330	10	3.06E+02	1.82E+02	1.50E+01		
Methylphenol, 4- (p cresol)	330	10	3.06E+01	1.82E+01	na		
Nitrophenol, 2-	330	10	na	na	na		
Nitrophenol, 4-	990	50	na	na	na		
Pentachlorophenol	990	50	2.98E+00	5.60E-01	3.00E-02		7.90E+00
Phenol	330	10	3.67E+03	2.19E+03	1.00E+02		
Trichlorophenol, 2,4,5-	990	50	6.11E+02	3.65E+02	2.70E+02		
Trichlorophenol, 2,4,6-	330	10	6.11E-01	3.65E-01	2.00E-01		
Pesticides and PCB's - SW846 8081A and 8082			**mg/Kg**	**ug/L**	**mg/Kg**	**mg/Kg**	**mg/Kg**
alpha-BHC	1.7	0.05	9.02E-02	1.07E-02	5.00E-04		
beta-BHC	1.7	0.05	3.16E-01	3.74E-02	3.00E-03		
delta-BHC	1.7	0.05	na	na	na		
gamma-BHC (Lindane)	1.7	0.05	4.37E-01	5.17E-02	9.00E-03		
Heptachlor	1.7	0.05	1.08E-01	1.49E-02	2.30E+01		3.60E-03
Aldrin	1.7	0.05	2.86E-02	3.95E-03	5.00E-01		
Heptachlor epoxide	1.7	0.05	5.34E-02	7.39E-03	7.00E-01		3.60E-03
Endosulfan I	1.7	0.05	3.67E+01	2.19E+01	1.80E+01		
Dieldrin	3.3	0.1	3.04E-02	4.20E-03	4.00E-03		1.90E-03
4,4'-DDE	3.3	0.1	1.72E+00	1.98E-01	5.40E+01		
Endrin	3.3	0.1	1.83E+00	1.09E+00	1.00E+00		2.30E-03
Endosulfan II	3.3	0.1	3.67E+01	2.19E+01	1.80E+01		8.70E-03
4,4'-DDD	3.3	0.1	2.44E+00	2.80E-01	1.60E+01		
Endosulfan sulfate	3.3	0.1	3.67E+01	2.19E+01	1.80E+01		
4,4'-DDT	3.3	0.1	1.72E+00	1.98E-01	3.20E+01	1.60E-03	1.00E-03
Methoxychlor	17	0.5	3.06E+01	1.82E+01	1.60E+02		3.00E-02
Endrin ketone	3.3	0.1	1.83E+00	1.09E+00	1.00E+00		
Endrin aldehyde	3.3	0.1	1.83E+00	1.09E+00	1.00E+00		
alpha-Chlordane	1.7	0.05	1.62E+00	1.92E-01	1.00E+01		4.00E-03
gamma-Chlordane	1.7	0.05	1.62E+00	1.92E-01	1.00E+01		4.00E-03
Toxaphene	170	5	4.42E-01	6.11E-02	3.10E+01		2.00E-04
Aroclor-1016	33	1	3.93E-01	9.60E-01	na		1.40E-02
Aroclor-1221	67	2	2.22E-01	3.36E-02	na		1.40E-02
Aroclor-1232	33	1	2.22E-01	3.36E-02	na		1.40E-02
Aroclor-1242	33	1	2.22E-01	3.36E-02	na		1.40E-02
Aroclor-1248	33	1	2.22E-01	3.36E-02	na		1.40E-02
Aroclor-1254	33	1	2.22E-01	3.36E-02	na		1.40E-02
Aroclor-1260	33	1	2.22E-01	3.36E-02	na		1.40E-02
Explosives - SW846 8330			**mg/Kg**	**ug/L**	**mg/Kg**	**mg/Kg**	**mg/Kg**
1,3,5-Trinitrobenzene	250	5	1.83E+02	1.09E+02	na		
1,3-Dinitrobenzene	250	5	6.11E-01	3.65E-01	na		
2,4,6-Trinitrotoluene	250	5	1.62E+01	2.24E+00	na		
2,4-Dinitrotoluene	250	5	1.22E+01	7.30E+00	8.00E-04		
2,6-Dinitrotoluene	250	5	6.11E+00	3.65E+00	7.00E-04		
2-Nitrotoluene	250	5	na	na	na		
3-Nitrotoluene	250	5	na	na	na		
4-Nitrotoluene	250	5	na	na	na		
Hexahydro-1,3,5-trinitro-1,3,5-triazine	250	5	4.42E+00	6.11E-01	na		
Methyl-2,4,6-trinitrophenylnitramine	250	5	na	na	na		
Nitrobenzene	250	5	1.96E+00	3.40E-01	1.00E-01		
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine	250	5	3.06E+02	1.82E+02	na		
Metals - Appendix IX 6010	**mg/kg**	**ug/L**	**mg/Kg**	**ug/L**	**mg/Kg**	**mg/Kg**	**mg/Kg**
Antimony	6	60	3.13E+00	1.46E+00	5.00E+00		
Arsenic	1	10	3.90E-01	4.48E-02	2.90E+01	8.20E+00	3.60E+01
Barium	40	200	5.37E+02	2.55E+02	1.60E+03		
Beryllium	0.5	5	1.54E+01	7.30E+00	6.30E+01		
Cadmium	0.5	5	3.70E+00	1.82E+00	8.00E+00	1.20E+00	2.50E-01
Chromium	1	10	3.01E+01	1.09E+01	3.80E+01	8.10E+01	7.40E+01
Cobalt	5	50	9.03E+02	7.30E+01	na		
Copper	2.5	25	3.13E+02	1.46E+02	na	3.40E+01	3.10E+00
Lead	0.3	3	4.00E+01	na	na	4.70E+01	2.50E+00
Mercury	0.1	0.2	2.35E+00	1.09E+00	na		
Nickel	4	40	1.56E+02	7.30E+01	1.30E+02	2.10E+01	8.20E+00
Selenium	0.5	5	3.91E+01	1.82E+01	5.00E+00		5.00E+00
Silver	1	10	3.91E+01	1.82E+01	3.40E+01		
Thallium	1	10	5.16E-01	2.41E-01	na		
Vanadium	5	50	5.47E+01	2.55E+01	6.00E+03		
Tin	10	100	4.70E+04	2.20E+04	na		
Zinc	2	20	2.35E+03	1.09E+03	1.20E+04	1.50E+02	8.10E+01

SECTION 9

Data Reduction, Validation, and Reporting

Data reduction and reporting are steps in the overall management and use of both field and laboratory data, and data validation is a step in the overall management and use of laboratory data. The selected laboratory will provide a SOW and QAPP that will be included as an Addendum to the Master QAPP providing detail on methods of laboratory data reduction. Figure 9-1 illustrates the flow of information and sample-tracking forms.

9.1 Data Reduction

Data reduction, validation, and reporting will ensure that all documents for the investigations can be accounted for when they are completed. Documents requiring accountability include logbooks, field data records, correspondence, COC records, analytical reports, data packages, and reports.

9.2 Definition

Collected analytical data will be computerized. Electronic data will be requested for all Target Compound List (TCL) and Target Analyte List (TAL) analyses from the laboratory in a format agreed upon by the data manager. Other types of analytical data will be entered and then verified by spot-checking procedures. The sample manager will handle data entries that are unverified.

9.3 Background Data

Background data produced for internal records and not reported as part of the analytical data include the following: laboratory worksheets, laboratory notebooks, sample-tracking system forms, maintenance records, calibration records, and associated QC records. These sources will be available for inspection and for determining the data validation.

9.4 Data Validation

Validation of analytical data will be in accordance with NFESC QA guidance and EPA QA/QC requirements. The validation will be performed according to the updated *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, September 1999) and *USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* (EPA, February 1994). Data validation will be performed by a subcontractor to CH2M HILL utilizing EPA Region II data validation formats. Example data validation sheets will be provided following the selection of a BOA approved subcontractor. An example DQE Report is included as Attachment A. The Data Validation Report will meet all SW 846 requirements.

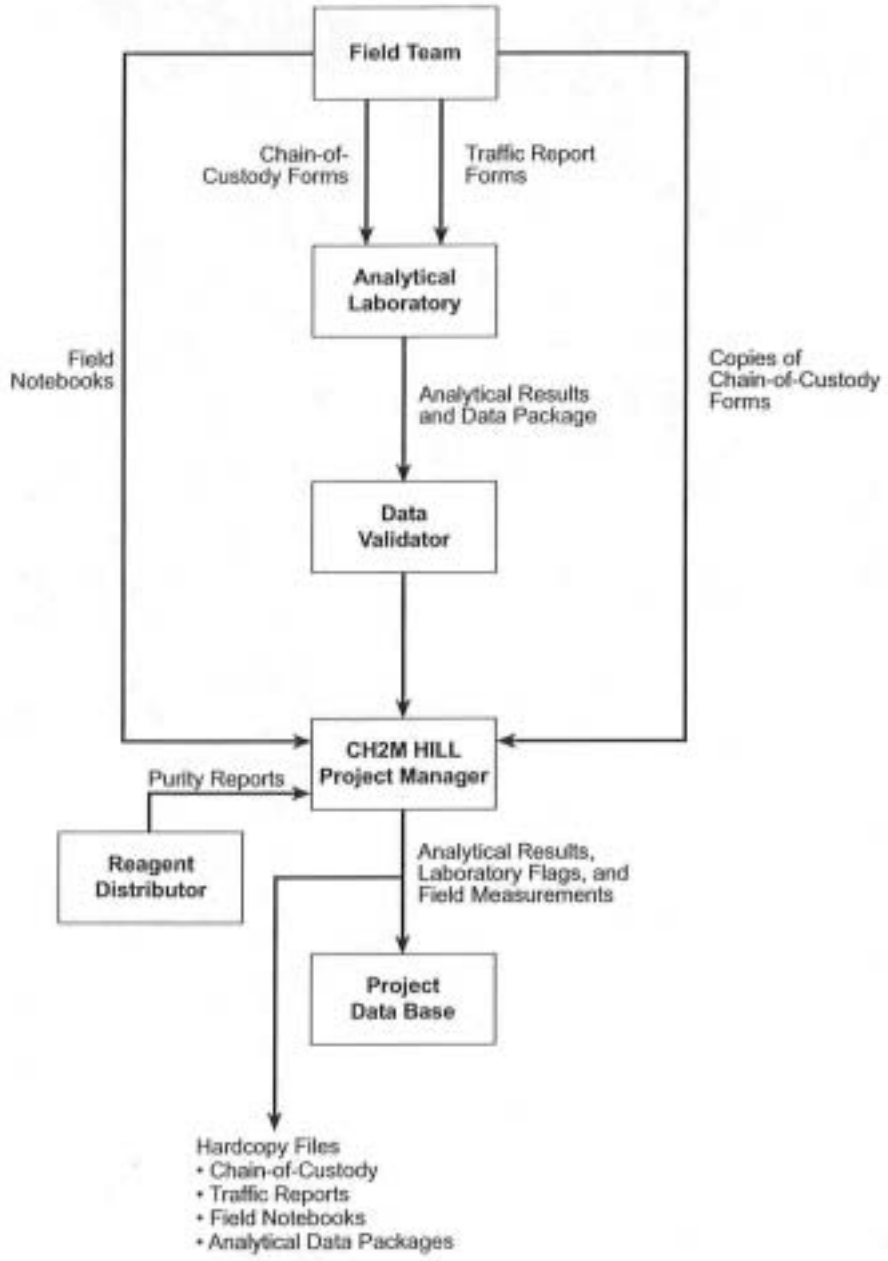

FIGURE 9-1
Flow of Forms and Sample and Analysis Information

CH2MHILL

The project, its objectives, and the intended use of the data will be discussed with the data validation personnel. Analytical results with low level DQOs will be evaluated for completeness and applicable precision, accuracy, and blank contamination.

9.5 Data Records

The following procedures will be used for maintaining the project records:

- The task manager will determine the records to be generated before the start of work. The records will be listed in the site-specific WPs and SAPs.
- Records of field activities that support the integrity of samples will be entered on bound and numbered pages. Such records will be dated and signed or otherwise authenticated on the day of entry. All entries will be made in indelible ink, and corrections will be made by crossing out mistakes with a single line so that the original entry is legible. Changes will be initialed and dated.
- Records retained on file will be indexed. The indexing system will include the locations of records within the indexing system. (The indexing system will be in alphabetical, chronological, or numerical order or as otherwise indicated in written procedures.)
- There will be sufficient information in records to permit identification between the record and the item(s) or activity to which it applies. Identification of records will be by means that permit traceability.
- The record storage system will provide for accurate retrieval of records without undue delay.

SECTION 10

Quality Control Checks

A number of QA/QC samples will be collected to check the adequacy of sample collection and analysis and to monitor laboratory performance. Duplicates, blanks, and spiked samples are used to determine if the sampling technique affects the analytical results, to measure the internal consistency of the samples, and to estimate variances or biases in the analytical process. The field and laboratory QA/QC sampling procedures are described below.

10.1 Field Sampling QC Procedures

QC duplicate samples and blanks are used to provide a measure of the internal consistency of the samples and an estimate of variance and bias. Table 10-1 shows the number of each type of field QC sample that should be collected for the number of investigative samples collected. The number and kinds of QC samples to be collected for each sampling event will be listed in each site-specific SAP.

TABLE 10-1
Summary of QC Collection Frequencies

Type of QC Sample	Frequency Collected
Field Duplicate	One per 10 samples per matrix
Trip Blank	One per cooler containing samples for VOC analysis
Field Blank	One per sampling event, and at least one per week (if very windy or dusty, collect one per day)
Equipment Blank	One each day per matrix
Temperature Blank	One per cooler
MS/MSD	One per matrix for each group of up to 20 samples sent to a single laboratory

One duplicate sample will be obtained for every 10 field samples collected. The sampling station from which the duplicate is taken will be selected with a bias toward locations where measurable concentrations are expected. Each duplicate sample will be split evenly into two sample containers and submitted for analysis as two independent samples.

MS/MSDs will be collected at the rate of one for every 20 field samples collected. MS/MSD samples give an indication of the laboratory's analysis accuracy and precision within the sample matrix.

Blanks provide a measure of cross-contamination sources, decontamination efficiency, and other potential errors that can be introduced from sources other than the sample. Three types of blanks can be generated during sampling activities: trip blanks, field blanks, and equipment rinsate blanks.

One trip blank will be included in each cooler used for the daily shipment of VOC samples. If more than one cooler is being sent on a given day, all of the VOC samples should be placed in one cooler, if possible, to minimize the number of trip blanks needed. The trip blanks will be prepared before each sampling event, shipped or transported to the field with the sampling bottles, and returned unopened for analysis. Trip blanks will indicate if there is contamination during shipment to the field, from storage in the field, or from shipment from the field to the analytical laboratory.

One equipment blank per sample medium will be obtained for each day of sampling. Equipment blanks will give an indication of the efficiency of decontamination procedures.

One field blank will be collected per sampling event. If sampling events extend beyond 1 week (5 working days) or for windy and dusty field conditions, the number of field blanks should be increased. Field blanks are used to determine the chemical quality of water used for such procedures as decontamination and blank collection.

EPA has recently requested that a temperature blank be included in each cooler containing samples for SW 846 analyses so that the laboratory can record the temperature without disturbing the samples. The temperature blank will not be given a sample number nor listed as a sample on the COC.

10.2 Laboratory Analytical QC Procedures

The analytical laboratory will use the QC elements, including method or laboratory blanks, initial and continuing calibrations, MS/MSDs, and surrogate spike standards as specified in the laboratory LQAP and in *Navy Installation Restoration Laboratory Quality Assurance Guide, Interim Guidance Document* (U.S. Navy, February 1996). The LQAP will identify the QC samples, frequency of analysis, acceptance criteria, and corrective actions for each laboratory method.

Method blanks monitor potential contamination introduced during analysis. Calibration standards are used to calibrate the instrumentation, thereby controlling the accuracy of the results. Once an instrument has been calibrated, calibration is confirmed periodically by monitoring the instrument response to internal standards. For some analyses, such as those performed by gas chromatograph/mass spectrometer (GC/MS), a sample and a blank are spiked with a surrogate compound or a system-monitoring compound (SMC) chosen for properties similar to those of the analyte of interest. The surrogate spikes or SMCs evaluate the efficiency of the analytical procedure in recovering the true amount of a known compound. Laboratory duplicates are performed in certain instances (especially for inorganic analyses) to evaluate the reproducibility of the method.

MS/MSDs are spiked by the laboratory in two separate aliquots of a sample selected by the sampler from each batch of 20 field samples. The MS/MSDs will be used to assess accuracy and precision. The MSD is identical to the MS; both are analyzed to determine the reproducibility of the results. The sampler will collect a triple volume of one sample to give the laboratory enough material for analyzing the sample, the spiked sample, and the spiked sample duplicate.

SECTION 11

Performance and Systems Audits

Both field and laboratory audits will be conducted.

11.1 Laboratory Performance and Systems Audits

The analytical laboratories will conduct internal QC checks as indicated in each laboratory's LQAP. Each approved BOA laboratory has been audited to qualify for the list and is subject to external audits by the Navy and CH2M HILL. Results of the audit will be available following the selection process.

11.2 Field Team Performance and Systems Audits

The project manager or designee will conduct a performance audit as needed during sampling activities to verify that the proper sampling and documentation procedures presented in the QAPP and the FSP are followed and that subsequent sample data are valid. The audit will focus on the details of the QA program. The audit checklist is the guide for performing audits for field procedures, and is shown in Figure 11-1. The audit will evaluate the following:

- Project responsibilities
- Sample collection and sample preservation procedures
- Equipment decontamination procedures
- Field equipment calibration procedures
- Sample custody procedures
- Document control
- Sample identification system
- QC corrective action procedures

An audit report summarizing results and corrections will be prepared and filed in the project files. Significant variances from established procedures will be reported to the project manager.

Figure 11-1

FIELD PERFORMANCE AUDIT CHECKLIST

Project Responsibilities

Project No.: _____ Date: _____

Project Location: _____ Signature: _____

Team Members:

Yes __ No __ 1) Was a SAP Prepared?
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 _____

_____

Figure 11-1

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 _____

_____

Figure 11-1

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 _____

_____

SECTION 12

Preventive Maintenance

Routine maintenance procedures and schedules for field sampling equipment are described in the manufacturers' instruction manuals. Maintenance procedures and schedules for all field instruments will follow the recommendations of the equipment manufacturers. All records of inspection and maintenance will be dated and documented in the field notebook for each site.

Routine laboratory equipment maintenance will be performed by laboratory personnel as needed or as indicated in the LQAP of the selected laboratory. Maintenance procedures and schedules for laboratory analytical instruments will follow the recommendations of the equipment manufacturers. All records of inspection and maintenance will be dated and documented in laboratory record books.

Critical spare parts for the pH meter, the OVM, the OVA, the conductivity meter, the DO meter, and the explosimeter include batteries, electrodes, and membranes. They will be included in the sampling kits to minimize downtime. In addition, backup meters will be available, if needed. Spare parts will be purchased from accepted vendors. An inventory of available spare parts for field equipment will be kept in the field logbook and updated as necessary. Daily inspections of field equipment will be conducted to ensure that equipment is functioning properly. If inspection results indicate that a piece of field equipment is deemed faulty or not useable, replacement equipment will be cleaned, calibrated if necessary, and used in place of the faulty equipment. The faulty equipment will then be shipped back to the vendor for repair.

SECTION 13

Data Assessment Procedures

The precision and accuracy of data will be assessed routinely to ensure that they meet the requirements of the DQOs.

All data will be validated before interpretation by a subcontractor. The validation will be performed according to *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, September 1999) and *EPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses* (EPA, February 1994).

Data with high level DQOs will be validated by an independent contractor. NFESC guidance does not allow CH2M HILL to validate data collected by CH2M HILL staff. Data that should be qualified will be flagged with the appropriate symbol.

Data with low level DQOs will be evaluated by CH2M HILL. The results for field and equipment blanks will be reviewed if available, and the data will be qualified if necessary. The data set as a whole will be examined for completeness, consistency, anomalous results, and reasonableness.

SECTION 14

Corrective Actions

Anyone who determines that a problem exists will initiate the corrective action process by consulting the project manager. Corrective action will include problem identification, investigation-responsibility assignment, action for eliminating the problem, increased monitoring of the effectiveness of the corrective action, and verification that the problem has been eliminated.

Documenting the problem is important to the overall QA program. A memorandum to file will be written for a problem associated with sample collection. A copy will be sent to the laboratory, if appropriate, to document corrections to sample identification. The memo will be written by the person discovering the QA problem or the person responsible for the problem. The memo should identify the problem, establish possible causes, and designate the person responsible for action. The responsible person will be either the project manager or the field team leader. The responsible person will verify that initial action has been taken and appears to be effective and, at an appropriate later date, will recheck to see if the problem has been resolved fully. A standard corrective action form is provided as Figure 14-1.

Examples of corrective actions include, but are not limited to, correcting COC forms, analysis reruns (if holding-time criteria permit), recalibration with fresh standards, replacement of sources of blank contamination, examination of calculation procedures, additional training in sample preparation and analysis, reassignment of analytical responsibilities using a different batch of containers, and recommending an audit of laboratory procedures. Additional approaches may include the following:

- Resampling and analyzing
- Evaluating and amending procedures for sampling and analysis
- Accepting the data and acknowledging the level of uncertainty or inaccuracy by flagging the data and providing an explanation for the qualification

FIGURE 14-1
CORRECTIVE ACTION REQUEST FORM

Originator: _____ Date: _____

Person responsible for replying: _____

Description of problem and when identified: _____

_____

Sequence of Corrective Action (CA): (If a responsible person is not identified, submit this form directly to the PM)

State date, person, and action planned:

_____

_____

_____

_____

_____

CA initially approved by: _____ Date: _____

Follow-up date: _____

Final CA approval by: _____ Date: _____

Information copies to:

Responsible person: _____

Field Team Leader: _____

Project Manager: _____

SECTION 15

Quality Assurance Reports

A QA report with attached corrective action forms will be distributed to all appropriate parties at the end of the field activity to summarize the QA/QC status of the project and problems, if any. The report will be an assessment of the measured QA parameters (for example, precision and accuracy), the results of performance audits, reported nonconformance, and significant QA problems and the recommended solutions. A change in the QAPP will be summarized in a report or a letter, and will be sent to NAVFACENGCOM, LANTDIV, the EPA, and distributed to the CH2M HILL project team.

Attachment A

Example Data Quality Evaluation Report

Example Data Quality Evaluation (DQE)

TO: Marty Clasen / TPA
Astrid Clarke / DFB

FROM: Kevin A. Sanders / GNV

DATE: 2 / 19 / 01

The purpose of the data quality evaluation process is to assess the effect of the overall analytical process on the usability of the data. The two major categories of data evaluation are laboratory performance and matrix interferences. Evaluation of laboratory performance is a check for compliance with the method requirements; either the laboratory did, or did not, analyze the samples within the limits of the analytical method. Evaluation of matrix interferences is more subtle and involves the analysis of several areas of results including surrogate spike recoveries, matrix spike recoveries, and duplicate sample results.

Introduction

Samples were collected from April 4, 2000 through June 12, 2000. Field QC samples collected included field duplicates, field blanks, trip blanks (analyzed for VOCs only), and equipment rinsate blanks. The number of each type of sample is listed by analytical method in Table 1. The samples were analyzed for the following analytical fractions:

- Volatile organic compounds (VOCs) by CLP SOW OLMO4.2
- Semivolatile organic compounds (SVOCs) by CLP SOW OLMO4.2
- Metals by ILMO4.0
- Organochlorine Pesticides and PCB's by CLP SOW OLMO4.2
- Explosives by SW846 method 8330
- Low Level Organics by OLCO2.1

Before the analytical results were released by the laboratory, both the sample and QC data were carefully reviewed to verify sample identity, instrument calibration, detection limits, dilution factors, numerical computations, accuracy of transcriptions, and chemical interpretations. Additionally, the QC data were reduced and the resulting data were reviewed to ascertain whether they were within the laboratory-defined limits for accuracy and precision. Any non-conforming data were discussed in the data package cover letter and case narrative.

The hardcopy data packages were reviewed by the project data validation subcontractor (Heartland Environmental Services, Inc) using the process outlined in the *EPA Region II's Functional Guidelines for Data Review* (Organic and Inorganic) SOPs. Data validation checklists used were those specified by EPA Region II. Areas of review included (when applicable to the SOW) holding time compliance, calibration verification, blank results, matrix spike precision and accuracy, method accuracy as demonstrated by LCSs, field duplicate results, surrogate recoveries, internal standard performance, and interference

checks. The Region II data review worksheet was completed for each of these data packages and any non-conformance documented. This data review and validation process is independent of the laboratory's checks and focuses on the usability of the data to support the project data interpretation and decision-making processes.

Data that were not within the acceptance limits were appended with a qualifying flag, which consists of a single or double-letter abbreviation that reflects a problem with the data. Although the qualifying flags originate during the database query process, they are included in the final data summary tables deliverable so that the data will not be used indiscriminately. The following flags were used in this text:

- **U -** Undetected. Analyte was analyzed for but not detected above the method detection limit.
- **UJ -** Detection limit estimated. Analyte was analyzed for, and qualified as not detected. The result is estimated.
- **J -** Estimated. The analyte was present, but the reported value may not be accurate or precise.
- **R -** Rejected. The data are unusable. (NOTE: Analyte/compound may or may not be present.)

Numerical sample results that are greater than the method detection limit or inorganic instrument detection limit (MDL or IDL) but less than the contract required reporting limit (CRDL) are qualified with a “J” for estimated as required by the EPA Functional Guidelines for Evaluating Data Quality.

The entire database was queried for frequency of detection in blanks and samples, detailed listing of blank detects, matrix spike/matrix spike duplicate (MS/MSD) results, field duplicate precision, surrogate recoveries, preparation and analysis dates pertaining to holding times. The queries were then manipulated to calculate necessary statistics for evaluation of the data.

Once the data review and validation process was completed, the entire data set were reviewed for chemical compound frequencies of detection, dilution factors that might affect data usability, and patterns of target compound distribution. The data set was also evaluated to identify potential data limitations, uncertainties, or both in the analytical results. Attachment A lists the changes in data qualifiers due to the validation processes. Attachment H presents all data which were rejected.

Holding Times

Table 3 reflects the data which were qualified as estimated (J or UJ) for being prepared outside of holding time criteria. None of the data were rejected for failure to meet holding times.

Calibration

Attachment A indicates that several organic compounds were qualified as estimated due to initial or continuing calibration deficiencies. Table 4 presents these data. Of the 1037 results qualified for calibration criteria outside control limits, 420 were rejected. The rejected data applied to acetone and 2-butanone only. These compounds are identified as poor performers in the CLP SOW. All other 617 qualifications were estimated (J or UJ).

Method Accuracy

The laboratory control sample (LCS) reflects method accuracy. The LCS consists of deionized water spiked with target compounds or elements and processed through the entire method of preparation and analysis. All LCS recoveries met control limit criteria for these data.

Potential Field Sampling and Laboratory Contamination

Four types of blank samples were used to monitor potential contamination introduced during field sampling, sample handling, shipping activities, as well as sample preparation and analysis in the laboratory.

- **Trip Blank (TB)**: A sample of ASTM Type II water that is prepared in the laboratory prior to the sampling event. The water is stored in VOC sample containers and is not opened in the field, and travels back to the laboratory with the other samples for VOC analysis. This blank is used to monitor the potential for sample contamination during the sample container trip. One trip blank should be included in each sample cooler that contained samples for VOC analysis. Twenty-three trip blanks were submitted to the laboratory with these samples.
- **Equipment Rinsate Blank (ERB)**: A sample of the target-free water used for the final rinse during the equipment decontamination process. This blank sample is collected by rinsing the sampling equipment after decontamination and is analyzed for the same analytical parameters as the corresponding samples. This blank is used to monitor potential contamination caused by incomplete equipment decontamination. One equipment rinsate blank should be collected per day of sampling, per type of sampling equipment. Depending on the method, up to twenty-six equipment rinsate blanks were submitted to the laboratory for this field effort.
- **Field Blank or Ambient Blank (FB or AB)**: The field blank is an aliquot of the source water used for equipment decontamination. This blank monitors contamination that may be introduced from the water used for decontamination. One field blank should be collected from each source of decontamination water and analyzed for the same parameters as the associated samples. Depending on the method, up to five field blanks were collected during this sampling event.
- **Laboratory Method Blank or Method Blank (MB)**: A laboratory method blank is ASTM Type II water that is treated as a sample in that it undergoes the same analytical process as the corresponding field samples. Method blanks are used to monitor laboratory

performance and contamination introduced during the analytical procedure. One method blank was prepared and analyzed for every twenty samples or per analytical batch, whichever was more frequent.

According to the EPA Functional Guidelines, concentrations of common organic contaminants detected in samples at less than ten times the concentration of the associated blanks can be attributed to field sampling and laboratory contamination rather than environmental contamination from site activities. Common organic contaminants include acetone, methylene chloride, 2-butanone, and the phthalates. For other inorganic and organic contaminants, five times the concentration detected in the associated blanks (rather than ten times) is used to qualify results as potential field and/or laboratory contamination rather than environmental contamination. The ten times rule was applied on an SDG by SDG basis and not globally. EPA Region II direction does not provide for the validation contractor to use any blank value determined below the CRDL. Additionally, use of field blank data is left to the validation contractors discretion and is generally not applied, as was the case with this data set.

Field blank or global blank application would account for anomalous data which should also be attributed to laboratory or field blank contamination and, or instrument noise for many organic compounds and metals.

Attachment A (Change in Qualifiers) lists all changes in qualifier due to data validation and blank contamination. A comprehensive list of all detects in each blank is provided in Attachment B. Table 2 compiles the blank detections into a “frequency of detection” by target parameter. Additionally, Attachment G compiles frequency of detection by target analyte for all field samples after validation.

Eleven volatile compounds were reported in laboratory and/or field blanks. Two common disinfection byproducts (DPBP) were detected in ambient and rinsate blanks. Chloroform, a trihalomethane (THM) was reported in all ambient and rinsate blanks. Bromodichloromethane, also a THM, was detected in ambient and rinsate blanks. Chloromethane was detected in a single ambient and rinsate blank. No field samples reported detections for these THM compounds. As Table 2 indicates, 1,1-dichloroethene, 1,2-dichloroethane, ethylbenzene, sum of m.p-xylene, o-xylene, styrene, toluene, and total xylenes were reported in a minimal number of blanks at concentration levels well below the reporting limit. No field samples were qualified by the subcontractor for these compounds.

Phthalates are used as plasticizers. The most common phthalates are bis(2-ethylhexyl) phthalate (BEHP), Di-n-butylphthalate, and Diethyl phthalate. Phthalates are often introduced into samples during handling. Gloves are often used when handling sampling equipment such as pumps, hoses, split spoons, dredges and bailers. Additionally, laboratory chemists use gloves when handling samples and extracts. Gloves are coated with plasticizers such as BEHP to facilitate release of the gloves from the skin. Table 2 indicates that BEHP was detected in ambient and rinsate blanks; Diethylphthalate in equipment and laboratory blanks, and Di-n-octylphthalate in a laboratory blank. Attachment A indicates that 10 and 31 samples were qualified as non-detect for BEHP and di-ethylphthalate, respectively. If global application of the flags were applied, the majority of all phthalate detections would be qualified as not detected due to contamination. Thus, caution should be utilized when making decisions based upon phthalate data.

Phenol, benzo(g,h,I)perylene, and indeno(1,2,3-c,d)pyrene were detected in a single rinsate blank at concentrations below the reporting limit. No field samples were flagged for these compounds due to blank contamination.

A single soil laboratory method blank and a single water laboratory method blank were reported to contain low levels of p,p'-DDT and PCB-1016, respectively. No field samples were qualified for blank contamination for these compounds.

As listed in Table2, several metals were reported in either the laboratory method, equipment rinsate, and/or ambient field blanks. However, no samples were qualified due to metallic blank contamination.

Matrix Effects

Surrogate Spike Recovery

Surrogate spike compounds were added to every sample analyzed for the organic parameters including field and laboratory blanks as well as field environmental samples. Surrogate spikes consist of organic compounds which are similar to the method targets in chemical composition and behavior in the analytical process, but which are not normally found in environmental samples.

Surrogate spike recoveries were used to monitor both laboratory performance and matrix interferences. Surrogate spike recoveries from field and laboratory blanks were used to evaluate laboratory performance because the blanks should represent an "ideal" sample matrix. Surrogate spike recoveries for field samples were used to evaluate the potential for matrix interferences. According to *Functional Guidelines*, data are not qualified with respect to surrogate recoveries unless one or more volatile surrogates are out of specifications. Semivolatiles are not qualified unless two or more surrogates, within the same fraction (base/neutral or acid fraction), are out of specification.

All reported surrogate spike recoveries for field and QC samples are presented by each analytical fraction in Attachment C.

As Attachment C indicates, the majority of surrogate recoveries were well within method acceptance ranges. A single sample (NDA104FD1) was rejected for the 12 method 8330 compounds due to poor surrogate recovery. All other samples affected by surrogates outside control limits were estimated. The recoveries indicate that the matrix did not significantly influence the analytical method or the final analytical result.

Matrix Spike/Matrix Spike Duplicate Precision and Accuracy

A matrix spike is an aliquot of sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. The matrix spike duplicate is an intralaboratory-split sample spiked with identical concentrations of target analyte(s) as the MS. This spiking also occurs prior to sample preparation and analysis. They (the MS/MSD pair) are used to document the accuracy and precision of a method as influenced by a given sample matrix. For the MS/MSD measurement, three aliquots of a single sample are analyzed; one native sample and two spiked with target analytes or compounds. Matrix accuracy is evaluated from the spike recoveries, while precision is

evaluated from comparison of the percent recoveries of the MS and MSD. All MS/MSD precision and accuracy results are listed in Attachment D. Another measurement of precision is the native duplicate. This is an intralaboratory-split sample which is not spiked, but reflects the actual concentrations in the sample and its duplicate. The results are compared and precision calculated. Results which are non-detect or near the reporting limit cannot be calculated for the precision statistic. Attachment E presents laboratory native duplicate precision statistics.

Organic results are not qualified upon the results of MS/MSD results alone. Evaluation is in conjunction with surrogate and internal standard (if applicable) results. Additionally, many MS/MSD samples require dilution and thus the spike compounds added are diluted out and unable to be evaluated. The majority of the accuracy and precision results were well within established criteria, indicating that the specific sample matrix did not influence the overall analytical process or the final numerical sample result. No organic methods required qualification due to the MS/MSD precision and accuracy measurements indicating that the matrix did not influence the method or the final analytical result.

Inorganic results may be qualified solely upon the results of the matrix spike/matrix spike duplicate precision and accuracy. Instances where the native sample concentration for a given element exceeds the spike added concentration by a factor of four or more are disregarded as the spike added would be masked by the native concentration. According to *Functional Guidelines*, metals results obtained through analysis by traditional methods with recoveries of greater than 30% and outside the 75-125% recovery control limits are required to be flagged as estimated. Precision requirements for soils and waters are at 35 and 20 relative percent difference (RPD), respectively.

As Attachments D and E indicate, the majority of the accuracy and precision results were well within established criteria. Only 10 barium, 9 manganese, 5 dissolved iron, and 5 mercury results were rejected due matrix spike recoveries. These data indicate that the specific sample matrix did not greatly influence the overall analytical process or the final numerical sample result.

Field Duplicate Sample Results

Field duplicate analyses measure both field and laboratory precision and can also be affected by the homogeneity of the samples. Therefore the results may have more variability than lab duplicates, which measure only lab performance. According to the EPA *Functional Guidelines*, there are no qualification criteria for field duplicate precision.

Dependent upon the method, there were up to ten sets of field duplicates collected during this field effort. Both the native and duplicate samples were analyzed for the same parameters.

An aqueous control limit of ± 20% for the RPD was used for original and duplicate sample values greater than or equal to five times the RL. Solid samples utilized a control limit of 35 RPD. A control limit of ± the RL was used if either the sample for the duplicate value was less than five times the RL for waters and 2 times the RL for soils. In the cases where only one result is above the five times the RL level and the other is below, the ± RL criteria were applied. Attachment F includes a summary of the field duplicate measurements and their associated precision statistic.

As the attachment reflects, the vast majority of the calculated precision data were within the defined control limits. Thus, the precision data indicate that matrix heterogeneity and sampling technique did not greatly influence the final numerical result.

Sample Results for Metals Near the Method Detection Limit (MDL)

The MDL is defined as the minimum concentration of an analyte that can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero. Sample results at, or near the MDL may be false positives caused by instrument noise or low-level background shifts enhanced by a matrix, rather than a true analyte signal. Additionally, concentrations reported at up to 5 times the MDL should be recognized as lacking accuracy or precision.

PARCCs

Precision—is defined as the agreement between duplicate results, and was estimated by comparing duplicate matrix spike recoveries, native laboratory duplicates, and field duplicate sample results. MS/MSD and laboratory duplicate precision was documented as well within control limit criteria for most samples and targets. Other than the documented exceptions, the precision between native and field duplicate sample results were within acceptable criteria for the majority of the measurements indicating that sample matrix did not significantly interfere with the overall analytical process.

Accuracy—is a measure of the agreement between an experimental determination and the true value of the parameter being measured. For the organic analyses, each of the samples was spiked with a surrogate compound; and for organic and inorganic analyses a MS/MSD, and LCS were spiked with a known reference material before preparation. Each of these approaches provides a measure of the matrix effects on the analytical accuracy. The LCS results demonstrate accuracy of the method. MS/MSD results establish precision and accuracy of the matrix. Spike recoveries were within the method acceptance limits for the majority of the measurements; therefore, other than the documented exceptions, there was no evidence of significant matrix interferences that would affect the usability of the data.

Representativeness—this criteria is a qualitative measure of the degree to which sample data accurately and precisely represent a characteristic environmental condition. Representativeness is a subjective parameter and is used to evaluate the efficacy of the sampling plan design. Representativeness was demonstrated by providing full descriptions in the project scoping documents of the sampling techniques and the rationale used for selecting sampling locations.

Completeness—is defined as the percentage of measurements that are judged to be valid compared to the to total number of measurements made. Other than the 34 non-detected acrolein results rejected for poor continuing calibration statistics as previously mentioned, no other data were rejected. A goal of 90 percent usable data was established in the project scoping document and 98 percent (60437/61685) of the data was determined to be valid.

Comparability—is another qualitative measure designed to express the confidence with which one data set may be compared to another. Factors that affect comparability are sample collection and handling techniques, sample matrix type, and analytical method.

Comparability is limited by the other PARCC parameters because data sets can be compared with confidence only when precision and accuracy are known. Data from this investigation are comparable with other data collected at the site because only EPA methods were used to analyze the sample and EPA Level III QC data are available to support the quality of the data.

Summary and Conclusions

Conclusions of the data quality evaluation process include:

- The laboratory analyzed the samples according to the EPA methods stated in the work plan as demonstrated by the deliverable summaries and analytical run sequences
- Sample results for metals above the IDL but less than the CRDL may be attributed to instrument noise and/or low level contamination and not site-related activities and as such may be false positives.
- Sample results for target organic compounds above the MDL but less than the RL should be considered as uncertain but indicative of the presence of that compound at an estimated concentration
- Spike recoveries, surrogates, and duplicate sample results (other than the exceptions documented in the text and attachments) indicate that the specific sample matrix did not significantly interfere with the analytical process or the final numerical result.

The project objectives or PARCCs were met, and the data can be used in the project decision-making process as qualified by the data quality evaluation process.

Master Data Management Plan

FINAL

Data Management Plan for RCRA Facility Investigation

Atlantic Fleet Weapons Training Facility
Vieques Island, Puerto Rico

Contract Task Order 031

Prepared for

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List of Acronyms

A/E	Architect/Engineer
AFWTF	Atlantic Fleet Weapons Training Facility
CADD	Computer-Aided Drafting and Design
DCQAP	Data Collection Quality Assurance Plan
DMP	Data Management Plan
EDMS	Electronic Data Management System
EPA	U.S. Environmental Protection Agency
ERMA	Environmental Resource Management Application
FTP	File Transfer Protocol
GIS	Geographic Information System
IDW	Investigation-Derived Waste
IIS	Internet Information Server
Kbps	Kilobytes
LANTDIV	Atlantic Division
MB	Megabyte
MCL	Maximum Contaminant Level
MGE	Modular GIS Environment
MHz	Megahertz
NAVFACENGCOM	Naval Facilities Engineering Command
NFEC	Naval Facilities Engineering Command
NTR	Naval Technical Representative
PWC	Navy Public Works Center
QA/QC	Quality Assurance/Quality Control
RBC	Risk Based Criteria
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
WEDMS	WEB Environmental Data Management System
WWW	World Wide Web
X-Ref	External Reference File

SECTION 1

Introduction

This data management plan (DMP) has been developed for the field investigation activities at the Atlantic Fleet Weapons Training Facility (AFWTF) on Vieques Island, Puerto Rico.

The DMP is broadly applicable to the management of data generated during environmental investigations. The DMP is intended to be a living document and will be amended or revised to accommodate changes in the scope of environmental investigation or data management requirements.

During the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI), CH2M HILL will collect a variety of environmental information that will support data analysis, reporting, and presentation activities. These activities will ultimately support a determination of risk to human health and the environment posed from releases at the RCRA facility. Environmental analytical samples and various types of field data will be collected during the investigation. These data must support subsequent data analysis for site characterization and reporting. The data also must support any subsequent decisions for remedial action and the presentation of investigation results to the Navy, regulatory agencies, and the public. To meet quality assurance (QA) provisions of current regulatory requirements, a complete audit trail of the information flow must be established. Each step in the data management process (data collection, handling, control, storage, access, and analysis) must be adequately planned, executed, and documented. To meet this requirement, CH2M HILL will employ an environmental data management system (EDMS) that manages mission-critical information throughout the RFI process.

The EDMS will broadly support the collection and storage of analytical and field environmental data and project documentation in electronic format; the analysis of data and the presentation of investigation findings using geographic information system (GIS) technology; and the access to environmental data and mapping through interactive viewer tools that facilitate management review and decision-making processes. This program is not proprietary and is available for use on Navy projects. It should not be distributed outside of the Navy for use on non-Navy projects.

The EDMS will be a networked information 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 RFI.

This DMP addresses data management practices for the following types of RFI data:

- Organic and inorganic analytical results from fixed-based laboratories for:
  - Groundwater
  - Surface soil
  - Surface water
  - Subsurface soil

  - Sediment
  - Investigative-derived waste (IDW)

- Field Characterization Data:
  - Geologic logs and subsurface stratigraphy / hydrography
  - Well construction information
  - Potentiometric measurements
  - Field geochemical parameters

- Spatial Data:
  - Sample station locations (surface and subsurface soil, sediment, and groundwater)
  - Well casing and ground survey elevations
  - Latitude / longitude coordinates
  - Buildings, roads, site features, and utilities

This DMP is composed of seven sections. Section 1 of this document introduces the DMP and documents the RFI data management scope and objectives. Section 2 contains the organization of the CH2M HILL data management team. Section 3 contains data format and organization specifications for various types of data and maps. Section 4 outlines the structure of the EDMS database. Section 5 documents data management deliverables. Section 6 summarizes the formats of data management deliverables; and Section 7 contains the proposed data sharing and information management strategy.

1.1 RFI Data Management Scope and Objectives

The objectives of RFI data management are as follows:

- Standardize and facilitate the collection, formatting, and transfer of field generated data to the EDMS.
- Provide an accurate, structured data set that will support environmental investigation planning and decision-making.
- Minimize the uncertainties associated with the data, data-derived products, and interpretation of results through quality assurance and quality control (QA / QC) defined measures and practices.
- Ensure the accessibility of environmental data for environmental characterization, report generation, risk assessments, and other environmental needs.
- Ensure that data are adequately documented with descriptive information to ensure the technical defensibility and legal admissibility of the data.

The scope of the RFI data management activities addressed by this plan includes, but is not limited to:

- Modification, operation, and maintenance of the EDMS database to organize and store current environmental information generated by this RFI and historical information (28 wells previously installed at AFWTF)

- Conversion of geologic and geographic information into a GIS format for use in hydrogeologic data analysis, report preparation, and graphical presentation of environmental data
- Three-dimensional data analysis and visualization
- Implementation of a World Wide Web (WWW)-viewer program to facilitate remote access of the project data and graphics
- Implementation and modification of a field data entry system for transferring of field data into the EDMS database
- Incorporation of existing data into the EDMS
- Management of project documentation, hard copy, or electronic copy in document libraries
- Standardized electronic data deliverables, as agreed to by LANTDIV
- Protection of data through read-only mechanisms, backup procedures, and selective access
- Periodic provision of a copy of the GIS database to LANTDIV for their use

SECTION 2

Data Management Team Organization

The CH2M HILL data management team will work together to properly execute the DMP and ensure that the project objectives and scope are realized. The team is composed of qualified specialists and managers. The functional responsibilities of the data management team are described below; the responsibilities are identified by titles but are not necessarily individual staff positions.

Data management specialists have broadly defined multidisciplinary responsibilities. Their tasks include the following:

- Responsible for the proper execution of the DMP and interface with the team to identify all relevant data, ensure that data are complete and consistent, and resolve problems associated with data
- Oversee contracted analytical and data validation services, which may include pre-award auditing and review, coordination of the project / laboratory / data validation interfaces, and continuing performance review of the laboratory and data validator
- Participate in QA / QC activities including nonconformance investigations and reports and QA reviews; when coordinating data support for the multidisciplinary technical team, prepare work agreements as necessary, review sample receipt acknowledgments, and receive laboratory and data validator data packages
- Conduct verification activities following receipt of electronic data and participate in QA / QC activities to resolve nonconformances as necessary
- Evaluate the effectiveness of QA activities through scheduled audits and surveillance, and help resolve quality problems and ensure that corrective actions are taken and appropriately documented
- Manage the recorded information about project activities that is keyed input into the data management system

Database administrators have overall responsibility for the design, operation, and maintenance of the databases. They also control the interface between data entry programs and databases. Some database administrators also will serve as programmers responsible for designing, developing, and implementing databases and data entry tools.

Data entry clerks have responsibility for the entry of new or existing data generated by field activities or as a result of laboratory analyses, and for verifying data that has been entered.

Field team leaders help prepare the work plan and implement it in the field; 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 the chain-of-custody (COC) form is completed correctly. The field team leaders also compile and perform QC checks on field data.

Project scientists perform statistical summaries of physical and chemical data by medium, location, and sampling event, and present these summaries in tables, charts, graphs, and maps. The data are examined for consistency with the data collection quality assurance plan (DCQAP). The analysts identify anomalies in the data and determine whether corrections or qualifiers are required, performing statistical analyses as needed, and prepare data for input to numerical models.

GIS applications specialists prepare maps that illustrate geographical features and area characteristics, such as topology, land use, ground cover, roads, buildings, and hydrography; digitize existing maps; edit and format spatial data, combine them with attribute data from the project database, and prepare topological overlays; and display results through graphic outputs that include maps, color displays, and tabular information. Some of our GIS specialists also are hydrogeologists who prepare geologic cross sections, fence diagrams, chemical isoconcentration maps, water table maps, three-dimensional block diagrams, and well construction diagrams as part of hydrogeologic analyses and reporting and presentation.

SECTION 3

Data Specifications

This section documents the specifications for types of data that will be managed in the RFI. The types of data include field station data, analytical data, geographic data, geological data, and project documentation. The section also specifies the electronic data deliverable formats for analytical laboratories, data validators, and surveyors.

3.1 Specifications for Field Location Data

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 for a key in a database to which any samples collected from that location can be linked in order to form a relational database structure.

The field team leader will maintain a list of the location identification numbers, and is responsible for enforcing the use of the standardized numbering system during all field activities. Each station will be designated by an alphanumeric code that will identify the stations location by facility, site type, site number, station type, and sequential station number. Table 3-1 documents the scheme that will be used to identify field station data.

For example, a monitoring well located near Building 33 (Site 2) at the AFWTF would be called WS02-MW02. Similarly, the deep well of a paired set of wells (both shallow and deep) at the same location would be called WS02-MW02D.

3.2 Specifications for Analytical Data

Analytical data will be generated through sampling of various media at the AFWTF. Each analytical sample collected in the field will be assigned a unique sample identifier. The scheme used as a guide for labeling analytical samples in the field is documented below.

The format that will be used for electronic deliverables from the analytical laboratory and the data validator also is documented below.

3.2.1 Sample Identification Scheme

A standardized numbering system will be used to identify all samples collected during the sampling activities. The numbering system will provide a tracking procedure to ensure accurate data retrieval of all samples taken. A list of the sample identification numbers will be maintained by the field team leader, 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 following format.

TABLE 3-1
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: CG = Camp Garcia Station Type: S = Site W = SWMU O = Operable Unit U = UST A = AOC 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	Station Type: DW = Direct Push - Soil DW = Direct Push - Water DG = Direct Push – Soil Gas GB = Geotechnical Boring GG = Geophysical Grid Node MW = Monitoring Well PW = Purge Well PZ = Piezometer RW = Residential Well SB = Soil Boring SD = Sediment Sample Location SS = Surface soil Sample Location SW = Surface Water Sample Location TS = Tissue Sample Station Number: Sequential Station Number Qualifier: S = Shallow D = Deep K = Background	

Note: Read subsection 3.1 of the text.

Each sample will be designated by an alphanumeric code that will identify the facility, site, and matrix sampled and contain a sequential sample number. QA/QC samples will have a unique sample designation. The general guide for sample identification is documented in Table 3-2. If one qualifier is pertinent to the sample ID but another is not, use only the applicable qualifiers. A character space does not have to be maintained.

3.2.2 Electronic Deliverable File Format

An offsite analytical laboratory will analyze the RFI samples and tabulate results in an electronic format specified by CH2M HILL. The data validator will add data validation qualifiers to the table of analytical results. In addition to a hard copy data package deliverable, CH2M HILL will receive an electronic file from the data validator in a table format that will facilitate downloading into the EDMS. The EDMS then will assign a sequential sample ID to each sample to assure uniqueness within the database. Table 3-3 documents the format to be used for electronic deliverables from the analytical laboratory and the data validator.

3.3 Specifications for Geographic Data

Specifications for geographic data pertain primarily to graphical standards for mapping. Mapping specifications and base map standards are documented below.

3.3.1 Mapping Specifications

Geographic data contained in the EDMS will conform as applicable to the Computer-Aided Drafting and Design (CADD) and GIS spatial data standards being developed by the Tri-Service CADD/GIS Technology Center. The Tri-Service Spatial Data Standards were developed as a single comprehensive master and environmental planning data model for the U.S. Air Force, Army, and Navy installations, as well as U.S. Army Corps of Engineers civil works projects. The Spatial Data Standards were 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]).

3.3.2 Installation Base Maps

All mapping activities performed on the RFI will utilize base map files of the installation provided by the Navy Public Works Center (PWC). The PWC maps will include a set of electronic images (raster data) and a set of CADD files (vector data) that were derived from aerial photography taken in 1995 by Photo Science, Inc.

3.3.2.1 Coordinate System

All mapping and surveying performed during the RFI will conform to the following:

Coordinate System	=	Maryland State Plane
U.S. Geological Survey Zone Code	=	4126
Horizontal Datum	=	North American Geodetic Datum 1983
Vertical Datum	=	North American Vertical Datum 1988

TABLE 3-2
Sample Designation Scheme

First Segment	Second Segment		Third Segment
Facility, Station Type, Site Number	**Sample Type**	**Sample Location + Sample Qualifier**	**Additional Qualifiers (sample depth, sampling round, etc.)**
AANN	**AA**	**NNNA or NNAA**	**ANN or NNNN**
Notes: "A"= alphabetic "N"= numeric			
Facility: CG = Camp Garcia Station Type: S = Site W = SWMU O = Operable Unit U = UST 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	Sample Type: DS = Direct Push – Soil Sample DW = Direct Push – Water Sample DG = Direct Push – Soil Gas Sample GB = Geotechnical Boring Sample MW = Monitoring Well Sample PW = Purge Well PZ = Piezometer Sample RW = Residential Well Sample SB = Soil Boring Sample SD = Sediment Sample SS = Surface Soil Sample SW = Surface Water Sample TB = Trip Blank EB = Equipment Blank FB = Field Blank Sample Location: 1. Station Samples (NNA) NNA – refers to sequential station number NNA – letter qualifier for deep or shallow sample (if applicable) 2. QC Samples (NNN) NNN- numbered sequentially for each type of blank (i.e., 1,2,etc.) collected for that day's sampling. NNN – refers to month of sampling event Sample Qualifiers: F = filtered sample P = duplicate sample K = Background sample		Additional Qualifiers: 1. Monitoring Well Groundwater Sample (refers to sampling round for that well): R01 – Round 1 R02 – Round 2 R03 – Round 3 2. Direct Push Subsurface Sample (refers to depth of sample): Enter depth of top of sample interval 3. QC Samples NNNN – refers to day and year of sampling event

Note: Read subsection 3.2.1 of the text.

TABLE 3-3
Analytical Data Electronic Deliverable Format

Field Name	Field Type	Description
Sample_ID	A	The CH2M HILL sample ID (taken from the Chain-of-Custody)
Sample-Analysis	A	The method code
Date_Analyzed	D	The date the sample was analyzed.
Date-Received	D	The date the sample was received in the lab.
Lab_Sample ID	A	The lab sample ID.
Dilution Factor	N	The dilution factor used, if applicable.
SDG Number	A	The Sample Delivery Group number
CAS Number	A6-A2-A1	CAS Number (Note dashes)
Chem_Name	A	The compound being analyzed
Ana-Value	N	The analytical result
Std_Qual	A	The lab qualifiers, if any (e.g., U, UJ, B)
DV_Qual	A	Leave blank; used for data validation
Units	A	The unit of the result (e.g., mg/L)
Detect Limit	N	The detection limit for the compound
Method	A	Analytical method used to analyze the sample fraction

Note:
CAS = chemical abstract service
SDG = sample delivery group

Survey data will be collected in an electronic format either from a global positioning survey conducted by CH2M HILL personnel, or by floppy disk transfer from a licensed surveyor. The file format for survey information will be provided to the surveyor in advance of the survey.

3.3.2.2 Vector Data

The vector data files are in MicroStation CADD format and include levels for buildings, roads, parking lots, piers, transportation, and vegetation. The MicroStation files will be utilized by the Intergraph GIS which uses MicroStation as its graphical engine. Vector data will be stored in the GIS database.

3.3.2.3 Raster Data

The raster data will be in 24-bit color tagged information file format and consist of aerial photography. Because of the size of the image, the facility has been divided into a number of files that may be composited to create a complete facility-wide image.

3.4 Geological Data

Geological data that will be collected in the field during the RFI include direct-push log data, monitoring well construction data, soil boring log data, field parameters for well development and water sampling, and depth-to-groundwater data. Where possible, these data will be entered into a remote database application that will reside on a laptop computer in the field. CH2M HILL will modify the database to facilitate the entry of field data in a logical format that follows the method and order of data collection. Input screens will be developed for each of the field forms. Field data will be input at the end of each day and provided to the data management specialist for inclusion into the EDMS. The field team leader will be responsible for the process of inputting the field data and ensuring that the data are complete before they are transferred to the data management specialist. Where a paper copy of the data is required, the program will print the data in the required format. The site data entry program will interface with Oracle database to facilitate automated transfer of field data into the Oracle database.

Historical environmental data that will be entered into the EDMS database will be entered using a double-key entry process. Upon completion of doubly-key entry, the data sets will be compared electronically. Errors will be reported and rectified so that both data sets match. Then, one data set will be assigned to populate the EDMS database. This quality control procedure will ensure that the data are complete and correct. Data completeness and correctness are of paramount importance when such a large investment is made in creating a geographic database.

3.5 Project Documentation

A large variety of technical data will be generated during the course of the RFI. 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 RFI.

3.5.1 General Data Records and Logs

Selected data from past investigations and from the RFI will be compiled and summarized in tables that will comprise reports. Types of data that will be tabulated include:

- Analytical data laboratory summaries
- Data validation summaries
- Well construction information
- Well development information
- Chain-of-custody records
- Field logbooks
- Location sketches
- Photographs (if necessary)
- Telephone conversation logs

3.5.2 Document Tracking

A document tracking system that uses a spreadsheet will identify the titles, authors, contents, and locations of non-electronic reports and files. All incoming data and reports will be logged and dated, and given a location designation. Reports may be checked out by leaving a signed and dated card in place of the document.

Electronic files will be housed on the CH2M HILL intranet using the Saros Document Manager system through the Mezzanine® library. AFWTF will have its own “smart folder” for project documents. The system will provide accessibility, security, version control, and document integrity. Public documents can be viewed or printed, but only designated personnel will be able to revise the documents. Confidential documents will be secured from public access. Incremental backup of the electronic files will occur daily, and there will be a full backup every Friday. CH2M HILL documents will generally exist in a Microsoft file format.

SECTION 4

Database Structure

This section documents the structure of the EDMS/GIS database, the relationships between the various data tables, and the valid entries for each field.

4.1 Data Table Relationship Diagram

The EDMS relies on multiple relational database tables designed to facilitate the efficient storage and retrieval of project data. This database serves the EDMS and the Intergraph GIS. Figure 4-1 diagrams the primary data tables and how they are related to one another.

4.2 Relational Database

A relational database is at the heart of the EDMS. The core database resides in Oracle. The Intergraph GIS uses this database. A front-end database resides in MS Access. The front-end database is used for electronic analytical data entry, database statistics, entry of field data that cannot be entered electronically, and entry of historical data for which no electronic information exists. The front-end database periodically updates the Oracle database.

Table 4-1 documents the EDMS database structure. The primary or parent database table is the site table. The database fields have relationships. For example, one site can have many stations, one station can have many wells, and one well can have many casings. This type of design maximizes the efficiency of the database for storage space and data access and maintenance.

4.3 GIS Functionality

The GIS software implemented for CH2M HILL's EDMS is Intergraph's modular GIS environment (MGE) and Environmental Resource Management Applications (ERMA). This GIS software runs on a PC under the Windows NT environment. MGE provides full GIS mapping and spatial data analysis, and is similar to ARC/INFO in functionality. The graphics engine for MGE is Intergraph/Bentley MicroStation. MGE can import a wide variety of spatial data and similarly can export a range of formats (e.g., ARC/INFO). ERMA provides a range of analysis and visualization tools that can help interpret the resulting project data.

TABLE 4-1
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 an (e.g., U, UJ, B).
DV_Qual	A5		Left blank for data validation qualifiers.
Units	A15	R	The unit of the result (e.g., m /L).
Detect_Limit	N11	R	The minimum available sample-specific detection limit for the compound.
MDL	N1	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	The matrix of the sample.
Result_Type	A15	R	The laboratory QC type (e.g., SURR, MS, MSD, LCS).
Analysis_Anomaly	A15	R	To note more than one analysis of a sample.
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	A30	NR	For laboratory to note exceptions.

Notes:
R - required field
NR - not required
RA - Required as appropriate

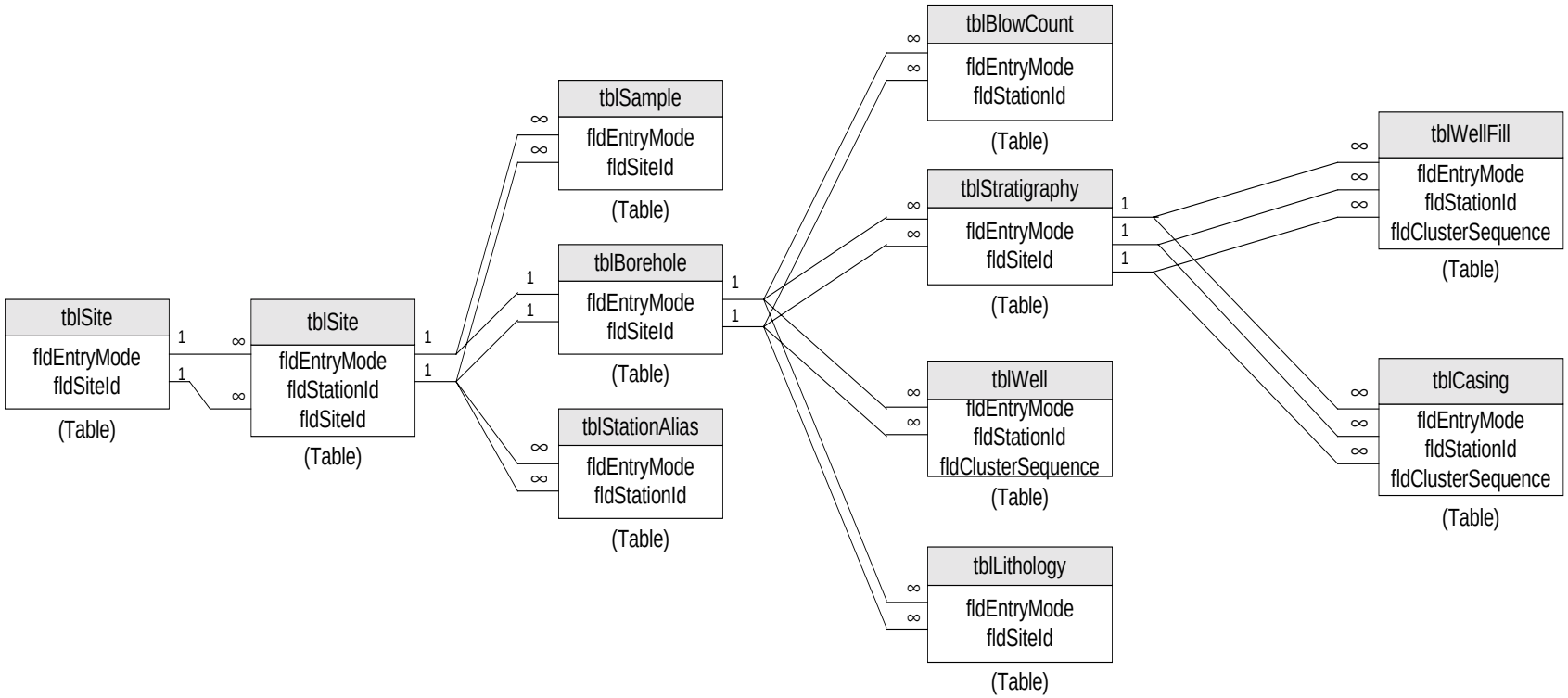

FIGURE 4-1
Relationships Diagram

SECTION 5

Data Management Deliverables

Several maps to support the RFI are proposed for development using the EDMS and GIS workstation. The format and content of these maps could vary depending on the ability to perform areal statistics for contouring, the density of the data, or the effective three-dimensional depiction capability of a data set as a whole. Some of the maps will use a photographic layer. The maps will be available for viewing and queries over the internet connection with the GIS database. Proposed RFI map deliverables for the sites at AFWTF include:

- Map that illustrates the location of the facility within the geographic area
- Maps that illustrate the site locations within the facility
- Maps that illustrate the sample locations within the sites
- Map that illustrates what types of sampling activities have occurred at each station location
- Maps that illustrate the sampling results, posting exceedances of regulatory standards for various media
- Maps that contain contours or other scalers of contaminant concentrations with respect to an aerial distribution for various media
- Geologic cross sections
- Approximately 14 water table elevation maps
- Block diagrams that illustrate the locations of contaminant plumes and their subsurface distribution

Other data management deliverables that will be part of the RFI are:

- A data catalog of all analytical samples and pertinent information related to them
- A library catalog of electronic documentation that is a part of the RFI
- A spreadsheet tabulation of nonelectronic RFI documentation

SECTION 6

Electronic Deliverables Format

LANTDIV has issued standards for electronic deliverables. These standards will be observed for all RFI electronic submittals of documents or maps.

6.1 Policy for 3.5-inch (1.44 Megabyte [MB]) Floppy Disk Submittals

The following system will be used in the preparation process when making final submittals on floppy disks:

- Do not arbitrarily compress multiple files for efficiency of storage. If compression is required, follow the prioritized methodology stipulated below using the PKZIP compression software. File names should be ISO 9660 compliant using permissible characters. A DOS text file shall be included in all floppy disk submittal packages.
- Use native file formats where possible. In general, files shall remain in their native uncompressed format—be it AutoCAD drawing, word processing, cost estimating, or SPECINTACT format. Place as many uncompressed files as possible on a single MS DOS-formatted 1.44 MB floppy disk.
- Compress files in self extracting (.exe) formats. Avoid compression of multiple files during a single session if the final resulting compressed file is larger than 1.44 MB. Do not use multiple floppy disks to produce a single compression file.
- If the compressed version of a single file exceeds 1.44 MB, use the “span” option of the compression software to provide file linking across multiple diskettes. The compression technique for “spanned” files will be the (.zip) zipped format. Do not use self-extracting (.exe) compression formats for single files spanning multiple floppy disks.

6.2 Policy for Recordable Compact Disks (CD-R)

The following system will be used in the preparation process when making final submittals on floppy disks:

- Media that will be used will be 75-year or longer shelf life recordable CDs. All CD media should be manufactured with a protective coating on the label side surface. Most name brand disks have the coating but check the supplier to be sure.
- CDs will be recorded in ISO 9660 format.
- All filenames will be ISO 9660 compliant. Do not use characters that do not comply with ISO 9660 in any filename or AutoCAD X-ref because they will be rewritten when the CD is recorded. ISO 9660 Level 1 filenames allow capital A to Z, 0 to 9, and the underscore (_) character.

- Record all files in one recording session. Multi-session CDs are not acceptable at this time because they are not readable by all CD-ROMs.
- Files on CDs will be in uncompressed, native format, and devoted to a single project.
- A DOS text file named PROJxxxx.TXT, where "xxxx" is the last four digits of the construction contract number, will be included in the root directory of the CD. This file will contain pertinent project information such as the project title, location, specification number, construction contract number, Architect/Engineer (A/E) firm names (both prime and sub) with applicable addresses and phone numbers, listings of the project design team members, and a listing or table cross-indexing file names to their corresponding directory path, sheet titles, sheet numbers, and Naval Facilities Engineering Command (NAVFACENGCOM) and EFD drawing numbers.
- All external reference files (X-REFs) will be included in the CD-ROM. Do not "bind" XREFs to the drawing files.
- The exact content, quantity, submittal dates, and milestones for digital submittals are addressed separately in the *Guide for Architect Engineer Firms Performing Services for the Atlantic Division* (the A&E Guide) and specified in the *Appendix A* project scopes. Although not all directories and associated data are to be included with every submittal, a standard directory structure will be as follows:

/DWD	=	for all drawings
/XREF	=	for all external reference files
/SPECS	=	for all specifications
/PHOTOS	=	for all digital photos
/OTHER	=	for any other pertinent project files

SECTION 7

Data Sharing and Information Management

The WWW provides superb tools for sharing and disseminating data not only to project team members, but also on a controlled basis to the general public. This section documents the proposed methods for GIS data sharing between the Navy, the contractor, regulators, and other authorized personnel. Both WWW-based data sharing and desktop-applications data sharing are discussed. At this time, however, only WWW-based data sharing is proposed. Document sharing, data sharing system requirements, and data security also are discussed.

7.1 Web-Based GIS Data Sharing

CH2M HILL proposes to use the WWW to provide ready access by project team members to up-to-date data at AFWTF. Because of the high visibility of activities at AFWTF, and the number of parties that might need to provide collaborative evaluation of the data, data sharing to authorized users via the WWW will provide the most efficient and cost-effective method of information management and distribution.

The site will contain access to a Web Environmental Data Management System (WEDMS) that handles the web-based GIS data sharing functions. The site will provide team members with current lab results, queries for selected information, and online GIS map viewing and querying capability. The WEDMS will provide access to information through a direct link to the EDMS database. (Depending on the size of the database and site maps, along with network traffic volume, response time could be unacceptably slow. In that case, a replicated database and maps that are updated frequently can be placed on the Web Server to increase speed.)

We will include a Project Management section for the AFWTF site where documents can be stored and downloaded. A common project calendar will be maintained for the project. Furthermore, a section of the AFWTF site can be created for public access. Selected data and materials and links to other sites could be placed in this part of the AFWTF site, if the Navy chooses to do so. This feature could be a particularly powerful public information tool. The other parts of the site would remain secure, requiring a login and a password for access. Security is discussed later in this section.

We plan to work with the Navy in designing this site, and have factored in costs for time to review and revise the design of the site. The design will be particularly important if the Navy decides to provide public access to the site.

7.1.1 Web-Based GIS Data Sharing

Web-based GIS data sharing is centered around GIS data viewing capability over the WWW. WWW-based GIS data sharing allows a viewer to query and view data but not to make changes to the data or maps. Using WWW-based GIS data sharing for viewing data provides several advantages over standard publication and distribution methods:

- Web-based access to GIS data provides a powerful way to publish data for sharing to a targeted audience with minimal expense. Access to the varying levels of information data can be controlled through password access privileges. This provides significant savings over the usual approach of loading data into a desktop PC data management system and periodically producing paper reports with varying content, for distribution to various readers. Users will have the increased power and flexibility of being able to use the GIS to query the data, as well as obtaining database reports.
- The viewer needs no specialized GIS software. The only necessary component that potentially has a cost is the link to the Internet, and possibly a modem. Anyone designated by the Navy can access the site and the data at no additional cost or effort. Each viewer will be provided with a login name and a password.
- The WWW GIS will have the most current data available because the Web GIS server can easily link to the database that contains the analytical data. Therefore, data currency issues are greatly minimized and all viewers will be accessing the same set of data on the WWW GIS server.
- The interface is familiar to anyone who uses a WWW browser.
- The WWW site can easily integrate other functionality such as a document library, project calendar, or information sharing.

One limitation to WWW-based GIS data sharing as compared to desktop applications data sharing is that the functionality is more limited than having a full desktop GIS, and its functionality must be programmed. This does not have to be a limitation because few of the features in a desktop application are used on a regular basis. The WWW site will contain the key functionality. Also, the GIS WWW software, which resides on the server and translates map (vector) data across the WWW, is more costly than a desktop GIS viewer. Because the Web-based GIS software can serve an unlimited number of users, however, the software and its programming can quickly become much less expensive than the cost of multiple desktop GIS software packages.

Several software packages will translate GIS map data over the WWW. Each has its own advantages. CH2M HILL will be able to support and implement whichever system best meets the needs of the AFWTF. Depending upon the tool selected, and where the site is hosted, CH2M HILL may be able to link the WWW site directly to a current copy of the EDMS database that contains the ERMA-generated site maps so that the maps and other environmental data will not require replication to a separate server. This will ensure that the maps and site data are always current. Other data, such as historical building information, can also be imported to the Web GIS for viewing along with mapping and analytical data.

7.1.2 Web-Based GIS Data Sharing Features

The AFWTF WWW Site will contain access to the WEDMS as well as to other features and information such as a project calendar, discussion group feature, and links to other WWW sites. The site will provide up-to-date analytical data directly to users because they will be able to query the database directly. The data can be downloaded to the user's computer for further analyses and reporting. The functions of the WEDMS and the additional WWW site features are discussed below.

7.1.2.1 WEDMS Analytical Reporting

Analytical results from the AFWTF RFI will be available on a site-by-site basis. Users will be able to browse the analytical results and compare them to the limits defined for this project (Environmental Protection Agency [EPA] Region III Risk Based Criteria [RBC] for soil and a combination of EPA Drinking Water maximum contaminant levels [MCLs], EPA Region III RBCs, and Washington, D.C., Water Quality Standards, for ground water).

7.1.2.2 Query Selection and Data Downloading

Users will be able to point-and-click to select from a set of pre-designed, pre-built queries. The results of the query will display within the user's browser. Users will have the choice of viewing the results in a table format or packaged to be downloaded to their PCs. Downloading of data can be accomplished using two different methods. For convenience, the data can be mailed to the user electronically, or it can be displayed on their screen so that it can be saved as ASCII text. ASCII text can be loaded directly into spreadsheets or desktop databases.

7.1.2.3 WEDMS Two-Dimensional Mapping

The WEDMS will serve several interactive mapping applications that will enable users to view and query several types of information from facility and site maps, including site locations, sample locations, analytical results, water table elevations, and locations where regulatory limits are exceeded for various sampled media. The interactive mapping applications will utilize installation base maps derived from 1995 aerial photography.

Historical drawings and documentation from the AFWTF administrative record also could be added to the inventory of viewed material. However, that functionality is not currently included in the scope of work.

7.1.2.4 WEDMS Three-Dimensional Viewing

ERMA's Voxel Analyst has the ability to produce three-dimensional views of the site data. Selected views can be stored on the WEDMS for viewing. CH2M HILL will work with users to identify a set of views to be available for each site that contains a data set conducive to meaningful three-dimensional graphical representation. The Voxel images will be based on analyses done in ERMA and processed for viewing.

7.1.3 Document Reference Section

The WEDMS will include a document reference section using the Saros Document Manager system in the Mezzanine® library. The AFWTF will have its own "smart folder" for project documents. The system will provide accessibility, security, version control, and document integrity. Public documents can be viewed or printed, but only designated personnel will be able to revise the documents. Confidential documents will be secured from public access. The online document library will be useful for reviewing scopes of work, project plans, regulatory standards and screening levels, and other relevant information. Users also will be able to upload documents to the Reference Section to make them available to others. These documents will be available to all authorized users of the WEDMS.

7.1.4 Data and File Transfer

Data and file transfers to the WEDMS will be performed either through the Saros Document Manager system in the Mezzanine® library (discussed above) or by file transfer protocol (FTP). End users may use any available FTP software package to perform the file transfers. Information on the type of file or data transfer process required to view or download a document will be provided to site users directly on their screens.

7.1.5 WWW Site Project Calendar

The WWW Site will include a management section for coordination and communication. It will include a calendar that any authorized user may update with activities. The calendar will enable maintenance of delivery schedules along with notes about individual items. Meetings and other activities also can be included on the site. This has been a useful feature on other project sites, and is used internally within CH2M HILL.

7.1.6 WWW Site Discussion Topics

The discussion group feature of the WWW Site can be particularly useful in selected situations where responses are made to a message posted by another user. The system groups the responses so that users can readily see when a response has been made. It provides a ready record of discussion on a topic that can easily be searched and reviewed, unlike phone calls.

7.1.7 Site Online Help Applications

Help information will be provided at selected areas of the site.

7.2 Desktop-Applications GIS Data Sharing

Desktop-applications GIS data sharing is centered around desktop GIS applications that run on a user's desktop PC and access data and maps from an EDMS database. Desktop systems also have the ability to link to a variety of spatial databases (e.g., historic building information), enabling users to conduct a range of spatial queries. Several powerful and flexible tools are available for viewing and analyzing GIS data. ArcView is a widely used desktop tool. Similarly, the recently released GeoMedia desktop GIS also provides a wide range of viewing capability. In either case, users must have these tools available on their desktop PC to view the data. Thus, there are generally some client software purchase requirements to provide desktop data analysis capabilities to individual users. CH2M HILL will be able to provide support (e.g., interface customization, data conversion, data loading, and database linking) for whichever desktop GIS system meets the needs of the AFWTF. Once a specific system is selected, a detailed scope of GIS desktop support services can be provided.

7.3 Site Maintenance

Periodic maintenance of the site will be necessary to update data, provide minor enhancements, and deal with a changing network environment.

7.4 User Access

Users interested in gaining access to the WEDMS will be able to fill out an online registration form available from the WEDMS home page. The information will be captured and forwarded to the Navy Technical Representative (NTR) for approval. If access is granted, a user name and password will be assigned by the WEDMS administrator and forwarded to the requester along with any additional information necessary to establish the appropriate connection. If access is denied, the requester will be notified via e-mail if possible.

7.5 System Specifications

WEDMS system specifications, data security measures, and system backup specifications are documented below.

7.5.1 WWW Site Access Requirements

Access to the WEDMS will be available on the Internet to a controlled group of users. Access will require an authorized user name and password. Users are required to use the Microsoft Internet Explorer 3.02 (or higher) WWW browser for guaranteed data access and retrieval. Netscape Navigator (version 3.0 or later) should also work. Internet Explorer is available free to users with a legal license for any Microsoft operating system. The WEDMS WWW home page will contain a hyperlink to download Internet Explorer for users who need it.

CH2M HILL recommends that users have at least a 100 megahertz (MHz) Pentium-class CPU, a minimum of 16 MHz of RAM, a video graphics card capable of displaying 256 colors, and connection to the Internet at 28,800 kilobytes (kbps) or faster.

7.5.2 WEDMS Server System Configuration

The WEDMS design will enable any authorized user with internet access to reach the site. CH2M HILL plans to host the site on its WWW server. The site could be hosted either at the Navy or through an Internet Service Provider. Either of the options would probably increase cost, however, since additional software (already in service at CH2M HILL) will have to be purchased. In addition, hosting the site elsewhere would likely require that the ERMA database be copied and run from that server.

7.5.2.1 Hardware Specifications

If the AFWTF Site is hosted somewhere other than on CH2M HILL's WWW server, it will require a 200 MHz Pentium Pro file server, with 32 MHz of RAM, a video graphics card capable of displaying 256 colors, and minimum of 4 gigabytes fixed-disk storage space. The file server should be connected to the Internet via a 64 kbs ISDN gateway (or faster connection).

7.5.2.2 Software Specifications

The WEDMS server requires the Windows NT Server 4.0 industry standard multi-user operating system. It will include FTP and WWW services along with either Oracle or structured query language server database accessibility.

7.5.3 System Security

In placing the WEDMS on a publicly accessible network, a number of security issues need to be examined at a variety of levels. In examining the security issues, two distinct areas of concern are identified:

1. Access level security
2. Transaction-based security

7.5.3.1 Access Level Security

Windows NT Server 4.0 provides a secure operating environment for WEDMS. Access rights can be set based on users and groups. NT's Internet Information Server (IIS) also enables access to be restricted to specific internet addresses, thereby blocking out all but a selected set of users.

7.5.3.2 Transaction-Based Security

Beyond the detail of access level security, issues may arise as to the need for some degree of transactional security (i.e., the encryption of data packets as they are transferred across the Internet). Should the need for this level of security be determined, an Internet server product utilizing the Secure Socket Layer protocol will be utilized along with compatible client browser software and digital certificates to ensure an encrypted connection between the server and the client browser.

7.5.4 Data Backup and Retrieval

The method and schedule for data backup and retrieval are documented below.

7.5.4.1 Method

The file server disk subsystem will be backed up automatically through scheduled system services of the selected operating system. Backups will be maintained offsite from the server location to facilitate full system recovery in the event of a physical catastrophe at the server location.

7.5.4.2 Schedule

A backup schedule will be implemented that will ensure a minimal loss of mission-critical data and minimize the time required to recover files and operation.

A full backup will occur on a weekly basis. Daily backups will occur at the end of each day to capture any files changed since the previous daily backup. This will ensure that the maximum amount of data loss will not exceed 1 day of activity on the system.

Master Investigation-Derived Waste Management Plan

FINAL

Master Investigation-Derived Waste Management Plan

Atlantic Fleet Weapons Training Facility
Vieques Island, Puerto Rico

Contract Task Order 031

Prepared for

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Abbreviations and Acronyms

AFWTF	Atlantic Fleet Weapons Training Facility
EPA	Environmental Protection Agency
FS	Feasibility Study
IDW	Investigation-Derived Waste
IDWMP	Investigation-Derived Waste Management Plan
NFESC	Navy Facilities Engineering Services Command
PPE	Personal Protective Equipment
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
SSA	Site Screening Area
TCLP	Toxicity Characteristic Leaching Procedure

SECTION 1

Introduction

The Remedial Investigation (RI) and Site Screening Area (SSA) activities at the Atlantic Fleet Weapons Training Facility (AFWTF) on Vieques Island, Puerto Rico will produce investigation-derived waste (IDW). IDW will subsequently require waste management and disposal in a manner that minimizes potential hazards to the public. This Master Investigation Derived Waste Management Plan (IDWMP) describes methodologies and procedures that CH2M HILL field personnel will implement to handle, manage, and dispose of IDW at AFWTF.

Site-specific IDW will be addressed in the site-specific IDWMP. 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 wastewater 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 RI/Feasibility Study (FS) and SSA 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

Soil cuttings generated during field activities will be contained in 55-gallon drums if the existence of contamination at the site has either been confirmed or suggested from previous investigations, or if no previous site investigation has taken place. Soil to be contained includes the soil cuttings generated during any intrusive activity, and any soil that accumulates in the decontamination pad from the washing of drilling equipment. Drums will be sealed and appropriately labeled.

If previous investigations have confirmed that contamination does not exist at the site, soil cuttings generated during the field activities will be returned to the borehole from which they were removed. Excess soil cuttings will be spread on the ground near the boring from which they were removed and graded and seeded as necessary. If the boring is located in an area with a maintained lawn, asphalt, or concrete surface, excess soil cuttings will be spread on the ground and graded and seeded at a location designated by the Navy.

At the conclusion of a drilling event, drums filled with potentially contaminated soil cuttings will be stockpiled temporarily at a location designated by Navy personnel. The Navy will then verify whether the site contains listed hazardous wastes, as specified in Title 40 of the Code of Federal Regulations, Part 261 (40 CFR 261).

If the site does contain listed hazardous waste, CH2M HILL's waste management subcontractor will dispose of the drummed soil as hazardous waste at a regulated hazardous waste landfill. If the site does not contain listed hazardous wastes, CH2M HILL's waste management subcontractor will collect composite soil samples from the drums and submit the samples to an approved laboratory for the waste characterization analyses required by the proposed disposal facility. The drums will remain at the temporary location until the waste management subcontractor and CH2M HILL receive the characterization sampling analytical results. The wastes must be handled and disposed of within 90 days of being stockpiled at the temporary location. For planning purposes, IDW will be stored at AFWTF for a maximum of 60 days in order to ensure compliance with the 90-day accumulation limit.

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 and, if requested by the Navy, to the EPA. Recommendations will be based on the analytical results of soil and groundwater sampling conducted during field activities and on the results of characterization sampling. If the site's soil and groundwater sampling analytical results are "clean," and if the characterization sampling results do not contain listed hazardous wastes and are below Toxicity Characteristic Leaching Procedure (TCLP) and Resource Conservation and Recovery Act (RCRA) 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, the drummed soil will be considered hazardous. The waste management subcontractor will ship the hazardous waste to a regulated hazardous waste landfill where it will either be treated or stockpiled, as appropriate, and as directed by the Navy.

The proposed steps for accumulating, handling, and disposing of IDW soils and soil cuttings are as follows:

1. If the existence of contamination at the site has either been confirmed or suggested from previous investigations, or if no previous site investigation has taken place, shovel soils and soil cuttings from the boring into 55-gallon drums.
2. If previous investigations have confirmed that contamination does not exist at the site, return soils and soil cuttings directly into the boring from which they were removed. Excess cuttings will be spread on the ground surface near the boring from which they were removed or shoveled into 55-gallon drums if the boring is located in an area with a maintained lawn, asphalt, or concrete surface.
3. Stockpile drums in the area(s) designated by the Navy.
4. Verify with the Navy whether the site contains listed hazardous wastes as specified in 40 CFR 261. If the site does contain listed hazardous wastes, as specified in 40 CFR 261, refer to step 9.
5. Upon completion of field activities, if the site does not contain listed hazardous wastes as specified in 40 CFR 261, notify the waste management subcontractor that drums are ready to be sampled for waste characterization.
6. The subcontractor will collect composite samples from the drums and submit them to an approved offsite laboratory for the analyses required by the proposed disposal facility.
7. Upon receipt of characterization results, write a memorandum to the Navy recommending whether to handle the soil as hazardous or non-hazardous waste.
8. 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.
9. 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, as designated by the Navy. The Navy will be responsible for signing all manifests.

2.1.2 Non-soil Solids

The disposable PPE used by CH2M HILL field personnel and CH2M HILL's subcontractors 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 used during sampling will also be contained in drums, such as in-line water filters, C-flex tubing, and paper towels. Drums will be sealed and labeled appropriately.

The PPE will be bagged and drummed pending receipt of sampling analytical results. If the sampling analytical results indicate that the site's soil and groundwater are non-hazardous, the PPE and sampling expendable items will be placed in marked bags and discarded in dumpsters. If sampling analytical results indicate that the site's soil and groundwater are hazardous, the handling and disposal procedures of PPE and sampling expendable items will be identical to those that apply for hazardous soils and soil cuttings.

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 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. In addition, water generated during decontamination processes and excessive liquids that separated from soil cuttings will be added to drums containing groundwater IDW. Drums will be sealed and appropriately labeled until final disposition is determined.

If groundwater is extracted from a background location where previous investigations have confirmed that contamination does not exist at the site, 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 stockpiled temporarily at a location designated by Navy personnel. The contained wastes must be disposed of within 90 days of being stockpiled at the temporary location. For planning purposes, IDW will be stored at AFWTF for a maximum of 60 days in order to ensure compliance with the 90-day accumulation limit.

The Navy will then verify whether the site contains listed hazardous wastes, as specified in 40 CFR 261. If the site does contain listed hazardous waste, CH2M HILL's waste management subcontractor will dispose of the liquid IDW as hazardous waste at a regulated hazardous wastewater treatment facility where it will be treated until it meets standards for disposal as appropriate, and as directed by the Navy.

If the site does not contain listed hazardous wastes, CH2M HILL will formulate a preliminary assessment of any potential hazards posed by the IDW and submit waste management recommendations to the Navy and, if requested by the Navy, to the EPA. Recommendations will be based on the analytical results of groundwater sampling conducted during field activities. If the site's groundwater sampling analytical results are "clean," CH2M HILL will recommend that the liquid IDW be discharged to the industrial wastewater treatment facility.

If the groundwater sampling results contain contaminant concentrations above regulatory limits, the drummed water will be considered hazardous. The waste management subcontractor will ship the liquid IDW to a regulated hazardous wastewater treatment facility where it will be treated until it meets standards for disposal as appropriate, and as directed by the Navy.

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. 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 where contamination is not expected, or if previous investigations have confirmed that contamination does not exist at the site, groundwater will not be contained during field activities.
3. Stockpile drums in the area(s) designated by the Navy.
4. Verify with the Navy whether the site contains listed hazardous wastes, as specified in 40 CFR 261. If the site does contain listed hazardous wastes, refer to step 7.
5. If the site does not contain listed hazardous wastes, CH2M HILL will write a memorandum to the Navy recommending whether to handle the drummed water as hazardous or non-hazardous waste. The recommendations will be based on results of groundwater sampling conducted during field activities.
6. 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.
7. 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, and as directed by the Navy. The Navy will be responsible for signing all manifests.

SECTION 3

General Considerations

General considerations pertinent to the generation and handling of IDW are documented below. 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, cuttings will be used to backfill the boreholes from which they were removed when previous investigations have confirmed that contamination does not exist at the site. Only excess cuttings will then be contained as IDW.

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 background locations where contamination is not expected, or if previous investigations have confirmed that contamination does not exist 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 AFWTF. 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, NSRR

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 contained wastes must be disposed of within 90 days of being stockpiled at the temporary location. For planning purposes, IDW will be stored at AFWTF for a maximum of 60 days in order to ensure compliance with the 90-day accumulation limit.

3.4 Waste Disposal and Manifesting

Upon the receipt of characterization and sampling analytical results, CH2M HILL will assess the potential hazards posed by the IDW and submit waste management recommendations to the Navy. If the test results indicate that the IDW is not a listed or characteristic hazardous waste, CH2M HILL will recommend that soil be disposed of at a non-hazardous landfill, that water be disposed of at an industrial wastewater treatment plant, and that PPE and sampling expendable items be disposed of in a trash dumpster for disposal with other non-hazardous trash generated at AFWTF.

If the test results or the Navy indicate that the IDW is generated from a site that contains a listed or characteristic hazardous waste, CH2M HILL will recommend that the soil, water, and PPE be manifested, handled, treated, and disposed of as a hazardous waste by a CH2M HILL waste management subcontractor. The waste management subcontractor will prepare manifests for a completeness review by CH2M HILL. The Navy will be responsible for signing all manifests.

Community Relations Plan

FINAL

Work Plan

for Community Relations Plan

Atlantic Fleet Weapons Training Facility and Eastern Maneuver Area

Vieques Island, Puerto Rico

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

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Acronyms and Abbreviations

AFWTF	Atlantic Fleet Weapons Training Facility
AOC	Area of Concern
AST	Aboveground Storage Tank
CERCLA	Comprehensive Environmental Recovery, Compensation, and Liability Act
CMS	Corrective Measures Study
CRP	Community Relations Plan
DOI	Department of the Interior
EMA	Eastern Maneuver Area
EPA	United States Environmental Protection Agency
IR	Installation Restoration (environmental restoration)
LANTDIV	Atlantic Division (Naval Facilities Engineering Command)
NASD	Naval Ammunition Support Detachment
NATO	North Atlantic Treaty Organization
NFRAP	No Further Remedial Action Planned
NFRAP-DD	No Further Remedial Action Planned—Decision Document
NSRR	U.S. Naval Station Roosevelt Roads
PAOC	Potential Area of Concern
PREQB	Puerto Rico Environmental Quality Board
RAB	Restoration Advisory Board
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
SWMU	Solid Waste Management Unit
TRC	Technical Review Committee
UST	Underground Storage Tank

1 Introduction

In January 2000, the U. S. Environmental Protection Agency (EPA) and the Department of the Navy entered into an Administrative Order of Consent (Consent Order) under Section 3008(h) of the Resource Conservation and Recovery Act (RCRA), as amended (U.S. EPA Consent Order Docket No. RCRA-02-99-7301). The Consent Order is designed to address potential environmental contamination at the Atlantic Fleet Weapons Training Facility (AFWTF) and Eastern Maneuver Area (EMA), on the eastern side of Vieques Island, Puerto Rico (Figure 1-1).

In accordance with the Consent Order, the Navy will perform an RCRA Facility Investigation (RFI) to fully determine the nature and extent of any releases of hazardous wastes, solid wastes, and/or hazardous constituents, from (or at) the EMA and AFWTF.

The Consent Order requires the investigation of nine Solid Waste Management Units (SWMUs) and three Areas of Concern (AOCs). These SWMUs and AOCs are located on the AFWTF and EMA; many are on Camp Garcia, which is part of the EMA (see Figure 1-2). Additional suspected areas could be added, if preliminary study shows that a release of hazardous materials may have occurred elsewhere.

If releases of hazardous wastes, solid wastes, or hazardous constituents are found that could threaten human health or the environment, the Consent Order requires that corrective measures be implemented to remediate those releases.

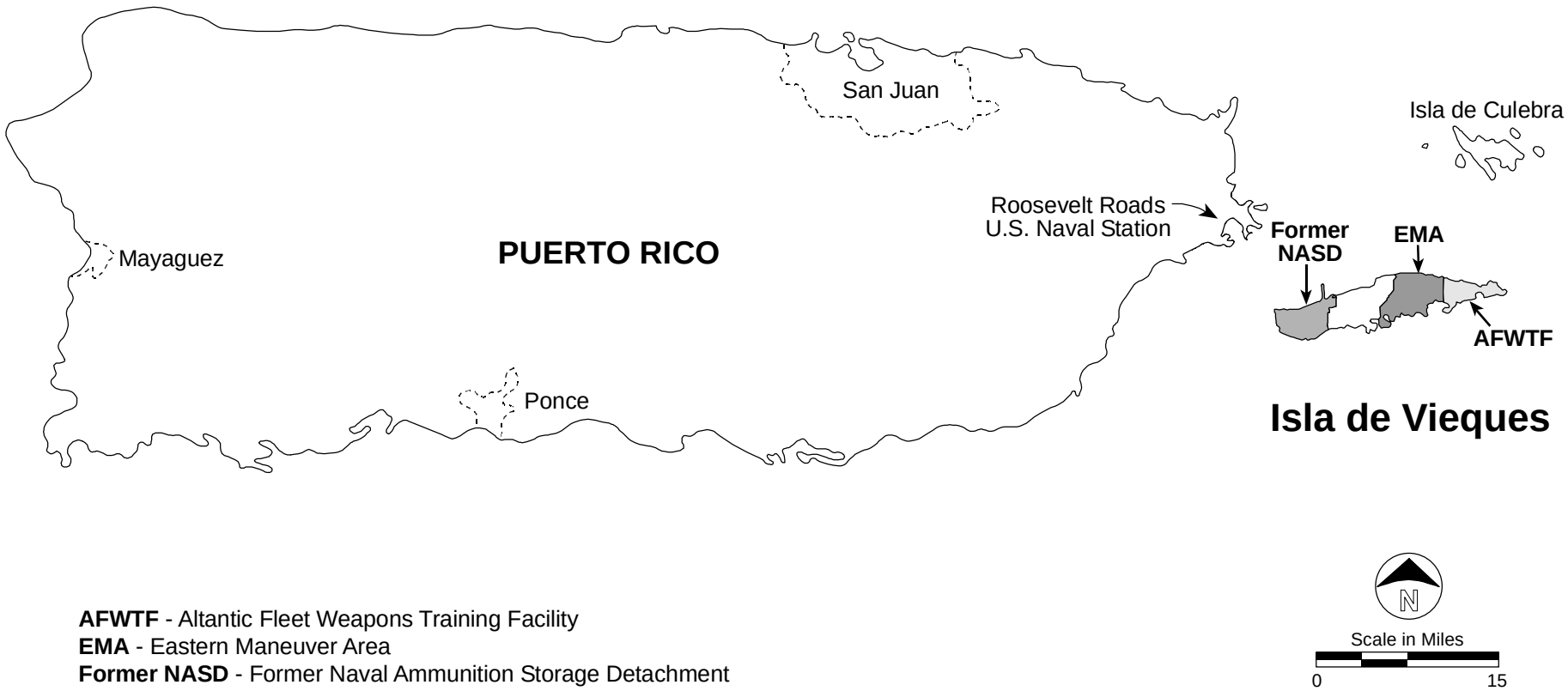
Another three known areas of contamination (SWMUs 3, 9, and 11) are not included in the RFI, because they are located in the active military range and thus, presently excluded from any corrective action requirements under the Consent Order's terms and conditions. These sites will be addressed separately if the active military range is closed.

1.1 Facility Background and Setting

Vieques Island lies about 7 miles southeast of the main island of Puerto Rico and the U.S. Naval Station Roosevelt Roads (NSRR) (Figure 1-1). According to the 2000 Census, approximately 9,106 people currently live on Vieques Island, a 5.9-percent increase from 1990. Most live in and around the towns of Isabela Segunda on the north shore and Esperanza on the south shore.

The Navy currently occupies approximately 14,700 acres (23 square miles) of the 33,000 acres (52 square miles) that make up Vieques Island. AFWTF occupies 3,600 acres on the eastern tip of the island, and EMA occupies 11,000 acres contiguous with the AFWTF and is located on the east-central portion of the island.

For many years, the AFWTF has provided facilities for naval gunfire support and air-to-ground ordnance delivery training for Atlantic Fleet and North American Treaty Organization (NATO) ships; air wings, as well as smaller air units from other allied nations;and



AFWTF - Altantic Fleet Weapons Training Facility
EMA - Eastern Maneuver Area
Former NASD - Former Naval Ammunition Storage Detachment

Figure 1-1
SITE LOCATION MAP
Vieques Island, Puerto Rico

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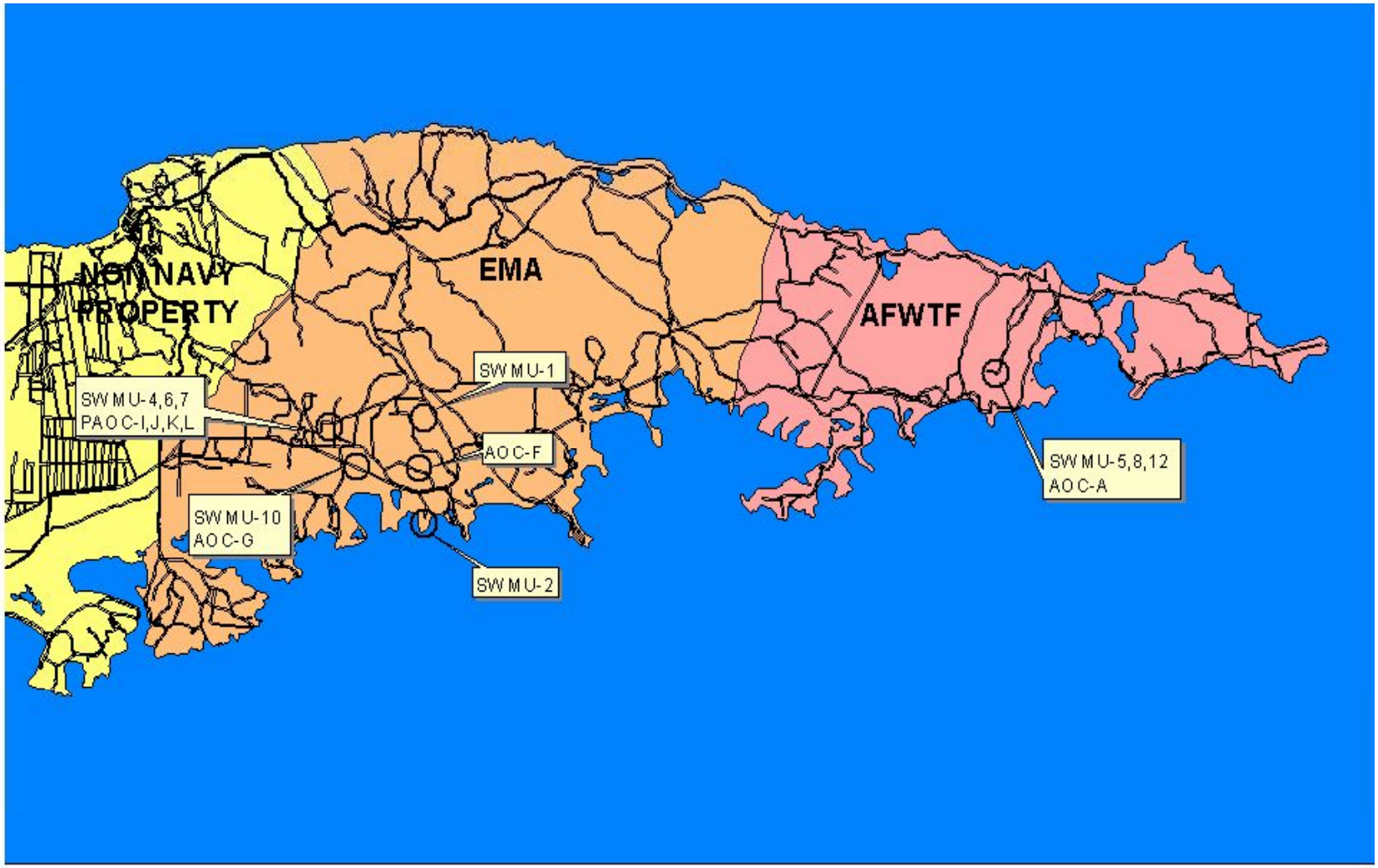

Figure 1-2
RFI Sites on AFTWF and EMA
Vieques Island, Puerto Rico

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the Puerto Rican National Guard. The Fleet Marine Force, Atlantic, has conducted training for Marine amphibious units, battalion landing teams, and combat engineering units in the EMA. On occasion, the Puerto Rican National Guard and naval units of allied nations (with a presence in the Caribbean) have also used the EMA. The training areas have been in continuous use since World War II, when the Navy acquired title to the land.

Until 2001, the Navy occupied another 8,000 acres on the western end of the island, known as the Naval Ammunition Support Detachment (NASD), formerly used to store ammunition and ordnance used by the Atlantic Fleet. It also contained public works facilities to support Navy activities.

On April 30, 2001, the Navy transferred about 4,000 acres of the former NASD property to the Municipality of Vieques; 3,100 acres to the U.S. Department of the Interior (DOI); and about 800 acres to the Puerto Rico Conservation Trust. The DOI lands are now being managed by the U.S. Fish and Wildlife Service (FWS) as the Vieques National Wildlife Refuge. The Navy has retained about 100 acres on the western side of the island, where the communications facilities on Monte Pirata and the Relocatable over-the-Horizon Radar are located.

In preparation for this transfer, the Navy Public Works facilities that provide vehicle and infrastructure (buildings, roads, and utilities) maintenance support for Navy activities on the island were relocated from the western side of the island to Camp Garcia, which is part of the EMA.

1.2 Purpose of This Work Plan

This work plan has been prepared to describe an approach to encourage public participation, including the preparation of a CRP(Community Relations Plan), to support the RFI and any removal actions for sites with environmental contamination on the U.S. Navy's EMA and AFWTF properties. It also describes the approach for conducting specific interim public participation activities while the CRP is being prepared. It is intended to be a collaborative effort between the Navy and EPA.

Since there are no statutory requirements or regulations mandating specific public participation activities under RCRA §3008(h) Consent Orders, public participation activities are based on guidance and on the terms of the Consent Order itself. For example, the Consent Order requires that a CRP be developed as part of the RFI Work Plan. This work plan has been prepared in accordance with the methods suggested for RCRA 3008(h) Consent Orders in EPA's 1996 *RCRA Public Participation Manual*.

Section 1 provides background information about the U.S. Navy's property on Vieques Island and the affected community. Section 2 describes the approach for preparing a CRP and interim public involvement activities.

1.3 RCRA Facility Investigation (RFI)

The Navy will conduct the RFI, as required by the Consent Order, in coordination with EPA Region 2 and in cooperation with the Puerto Rico Environmental Quality Board (PREQB).

The RFI objectives supplement data collected during previous investigations, concerning the nature and extent of potential contamination at the SWMUs and AOCs at the EMA and AFWTF, and to make recommendations for additional or no further action for each site, based on that data.

The RFI will focus on potential contamination at the nine identified SWMUs and three AOCs shown on Figure 1-2 and described in Table 1-1:

TABLE 1-1
Description of Sites

Area	Area Name	Description of Area
SWMU 1	Camp Garcia Landfill	55-acre landfill used from 1954 to 1978 to dispose of construction debris, scrap metal and food packaging
SWMU 2	Fuels Off-Loading Site (Camp Garcia)	Former location of four 20,000 to 30,000-gallon above-ground storage tanks (ASTs) and pipelines used to store diesel fuel and gasoline
SWMU 4	Waste Areas of Building 303 (Camp Garcia)	Waste areas include: a spent battery accumulation area, a hydraulic oil catch basin, degreasing basin and waste rag storage area
SWMU 5	Spent Battery Accumulation Area (Observation Post 1, Inner Range, AFWTF)	An outside storage area for waste batteries
SWMU 6	Waste Oil and Paint Accumulation Area (Seabees Area, Camp Garcia)	Area used to store 55-gallon drums of waste oil and paint
SWMU 7	Waste Oil Accumulation Area (outside Building 303 at Camp Garcia)	Vehicle maintenance area used to store 55-gallon drums of waste oil
SWMU 8	Waste Oil Accumulation Area (Observation Post 1, Inner Range, AFWTF)	Waste accumulation area outside generator building used to store waste oil and lubricants
SWMU 10	Sewage Treatment Lagoons (Camp Garcia)	Four unlined lagoons formerly used for the equalization and treatment of domestic wastewater
SWMU 12	Solid Waste Collection Unit Area (Observation Post 1, Inner Range, AFWTF)	A solid waste transfer area used to store domestic trash
AOC-A	Diesel Fuel Fill Pipe Area (Observation Post 1, Inner Range, AFWTF)	An area of petroleum-stained soil in the vicinity of a diesel fuel underground storage tank (UST)
AOC-F	Rock Quarry (Camp Garcia)	A rock quarry where used tires and waste paper were identified
AOC-G	Pump Station and Chlorinating Building at Sewage Lagoons (Camp Garcia)	Pump station and chlorination equipment stored in building next to former lagoons

Additional Potential Areas of Concern (PAOCs) suspected of possible contamination based on their prior use, and areas identified by aerial photos (where ground scarring and disturbed vegetation was identified) could also be investigated as part of the Phase I RFI, if it is determined that a release of hazardous materials has occurred.

2. Public Participation Planning

2.1 Overview

Both the Navy's Installation Restoration (IR) program and the EPA's RCRA corrective action process recommend a public participation effort to encourage public input and feedback into RCRA Facility Investigations, Corrective Measures Studies, permits, and removal actions. This section describes the approach for preparing and implementing a public participation program for the RFI at the EMA and AFWTF.

The Navy and EPA Region 2 will collaborate in planning and implementing the RCRA public participation program for the RCRA activities at the EMA and AFWTF under the Consent Order. The PREQB and interested community members may be asked to provide consultation.

Public participation materials, such as fact sheets explaining and summarizing environmental investigation results, and proposed clean-up plans (if necessary), will be produced in both Spanish and English, but draft technical documents will not be translated.

2.2 Community Relations Work Plan

This Community Relations Work Plan has been prepared following the approach suggested by the *RCRA Public Participation Manual* for public participation activities, including preparation of a CRP and some interim public participation activities to be conducted while it is being prepared. This work plan will be available for public review in public repositories (see section 2.4.1).

The CRP will be prepared during the initial stages of the RFI process. When the CRP is complete, it will replace this work plan as the outline for conducting public participation activities. The completed CRP for the RFI at AFWTF/EMA will be a self-contained supplement to the RFI Work Plans.

The rest of this section presents the approach for developing the CRP, as well as a description of public participation activities to be implemented in the short term and in the future.

2.3 Community Relations Plan

2.3.1 Background Review

The Navy (or its duly designated representative) will review existing documents to obtain additional background information if needed. Newspaper coverage and correspondence relevant to the RFI will be reviewed, to the extent that NSRR, EPA, or others can provide this material.

2.3.2 Community Interviews

The EPA's *RCRA Public Participation Manual* (1996) recommends community interviews when there is a high level of interest in the facility. Discussions with local officials and interested citizens provide an opportunity to determine public concerns and to find out how and when community members want to participate in the decision process for environmental remediation.

Community interviews were conducted in December 2000, to prepare a separate CRP for the CERCLA investigation of sites on the western side of the island (where land was transferred from the Navy to the Municipality and DOI in 2001). These interviews provided useful information about the community and public involvement methods, which will be incorporated into the RCRA community relations plan as appropriate, but the AFWTF and EMA were not specifically discussed at that time. Therefore, additional interviews will be conducted.

Lead agency personnel, preferably including the Remedial Project Manager or a technical representative should conduct interviews. The Navy and EPA will conduct the interviews. The Navy and EPA will prepare a list of questions or talking points for the interviews, in both English and Spanish, based on concerns identified during the background research phase and the previous interviews. The questionnaire will be used to record comments made by interview respondents.

The Navy and EPA will contact interested citizens and local officials to schedule the interviews. Community members who are interested in participating in CRP interviews should contact the EPA (points of contact are listed in Section 2.4.1). In addition, the Navy will ask community members who have expressed interest in the cleanup program on the western side of the island, if they wish to be interviewed or can help identify potential interview participants. As interviews are scheduled, participants will be asked to identify additional persons who might wish to participate.

The goal is to interview a variety of people, including local officials, community leaders, environmental group members, Vieques business owners, and Vieques residents—including some who were not interviewed for the CERCLA CRP and some who are not affiliated with any organized groups.

Interviews will be conducted in person on Vieques Island, at a location that is comfortable for the person being interviewed. In this case, a public facility such as a school, library, or local government office in Vieques may serve as a good location for conducting the interviews. It is expected that interviews will take place over a single week.

The Navy and EPA will conduct interviews together. Interviews will be conducted in English or Spanish, depending on the individual participants. At least one bilingual staff member from EPA, the Navy, or a designated representative, will be present at the interviews.

Every effort will be made to focus the discussions on identifying community concerns about the work specified in the Consent Order and on the RCRA process of preparing the RFI Final Report and any subsequent decision documents, which could include a Corrective Measures Study (CMS) Final Report and a Statement of Basis document for proposed

response actions (including for any No Further Remedial Action decision). Information will be provided about the process and the key points at which public participation will be invited.

2.3.3 Completing the CRP

The Navy, or its designated representative, will draft the CRP, based on the interview records and background information provided by EPA, PREQB, and the Navy. EPA will review the CRP and provide comments and the Navy, or its designated representative, will finalize the CRP.

The CRP will summarize the compiled information, with particular attention to the level and nature of environmental concerns. The design of the public participation program will depend largely on this information and on EPA's participation. The program will be flexible to allow expansion of involvement opportunities, depending on the level of community interest in the RFI of the nine SWMUs and three AOCs at the AFWTF and EMA (as opposed to other actions at Vieques). The stated preferences of the participants, such as written or face-to-face communication, will be important in planning and implementing specific public participation techniques.

Although planning for the RCRA CRP is focused on the RFI at the AFWTF and EMA, it will be coordinated as appropriate with public involvement activities for the CERCLA investigations at NASD and other remedial actions, if any, that may be ongoing on the western side of the island.

The CRP will consist of the following main sections:

- Introduction
- Facility Description and History
- Community Concerns
- Objectives of the Plan
- Public Participation Activities

Appendices may include:

- Mailing List of Interested Parties
  (addresses and telephone numbers of private citizens will not be published in the CRP)
- Locations for Meetings and Information Repositories
- Media Contacts
- Sample Fact Sheets and Public Notices

2.4 Public Participation Implementation

2.4.1 Short-Term Public Participation Activities

The objective of both the EPA and the Navy is to plan and implement public participation activities, including effective communications with the community about how residents can participate in the RCRA process. The public participation activities planned by the Navy and EPA to meet this short-term objective are described in the sections that follow.

Mailing List

The Navy maintains a mailing list of persons who have expressed interest in the environmental restoration of former and current Navy property on Vieques Island (Appendix B). At present, the list consists of about 120 persons, including both residents of Vieques Island and people who live elsewhere.

People who have expressed interest in any one of these properties (EMA, AFWTF, or the Navy's former property on the western side of the island) will be placed on the mailing list to receive public information about all of them.

Public notices and community updates will notify the public of the opportunity to be included on the mailing list and receive information and updates by direct mail. People can get on the mailing list by getting in touch with the points of contact who are identified in all fact sheets and public notices.

Technical Review Committee (TRC)

A TRC was established to enhance public participation in the CERCLA remedial investigation of the Navy's former property on the western side of the island. The TRC includes representatives of the Municipality of Vieques and US Fish & Wildlife Service (the new landowners), as well as EPA Region 2 CERCLA program staff and a number of local community members. PREQB has been invited to appoint a representative to the TRC, but has not thus far done so.

The primary focus of this group is and will continue to be the restoration of the former NASD. The Navy's *Installation Restoration Manual* states that public participation at RCRA sites will be accomplished by keeping the existing Restoration Advisory Board or Technical Review Committee informed of the status of site cleanup. Accordingly, the Navy will provide periodic updates about the RFI (and any subsequent RCRA activities) during regularly scheduled meetings of the existing NASD TRC. However, separate discussions about activities on the eastern and western sides of the island may become necessary at some point. In that event, the Navy and EPA will consult with TRC members and will consider either organizing a subcommittee of the existing TRC or providing RFI updates in a separate session of the existing TRC; either of which would be synchronized with the regularly scheduled meetings of the NASD TRC.

Public Information Repositories

Public information repositories are located in public libraries in the town of Isabela Segunda on Vieques Island and at EPA's Caribean Environmental Protection Division offices in Santurce, Puerto Rico. The addresses, telephone numbers and hours of operation for the repositories are provided in Appendix A.

At a minimum, the Navy will place the CRP and any bilingual fact sheets developed for the AFWTF and EMA in the public information repositories. As requested by EPA, the Navy will make the RCRA Facility Investigation Work Plan(s) and Final Report(s), draft and Final Corrective Measures Study, and any other documents developed under the Consent Order available for public review and comment in the public repositories.

Administrative Record File

An Administrative Record file consists of the information supporting the selected remedy for corrective actions and interim removal actions. An Administrative Record file for the Consent Order is maintained by EPA and is available for public inspection at EPA's Region 2 offices in New York City and at its Caribbean Environmental Protection Division offices in Santurce, Puerto Rico.

Fact Sheet

An introductory fact sheet will be distributed to provide an overview of the upcoming RFI and outline the opportunities for public participation. This fact sheet will inform community members about the RCRA process, the RFI work plan and upcoming activities, locations of the public information repositories (Appendix A) and the primary points of contact for the Navy, EPA, and PREQB (see Table 2-1). The Navy has prepared, and EPA has reviewed the introductory fact sheet; a final draft pending EPA approval is provided in Appendix C.

The fact sheet will be translated into Spanish and NSRR Environmental Engineering Division personnel will review the translation. The Navy or its designated representative will distribute the fact sheet through the existing mailing list of interested parties; additional copies will be placed in the repositories.

Public Review of Work Plans

After EPA completes the review and approval of the RFI Work Plan(s), EPA will place a public notice in local newspapers to notify the community that these documents are available for review. In addition to this community relations work plan, the other components of the RFI Work Plan are: a Description of Current Conditions report; a Project Description/Data Collection Plan; a Data Management Plan; a Quality Assurance/Quality Control Project Plan; and a Health and Safety Plan.

Points of Contact

Table 2-1 presents the primary points of contact designated within the Navy, EPA, and PREQB for public information and inquiries.

TABLE 2-1
Primary Points of Contact

Agency	Name	Contact Information
US Environmental Protection Agency, Region 2 (for public participation issues)	Mr. Carlos Ramos	US Environmental Protection Agency, Region 2 Office of Regional Administrator 290 Broadway, 26th Floor New York, New York 10007-1866 Phone: (212) 637-3588 Email: Ramos.Carlos@.epa.gov

TABLE 2-1
Primary Points of Contact

Agency	Name	Contact Information
US Environmental Protection Agency, Region 2 (for technical issues)	Mr. Timothy Gordon	US Environmental Protection Agency, Region 2 RCRA Programs Branch 290 Broadway, 22nd Floor New York, New York 10007-1866 Phone: (212) 637-4167 Fax: (212) 637-4437 Email: Gordon.timothy@.epa.gov
US Environmental Protection Agency, Caribbean Environmental Protection Division	Mr. Daniel Rodriguez	US Environmental Protection Agency Caribbean Environmental Protection Division Centro Europa Building, Suite 417 1492 Ponce de Leon Avenue Santurce, Puerto Rico 00907-4127 Phone: (787) 977-5849 Fax: Email: Rodriguez.Daniel@epa.gov
Naval Facilities Engineering Command	Mr. Christopher T. Penny Remedial Project Manager	Atlantic Division, Code EV23 1510 Gilbert Street Norfolk, VA 23511-2699 Phone: (757) 322-4815 Fax: Email: PennyCT@efdlant.navfac.navy.mil
U.S. Naval Station Roosevelt Roads, Environmental Engineering Division	Ms. Madeline Rivera	PSC 1008, Box 3021 FPO AA 34051-3021 Phone: (787)865-5337 Fax: (787) 865-4967 Email: riveramad@mercury.navstarr.navy.mil
Puerto Rico Environmental Quality Board	Mr. Eugene Scott or Ms. Yarissa Martínez	National Plaza Building, Office 225 431 Ponce de León Avenue Hato Rey, PR 00917 Phone: (787) 766-8181 Fax: Email: YarissaMartinezLeon@jca.gobierno.pr

2.4.2 Future Public Participation Activities

Additional public participation activities, to be conducted during the RFI and CMS and corrective measures implementation (if any), will be evaluated when the CRP is prepared. These potentially could include activities such as:

- Developing additional fact sheet(s) at appropriate point(s).
- Mailing public information, which could include public notices, fact sheets, or summaries of reports to the current mailing list of interested parties that is maintained by the Navy's Contractor (CH2M HILL). Additional entries will be added to the mailing list as requests are received.

- Holding public meetings or open houses, depending on the level of public interest, at key decision milestones.
- Providing information about the RCRA facility investigation at AFWTF and EMA during meetings of the existing TRC, which meets to discuss environmental restoration (under CERCLA) of former Navy lands on the western side of the island, or potentially to a separate subcommittee or separate session of the existing TRC.

2.4.3 Public Comment on Proposed Corrective Measure

The RCRA Consent Order (Docket No. RCRA-02-99-7301) and EPA's *RCRA Public Participation Manual* describe certain public participation activities that EPA and the Navy are expected to implement.

After the RFI and CMS are finalized, and EPA has approved the reports and tentatively selected the corrective measure(s), EPA will prepare a Statement of Basis or fact sheet to solicit public review and comment. The Statement of Basis will identify the proposed final corrective measure(s) selected, including any no further action determination, and will describe other alternatives that were evaluated in the CMS report. EPA will issue a public notice that the corrective measure(s) have been tentatively selected and that the Statement of Basis is available.

The Navy will make the RFI Final Report (and a summary), the CMS Final Report (and a summary), and other relevant portions of the Administrative Record, including EPA's Statement of Basis, available in the public information repositories, for public review and comment, for at least thirty (30) days.

Although not required by the Consent Order, if a public hearing is requested in response to the public notice, EPA and the Navy will collaborate in arranging the public hearing and EPA will take the lead in responding to public comments.

Following the public review and comment period, EPA will prepare the final notice of decision and a response to public comments. EPA will provide copies of these documents to the public information repositories and to all persons who submit comments or request a copy of the response.

EPA will notify the Navy of the corrective measure(s) selected by EPA after consideration of public comments. If directed to do so by EPA, the Navy (or its designated representative) will revise the RFI and/or CMS, based upon public comment, and place the revised documents in the public repositories.

2.4.4 Bilingual Public Outreach

Because English is not the primary language of many Viequenses, public information materials, such as fact sheets, public notices and the Statement of Basis, will be produced in both Spanish and English. Lengthy technical documents will be prepared in English. Local personnel (NSRR Environmental Engineering Division and/or EPA Caribbean office) will review translations, for both local idiom and technical terminology.

If a public hearing is held during the public comment period for the proposed corrective action, bilingual translators and stenographers will be hired to produce transcripts in English and Spanish.

2.4.5 Timing

Figure 2-1 presents a general schedule for conducting public participation activities related to the RFI and subsequent RCRA actions.

	RFI Work Plans Completed	During RFI	RFI Report Completed	CMS Completed
Community Relations Plan		▲		
Public notice	▽		▽	▲
Copies for repositories	▲		▲	▲
Fact sheet	▲		▲	
Statement of Basis *(summary fact sheet on final remedy determination)*				▲ (EPA)
30-day comment period	▽		▲ (with CMS)	▲
Public meeting *(on request)*			▽ (with CMS)	▽
Response to public comments				▲

LEGEND

▲ Required action ▽ Recommended action

Figure 2-1
GENERAL SCHEDULE FOR PUBLIC PARTICIPATION ACTIVITIES

APPENDIX A

Locations of Public Information Repositories

Public Information Repositories

Location	Hours	Telephone
EPA Caribean Environmental Protection Division Centro Europa Building, Suite 417 1492 Ponce de Leon Avenue Santurce, Puerto Rico 00907-4127	Hours: Monday–Friday, 8:00 a.m. to 4:00 p.m.	787-977-5849
Biblioteca Pública Jose Gautier Benitez Calle Baldorioty de Castro Vieques, PR 00765	Monday–Friday, 8:00 am-6:00 pm	787-741-3706

In addition, files will be available at the Puerto Rico Environmental Quality Board (see Table 2-1).

APPENDIX B

Mailing List of Interested Parties

List of Interested Parties
AFWTF, Vieques Island, Puerto Rico

(Note: As of the time of writing. The mailing list is continually updated.)

Federal Officials and Agencies

The Honorable Aníbal Acevedo Vilá
Resident Commissioner
U.S. House of Representatives
126 Cannon House Office Building
Washington, DC 20515-5401

Mr. Carlos Ramos
US Environmental Protection Agency, Region 2
290 Broadway, 26th floor
New York, NY 10007-1866

Mr. Daniel Rodríguez
Caribbean Environmental Protection Division
US Environmental Protection Agency
Centro Europa Bldg, Suite 417
1492 Ponce De Leon Avenue
San Juan, PR 00907

Mr. Tim Gordon
US Environmental Protection Agency, Region 2
290 Broadway
New York, NY 10007-1866

Mr. Robert Wing
Chief of Federal Facilities
US Environmental Protection Agency, Region 2
290 Broadway
E.R.R.D.
New York, NY 10007-1866

Ms. Susan Silander
US Fish & Wildlife Service
P.O. Box 510
Bóqueron, PR 00622

Sr. Felix López Arroyo
Boqueron Field Office
US Fish & Wildlife Service
P.O. Box 491
Bóqueron, PR 00622-0491

Sr. Oscar Díaz
Manager, Vieques National Wildlife Refuge
US Fish & Wildlife Service
PO Box 1527
Vieques, PR 00765-1527

Sr. Rafael W. Rodríguez
Puerto Rico State Representative
US Geological Survey
651 Federal Drive, Suite 400-15
GSA Center
Guaynabo, PR 00965

State Officials and Agencies

La Gobernadora Sila Maria Calderon
Governor of Puerto Rico
Oficina de la Gobernadora
La Fortaleza
San Juan, PR 00920

Representante Augusto C. Sánchez Fuentes
Electoral District 36
Camara de Representantes
El Capitolio
San Juan, PR 00920

Dr. Manuel Rivera
Department of Natural & Environmental Resources
Box #906600
Puerto de Tierra, PR 00906

Mr. Eugene Scott or Ms. Yarissa Martinez
Puerto Rico Environmental Quality Board
National Plaza Bldg., Office 225
431 Ponce de Leon Avenue
Hato Rey, PR 00917

Dr. Juan Fernández
(ATTN: Felipe Morales)
Oficina del Comisionado Especial para Vieques
Avenida Fernandez Juncos #635
San Juan, PR 00907

Sr. Radamés Tirado Guevara
Subcomisionado
Oficina del Comisionado Especial para Vieques
Calle Prudencio Quiñones # 35
Esquina Carlos Lebrum
Vieques, PR 00765

Lic. Esteban Mujica Cotto
President
Puerto Rico Environmental Quality Board
National Plaza Bldg.
431 Ponce de Leon Avenue
Hato Rey, PR 00917

La Senadora Yasmin Mejias
8th Senatorial District-Carolina
Senado de Puerto Rico
El Capitolio
San Juan, PR 00920

El Senador Juan Cancel Alegria
8th Senatorial District-Carolina
Senado de Puerto Rico
El Capitolio
San Juan, PR 00920

Local Officials and Agencies

The Honorable Dámaso Serrano López
Mayor of Vieques
Casa Alcaldia
Vieques, PR 00765

Sr. Miguel Pablo Connelly Pagan
Dir., Departamento Obras Publicas Municipal
Gobierno Municipal Vieques
Estado Libre Asociado de Puerto Rico
449 Calle Carlos Lebrum
Vieques, PR 00765

Sr. Fabian Martinez Rivera
Dir., Oficinia de Programs Federales
Municipio de Vieques
Calle Carlos Lebrum #449
Vieques, PR 00765

Sr. Rafael Rodríguez Vega
Director of Finance
Municipality of Vieques
PO Box 875
Vieques, PR 00765

Sr. Emeric Catarineau
President
Vieques Municipal Assembly
Vieques, PR 00765

Non-Governmental Organizations

Ms. Aimée Houghton
Associate Director
Center for Public Environmental Oversight
101 Connecticut Avenue, NW
Suite 1000
Washington, DC 20036

Mr. Lenny Siegel
Director
Center for Public Environmental Oversight
C/o PSC
222B View St.
Mountain View, CA 94041

Mr. John Lindsay-Poland
Director, Task Force on Latin America & Caribbean
Fellowship of Reconciliation
2017 Mission St. #305
San Francisco, CA 94110

Secretary/Treasurer
Union for the Protection of the Environment of Vieques
PO Box 1504
Vieques, PR 00765

Vieques Chamber of Commerce
c/o The Crow's Nest
PO Box 1545
Vieques, PR 00765

Public Relations Committee
Vieques Conservation & Historical Trust
Calle Flamboyán #138
Esperanza Beach
Vieques, PR 00765

Public

To protect privacy, names and addresses of private individuals on the interested parties mailing list are not published. There are currently 122 people on the mailing list, 73 of whom are private individuals who are not listed.

Media

Vieques Times
153 Flamboyan St.
Esperanza Beach
Vieques, PR 00765

U.S. Navy

RADM Green
U.S. Federal Building, Room 354
150 Carlos Chardon Ave
Hato Rey, PR 00918

CDR James Skinner
U.S. Federal Building, Room 354
150 Carlos Chardon Ave
Hato Rey, PR 00918

LCDR Carmelo Melendez
U.S. Federal Building, Room 354
150 Carlos Chardon Ave
Hato Rey, PR 00918

Public Affairs Officer
Naval Forces, U.S. Southern Command
FTO AA 34099-6004

Mr. Rick Urbanski
OESO Directorate, Code N59
Naval Ordnance Safety and Security Activity
Farragut Hall Bldg D-323
23 Strauss Avenue
Indian Head, MD 20640-5555

Captain John Warnecke
Commanding Officer
U.S. Naval Station Roosevelt Roads
PSC 1008
Box 3001
FPO AA 3405

Ms. Madeline Rivera Ruiz
Environmental Program Manager
U.S. Naval Station Roosevelt Roads
PSC 1008, Box 3021
FPO AA 34051-3021

Commander William N. Hughes
Executive Officer
U.S. Naval Station Roosevelt Roads
PSC 1008
Box 3001
FPO AA 34051

Mr. Christopher Penny
Installation Restoration Section
US Naval Facilities Engineering Command
Atlantic Division, Code EV23
1510 Gilbert Street
Norfolk, VA 23511-2699

APPENDIX C

Fact Sheet

Community Fact Sheet

Summer 2002

RCRA Facility Investigation

Eastern Maneuver Area and Atlantic Fleet Weapons Training Facility (Non-Range) Vieques Island, Puerto Rico

Background

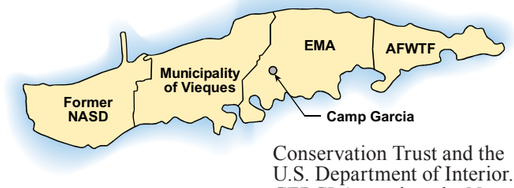
The U.S. Navy owns about 14,600 acres on the eastern side of Vieques Island. The Eastern Maneuver Area (EMA) takes up 11,000 acres on the east-central portion of the island and the Atlantic Fleet Weapons Training Facility (AFWTF) takes up 3,600 acres on the far eastern end of the island (see Figure 1). The AFWTF and EMA have been used for naval training exercises. Camp Garcia, located in the EMA, contains public works facilities to maintain the vehicles, buildings, roads and utilities that are needed for Navy activities on Vieques. These lands contain areas that may have been contaminated by past activities such as training exercises, maintenance activities, storage of supplies, and waste disposal.

Since May 1999, the Navy has only used inert (non-explosive) **ordnance** on the training range. However, most of the Navy's past training on the live impact area of AFWTF before that date used explosive ordnance. As part of normal operations, unexploded ordnance (UXO) has been periodically cleared from the training range and destroyed by open burning/open detonation at the AFWTF. Some expired or otherwise deteriorated munitions were also destroyed there.

The U.S. Department of the Navy is beginning an environmental investigation of potential contamination on some of its property on the eastern side of Vieques Island, Puerto Rico. The U.S. Environmental Protection Agency (EPA) is overseeing this work through an Administrative Order on Consent (Consent Order) signed with the Navy. This fact sheet explains the process for planning and carrying out this environmental investigation, as well as cleanup or other actions needed to protect the public and the environment, and opportunities for the public to provide input into this work. Terms and acronyms in bold print are explained in the Glossary.

Western Vieques

In April 2001, the Navy transferred 8,100 acres of land on the western side of island to the Municipality of Vieques, the Puerto Rico Conservation Trust and the U.S. Department of Interior. CERCLA requires the Navy to conduct all necessary investigations and cleanup work to protect human health and the environment from any hazardous substances remaining from past Navy activities on this transferred property. (CERCLA is the Comprehensive Environmental Response and Liability Act, which is more commonly known as "Superfund.")



Seventeen potentially contaminated sites on the western lands are currently being investigated, to determine what cleanup actions are needed. The Navy is the **lead agency** for the work on western Vieques, with guidance from the Puerto Rico Environmental Quality Board (EQB) and EPA.

What is RCRA?

The **Resource Conservation and Recovery Act (RCRA)** is the federal law through which EPA regulates and permits facilities that store, treat or dispose of solid and hazardous wastes. Under RCRA, EPA can also require facilities that are subject to RCRA permit regulations to investigate and clean up any wastes that may have been released into the environment. This cleanup process is called a **corrective action**. Figure 2 illustrates the RCRA corrective action process and the opportunities for public participation.

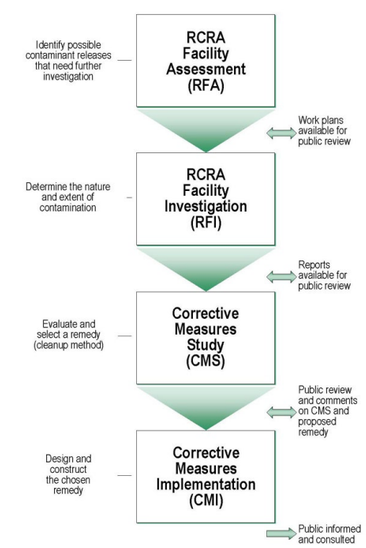


Figure 2
RCRA Process

Para mas Informacion. . .

Depositos de Informacion Publica

U.S. Environmental Protection Agency
Caribbean Environmental Protection Division
Atention: Daniel Rodríguez
Edificio Centro Europa, Suite 417
1492 Avenida Ponce De León
San Juan, PR 00907
Horas: lunes–viernes 8:00 a.m. 4:00 p.m.
Teléfono: (787) 977-5849
Correo electrónico: Rodriguez.Daniel@epa.gov

Biblioteca Pública
José Gautier Benítez
Calle Baldorioty de Castro
Isla de Vieques, PR 00765
Horas: lunes–viernes 8:00 a.m–6:00 p.m.
Teléfono: (787) 741-3706

A quien contactar para sus preguntas y comentarios:

U.S. Environmental Protection Agency, Region 2

Carlos Ramos
Office of Regional Administrator
290 Broadway, 26th Floor
New York, NY 10007-1866
Teléfono (212) 637-3588
Fax: (212) 637-4943
Correo electrónico: Ramos.carlos@epa.gov

Timothy Gordon
RCRA Programs Branch
290 Broadway, 22nd Floor
New York, NY 10007-1866
Teléfono: (212) 637-4167
Fax (212) 637-4437
Correo electrónico: Gordon.Timothy@epa.gov

Los archivos también están disponibles en la Junta de Calidad Ambiental de Puerto Rico, contactando a:
Eugene Scott or Yarissa Martínez
National Plaza Building, Office 225
431 Ponce de León
Hato Rey, PR 00917
Teléfono: (787) 767-8181
Correo electrónico: YarissaMartinez@jca.gobierno.pr

Marina de los EEUU

Christopher T. Penny
Remedial Project Manager
Atlantic Division, Code EV23
1510 Gilbert Street
Norfolk, VA 23511-2699
Teléfono 757-322-4815
Correo electrónico: PennyCT@efdlant.navfac.navy.mil

Madeline Rivera Ruiz
Environmental Engineering Division
U.S. Naval Station Roosevelt Roads
PSC 1008, Box 3021
PO AA 34051-3021
Teléfono (787) 865-4152, x 460
Correo electrónico: RiveraMad@navstarr.navy.mil

What Will the Navy Do Under its Consent Order with EPA?

In January 2000, EPA and the Navy voluntarily entered into a RCRA Administrative Order on Consent to address potential environmental contamination at certain (non-range) areas of the AFWTF and EMA. The Consent Order requires the Navy to perform a **RCRA Facility Investigation (RFI)** at nine **Solid Waste Management Units (SWMUs)** and three **Areas of Concern (AOCs)**. AOCs are areas that may be contaminated, but are not clearly linked to waste management activities. The twelve sites that will be investigated under the Consent Order do not include sites used as active military ranges, either for training or the disposal of waste munitions, such as the Live Impact Area and Open Burn/Open Detonation (OB/OD) area at AFWTF.

If the results of the investigations show that cleanup work or other actions are needed to address any threats posed to people's health or to the environment, the Consent Order also requires the Navy to perform a Corrective Measures Study (CMS) to evaluate alternatives to do this work. Also, the Consent Order requires the Navy to take **interim measures**, if necessary, to prevent or reduce any immediate threats to people's health (including Navy personnel working at Camp Garcia) or to the environment that might be discovered while the study process is underway.

All of the Navy's work under this Consent Order is subject to EPA's approval and oversight, with input from EQB. In addition, the public will be given the opportunity to review and comment on all significant documents and plans developed under this Consent Order.

Planning for the Investigations

The first step in the RFI is to prepare a *Description of Current Conditions Report*, which pulls together historical information and current knowledge about existing conditions at the identified SWMUs and AOCs, as well as any other areas of the facility currently or previously used for treatment, storage, or disposal of solid or hazardous waste. This report is then used to prepare the work plans for the investigations.

The RFI Work Plans describe the objectives, technical approach, and schedule for a site investigation. They describe where and how samples will be collected and handled, which contaminants will be investigated, and how the samples will be analyzed. A work plan has also been prepared for completing the baseline groundwater investigation along the western boundary of the EMA. This investigation will supplement previous groundwater investigations conducted by the Navy.

Once EPA has approved the RFI Work Plans and the *Description of Current Conditions* report, these documents will be released for public review.

Twelve sites will be investigated under the Consent Order

Nine **SWMU**s and three suspected **AOC**s are required to be investigated under the Consent Order. These SWMUs and AOCs were identified in the **RCRA Facility Assessments (RFA)** of the AFWTF and EMA that were prepared for EPA in 1988 and 1995. These twelve sites cover a total of approximately 80 acres. All are located on Navy-owned lands, mostly at or near Camp Garcia. Actions at another three SWMUs (#3, #9, and #11) are deferred, because they are currently part of active military ranges.

- SWMU 1 - Camp Garcia Landfill
- SWMU 2 - Fuels Off-Loading Site (Camp Garcia)
- SWMU 4 - Waste Areas of Building 303 (Camp Garcia)
- SWMU 5 - Spent Battery Accumulation Area (Observation Post 1, AFWTF Inner Range)
- SWMU 6 - Waste Oil and Paint Accumulation Area (Seabees Area, Camp Garcia)
- SWMU 7 - Waste Oil Accumulation Area (outside Building 303 at Camp Garcia)
- SWMU 8 - Waste Oil Accumulation Area (Observation Post 1, AFWTF Inner Range)
- SWMU 10 - Sewage Treatment Lagoons (Camp Garcia)
- SWMU 12 - Solid Waste Collection Unit Area (Observation Post 1, AFWTF Inner Range)
- AOC A - Diesel Fuel Fill Pipe Area (Observation Post 1, AFWTF Inner Range)
- AOC F - Rock Quarry (Camp Garcia)
- AOC G - Pump Station and Chlorinating Building at Sewage Lagoons (Camp Garcia)

Some Potential Areas of Concern (PAOCs), which are discussed in the *Description of Current Conditions Report*, could be added to the requirements of the Consent Order, if preliminary study finds evidence that hazardous or solid wastes might have been released at these areas.

Environmental Investigations and Results

After the RFI work plans are finalized, samples will be collected from the soil, surface water, or ground water at each of the twelve sites. Samples will be analyzed using EPA's quality control protocols. After the data are evaluated to determine what chemicals are present at each site, a draft RFI report will be prepared to describe these results and recommend further action (or no action) at each site. Further action may include active cleanup work. The report will be submitted to EPA Region 2 and the EQB for review and approval. This process could take one or more years to complete. EPA will notify the community when the draft RFI report is available for public comment and review.

In 1999, the Navy prepared a report indicating that the results of the groundwater, surface soil and subsurface soil sampling along the western border of the EMA did not detect munitions-related contaminants. This report, *Results of the Hydrogeologic Investigation, Vieques Island, Puerto Rico* (November 1999), was based on sampling work that the Navy initiated and completed independently, before entering into the January 2000 RCRA Consent Order. To satisfy EPA's RCRA requirements under the Consent Order, the Navy will collect more groundwater samples from designated groundwater monitoring wells and analyze these samples for additional contaminants as specified in the work plan. The *Work Plan for Groundwater Baseline Investigation at the US Navy's Eastern Maneuver Area, Puerto Rico*, describes how this additional work will be done. It will be made available for public review and comments, along with the other RFI work plans, before being finalized.

¿Cual el proximo paso?

Si el RFI confirma la necesidad de una limpieza o de alguna otra acción correctiva (corrective action) en uno o más sitios, se preparará un Estudio de Medidas Correctivas (CMS) será preparado para evaluar las alternativas. Después de finalizar el CMS y cuando la EPA seleccione tentativamente la acción de respuesta preferida, la EPA solicitará al público sus comentarios tanto sobre el informe CMS como sobre la acción recomendada. Una vez que la EPA haya revisado y considerado los comentarios públicos, y en el caso de que el CMS requiera que la Marina implemente un plan final de limpieza ambiental, la acción de respuesta será seleccionada y la Orden de Consentimiento RCRA sería modificada.

Area de Impacto Vivo

Otras áreas conocidas con contaminación potencial en el AFWTF incluyendo el Area de Quema/Detonación Abierta en donde se ha destruido artillería no estallada, y el Area de Impacto Vivo no están actualmente incluidas en la Orden de Consentimiento y el RFI, porque éstas forman parte del área de entrenamiento militar activo. Si el campo de entrenamiento militar activo se cierra, la remoción de los explosivos y artillería y las actividades de limpieza ambiental en este sitio serían tratadas por separado.

La Participacion Publica

La participación pública es una parte importante en el proceso de investigación y limpieza ambiental. La participación de los residentes viequenses ayudará a que la Marina y la la EPA tomen mejores decisiones. El público tendrá varias oportunidades formales para comentar sobre los documentos del estudio y las acciones de restauración propuestas. Sin embargo, se invitan los comentarios y preguntas en cualquier momento del proceso de la investigación. Al final de esta hoja de información se presenta una lista del personal de la EPA, la Marina, y la JCA que puede contestar sus preguntas.

La EPA y la Marina trabajarán con los miembros de la comunidad de Vieques para preparar un Plan de Relaciones Comunitarias. Este plan describirá la manera en la cual se mantendrá informada a la comunidad sobre las actividades realizadas bajo la Orden de Consentimiento y cómo se obtendrán los comentarios públicos. *Si usted está intersado en ayudarnos a desarrollar este plan, favor contactar a Carlos Ramos* (*ver al final de la hoja*).

La Marina mantiene una lista de direcciones de aquellas personas que desean recibir las hojas de información u otros detalles sobre el estudio ambiental y el proceso de limpieza en la Isla de Vieques. *Para incluir su nombre el la lista de direcciones, favor contactar a Carlos Ramos* (*ver al final*).

Existen algunos depósitos de información pública en los que se almacenan la Orden de Consentimiento, los planes de trabajo, las hojas de información, informes técnicos y otros documentos disponibles para revisión pública. Las direcciones y horas de atención de los depósitos de información pública se encuentran en la última página.

Un Comité de Revisión Técnica (TRC—Technical Review Committee) fue establecido en el año 2001 para proveer un foro para intercambiar información sobre la limpieza de las propiedades anteriores de la Marina en el lado Oeste de Vieques. Este grupo formado por residentes de Vieques interesados y representantes de las agencias gubernamentales será también un enlace valioso entre la Marina, la EPA, la JCA, y la comunidad local durante la investigación y limpieza de la EMA y la AFWTF bajo de la Orden de Consentimiento. *Para más información sobre las reuniones del TRC para la investigación ambiental del Oeste de Vieques, favor contactar a Madeline Rivera Ruiz o Christopher Penny* (*ver al final*).

Glosario

Acción Correctiva

La secuencia de acciones, comenzando con la evaluación inicial de la instalación hasta la finalización de la acción de restauración—que se toman para enfrentar el escape de desperdicios peligrosos en una instalación bajo un permiso RCRA.

Acción Provisoria o Acción Interina

Una acción a corto plazo adoptada para enfrentar un escape o amenaza de escape de sustancias peligrosas.

Agencia Implementadora o agencia principal

Es la agencia autorizada para tomar las decisiones finales. En los lugares regidos por CERCLA que no están dentro de la Lista de Prioridades Nacionales (NPL), la agencia principal es la Marina con intervención de la EPA. En los sitios CERCLA dentro de la NPL. En sitios RCRA, la EPA es la agencia implementadora.

Agua Subeterránea

Agua que fluye bajo la superficie de la tierra y que abastece pozos y fuentes. Puede venir de las aguas de lluvia que se filtran por la tierra, o puede fluir debajo de la superficie de la tierra puntos más altos. El agua subterránea puede desembocar en un riachuelo o en otro cuerpo de agua superficial hacia abajo. El agua subterránea puede llevar contaminantes de un lugar a otro.

AOC - Area de Interés

Un área que, según información sobre su uso previo, puede estar contaminada.

Artillería/Explosivos

Incluyen materiales militares tales como armas, municiones, vehículos de combate y el equipo utilizado para su mantenimiento. Los explosivos pueden incluir municiones, pólvora, cartuchos explosivos, cápsulas detonantes, etc.

CERCLA - Ley Comprensiva de Respuesta, Compensación y Responsabilidad Ambiental (generalmente conocida como "Superfund")

Esta ley provee el proceso para identificar, investigar y limpiar sustancias peligrosas que han sido liberadas al medio ambiente y que pueden presentar un riesgo a la salud humana o al medio ambiente. El Programa de la Restaruración de la Marina (RI) está conducido bajo la autoridad CERCLA del Departmento de Defensa (DoD's)

CMI - Implementación de Medidas Correctivas

La fase final de una acción correctiva RCRA, cuando la tecnología seleccionada se construye o se instala y se opera hasta el punto de alcanzar los niveles de limpieza.

CMS - Estudio de Medidas Correctivas

Examina las alternativas de limpieza ambiental en una acción correctiva RCRA; se basa en una Investigación de Instalación RCRA (RFI), y recomienda la acción correctiva preferida.

Orden de Consentimiento

Una acción correctiva RCRA puede ser una Orden de Consentimiento si el dueño de la instalacion (en este caso, la Marina) y la EPA están de acuerdo sobre la necesidad y los detalles de una acción correctiva; o es una Orden Unilateral cuando las partes no llegan a un acuerdo.

RFA - Evaluación de Instalación RCRA

Es el primer paso hacia una acción correctiva RCRA. Revisión de Registros, inspección visual del lugar y muestreo limitado; buscando evidencia que indique que escapes de desperdicios peligrosos han sido liberados (o pudieron sido liberados) hacia el medioambiente que pueden necesitar una acción correctiva.

RFI - Investigación de Instalación RCRA

Un estudio detallado para determinar la naturaleza (cuáles sustancias) y la extensión (cuánto, cuán grande es el área) de la contaminación; para evaluar el riesgo potencial a la salud humana y al medioambiente; para determinar si se necesita o no una acción correctiva; y para apoyar la evaluación de medidas de restauración alternativas.

SWMU - Unidad de Manejo de Desperdicios Sólidos

Un área determinada, que es, o se sospecha que es fuente de lieberación de desperdicios (peligrosos o no) en el medioambiente. Requiere de investigación y posiblemene una acción correctiva.

TRC - Comité de Revisión Técnica

El TRC consiste de un grupo de individios, incluyendo personal de la Marina, EPA, oficiales locales y estatales, miembros de la comunidad, quienes revisan y comentan sobre los informes técnicos.

¿Que hara la Marina de los EEUU con su Orden de Consentimiento con la EPA?

En enero del 2000, la EPA y la Marina convinieron voluntariamente en una Orden Administrativa de Consentimiento RCRA para tratar la contaminación ambiental potencial en ciertas áreas (no en los campos de tiro) de la AFWTF y la EMA. La Orden de Consentimiento requiere que la Marina realice una **Investigación de Instalación RCRA** (**RFI**—RCRA Facility Investigation) en nueve **Unidades de Manejo de Desperdicios Sólidos** (**SWMUs**—Solid Management Units) y en tres **Areas de Interés** (**AOC**—Area of Concern). Las AOC son áreas que pueden estar contaminadas, pero que no están claramente relacionadas a las actividades del manejo de desperdicios. Las 12 áreas que serán investigadas bajo la Orden de Consentimiento no incluyen los sitios utilizados ya sea como campos activos de ejercicios militares, tampoco aquellos utilizados para actividades de entrenamiento, o para disposición de municiones de desecho como sucede en la AFWTF en el Area de Impacto Vivo y Quema Abierta/ Detonación Abierta.

Si los resultados de la investigación indicarán la necesidad de una limpieza ambiental u otras acciones para controlar o evitar cualquier amenaza a la salud pública o al medio ambiente, la Orden de Consentimiento también requiere que la Marina realice un **Estudio de Medidas Correctivas** (**CMS**—Corrective Measures Study) para poder evaluar las alternativas para realizar este trabajo. Además, la Orden de Consentimiento requiere que la Marina tome, de ser necesarias, **medidas provisorias** (interim measures) para prevenir o reducir cualquier amenaza inmediata a la salud pública (incluyendo al personal de la Marina que trabaja en el Campamento García) o al medioambiente, y que podría ser descubierta mientras el proceso de estudio se está realizando.

Todo el trabajo realizado bajo esta Orden de Consentimiento está sujeto a la aprobación y supervisión de la EPA con comentarios de la JCA. Además, bajo esta Orden se le dará al público la oportunidad de revisar y ofrecer comentarios sobre todos los documentos y planes importantes.

Planificacando las Investigaciones

El primer paso en un RFI es preparar un *Informe de Descripción de Condiciones Actuales* (*Description of Current Conditions Report*) que compila información histórica y actual sobre las condiciones existentes en las SWMUs y AOCs identificadas, así como en otras áreas de la instalación que fueron o están siendo utilizadas para el tratamiento, almacenamiento, o disposición de desperdicios sólidos o peligrosos. De ahi que, este informe se utiliza para preparar los planes de trabajo para las investigaciones.

Los Planes de Trabajo RFI describen los objetivos, alcances técnicos y el calendario de actividades de la investigación del sitio. Describen dónde y en qué manera se colectarán y se tratarán las muestras; qué contaminantes serán investigados y cómo serán analizadas los resultados. También se ha preparado un Plan de Trabajo para completar el estudio de trasfondo base de agua subterránea a lo largo de la frontera Oeste del EMA. Esta investigación añadirá información a los estudios de agua subterránea realizados por la Marina.

Después deque la EPA apruebe los planes de trabajo para la RFI y el *Informe de la Descripción de Condiciones Actuales*, estos documentos estarán disponibles para la revisión del público.

12 lugares seran investigados bajo de la Orden de Consentimiento

Las nueve **SWMUs** (Unidades de Manejo de Desperdicios Sólidos/*Solid Waste Management Units*) conocidas y tres **AOCS** (*Areas de Interés/Areas of Concern*) sospechosas requieren ser investigadas bajo una Orden de Consentimiento. Estas SWMUs y AOCs fueron identificadas en las **Evaluaciones de Instalación RCRA** (**RFA**) de la AFWFT y la EMA que fueron preparadas por la EPA en 1988 y 1995. Estos 12 sitios cubren un total de aproximadamente 80 acres. Todos están localizados en terrenos pertenecientes a la Marina, la mayoría dentro o cerca del Campamento García. Acciones para otros tres SWMUSs (#3, #9 and # 11) han sido aplazadas ya que éstas actualmente forman parte de campos militares activos.

- SWMU 1—Vertedero de Campamento García
- SWMU 2—Area de Descarga de Carburantes (Campamento García)
- SWMU 4—Areas de Disposición del Edificio 303 (Campamento García)
- SWMU 5—Area de Almacenaje de Baterías Utilizadas (Puesto de Observación 1, Campo Interior de la AFTWF)
- SWMU 6—Area de Almacenaje de Desperdicios de Pintura y Aceite (Area Seabees, Campamento García)
- SWMU 7—Area de Almacenaje de Aceite Usado (fuera del Edificio 303 en el Campamento García)
- SWMU 8—Area de Almacenaje de Aceite Usado (Puesto de Observación 1, Campo Interior de la AFTWF)
- SWMU 10—Lagunas de Tratamiento de Aguas Negras (Campamento García)
- SWMU 12—Area de la Unidad de Colección de Desperdicios Sólidos (Puesto de Observación 1, Campo Interior de la AFTWF)
- AOC A—Area de la Tubería de Combustible Diesel, Puesto de Observación 1; Campo Interior de la AFWTF)
- AOC F—Cantera (Campamento García)
- AOC G—(Campamento García) Estación de Bombeo y Edificio de Clorinación en las Lagunas de Aguas Negras (Campamento García)

Algunas Areas de Interés Potenciales (PAOCs), las cuales se discuten en el Informe de *Descripción de Condiciones Actuales*, puede ser añadidas a los requerimientos de la Orden de Consentimiento, si un el estudio preliminar encuentra evidencia de que desperdicios peligrosos o sólidos pudieran haber sido liberados en estas áreas.

Las Investigaciones Ambientales y sus Resultados

Después de finalizar los planes de trabajo RFI, se colectarán muestras del suelo, agua superficial o agua subterránea en cada uno de los 12 lugares. Se analizarán las muestras según las reglas de garantía de calidad establecidas por la EPA.

Después de que los datos sean evaluados para determinar cuales sustancias químicas están presentes en cada sitio, se preparará un borrador del informe RFI para describir los resultados y recomendar acciones adicionales (o no acciones) en cada área. Acciones adicionales pueden incluir trabajos de limpieza ambiental activos. El informe será entregado a la Región 2 de la EPA y a la JCA para su revisión y aprobación. Este proceso puede tomar un año o más para ser finalizado. La EPA notificará a la comunidad cuando el borrador del informe RFI esté disponible para comentarios y revisión pública.

En 1999, la Marina preparó un informe indicando que los resultados del muestreo de agua subterránea, suelo superficial y subsuelo en la frontera Oeste de la EMA no indicaron la presencia de contaminantes relacionados a las municiones. Este informe *Resultados de la Investigación Hidrogeológica en Isla de Vieques, Puerto Rico—noviembre de 1999* (*"Results of the Hydrogeologic Investigation, Vieques Island, Puerto Rico—November 1999"*) se basó en el muestreo iniciado y finalizado independientemente por la Marina, antes de que entrara en el convenio de la Orden de Consentimiento de enero del 2000. Para satisfacer los requerimientos RCRA de la EPA bajo de la Orden de Consentimiento, la Marina colectará muestras adicionales de agua subterránea de pozos de muestreo designados y analizará estas muestras para determinar la presencia de contaminantes adicionales como está especificado en el plan de trabajo. El Plan de Trabajo para la *Investigación de Trasfondo Base de Agua Subterránea en en el Area Este de Maniobras de la Marina de los EEUU, Puerto Rico* (*Work Plan for Groundwater Baseline Investigation at the US Navy's Eastern Maneuver Area, Puerto Rico*) describe la manera como se realizará este trabajo adicional. Este documento y los otros planes de trabajo RFI estarán disponibles para la revisión y comentarios del público antes de éstos sean finalizados.

What Comes Next?

If the RFI confirms that a cleanup or other corrective action is needed at one or more of the sites, a Corrective Measures Study (CMS) will be prepared to evaluate alternatives. After the CMS is completed and EPA has tentatively selected the preferred response action, EPA will ask the public for its comments on both the CMS Report and the recommended action. Once EPA has reviewed and considered public comments, the response action will be selected and the RCRA Consent Order will be modified, if the CMS requires the Navy to implement a final cleanup plan.

Live Impact Area

Other known areas of potential contamination on the AFWTF, including the OB/OD area at which unexploded ordnance has been destroyed and the Live Impact Area, are not currently included in the Consent Order and the RFI, because they are part of the active military training range. If the military training range is closed, the removal of ordnance explosives and the environmental cleanup at the active military range will be addressed separately.

Public Participation

Public participation is an important part of the environmental investigation and cleanup process. Input from Vieques residents will help the Navy and the EPA make better decisions. The public will have several formal opportunities to comment on the study documents and the proposed remedies. However, questions and comments are welcome at any time during the study process. People from EPA, the Navy, and EQB who can answer questions are listed at the end of this fact sheet.

EPA and the Navy will work with community members from Vieques to prepare a Community Relations Plan. This plan will describe how the community will be kept informed about the activities carried out under the Consent Order and how public input will be obtained. *If you are interested in helping us to develop this plan, please contact Carlos Ramos (see last page).*

The Navy maintains a mailing list of people who want to receive fact sheets and other information about the environmental study and cleanup process on Vieques Island. *To get on the mailing list, please contact Carlos Ramos (see last page).*

Several public information repositories exist, at which the Consent Order, work plans, fact sheets, technical reports and other documents are available for public review. Locations and hours of the public information repositories are shown on the last page.

A Technical Review Committee was formed in 2001, to provide a forum for exchanging information about the cleanup of the Navy's former property on the western side of Vieques. This group of interested Vieques residents and government representatives will also be a valuable link between the Navy, EPA, EQB and the local community during the investigation and cleanup of the EMA and AFWTF under the Consent Order. *For information about meetings of the TRC for the environmental investigation of western Vieques, please contact Madeline Rivera Ruiz or Christopher Penny (see last page).*

Glossary

AOC Area of Concern.
An area that might be contaminated, based on information about its previous use.

CERCLA
The Comprehensive Environmental Response, Compensation and Liability Act (commonly known as "Superfund") provides a process for identifying, investigating, and cleaning up hazardous substances that have been released into the environment and may pose a risk to human health and the environment. The Navy's Installation Restoration (IR) program is conducted under DoD's CERCLA authority.

CMI
Corrective Measures Implementation. The final phase in a RCRA corrective action, when the selected cleanup technology is constructed or installed and operated until cleanup levels are reached.

CMS
Corrective Measures Study. Examines alternatives for cleanup in a RCRA corrective action, based on a RCRA Facility Investigation (RFI), and recommends a preferred remedy.

Consent Order
A RCRA corrective action order can be a Consent Order, when the facility owner (Navy) and EPA come to an agreement about the need for and details of a corrective action, or a Unilateral Order, when agreement cannot be reached.

Corrective action
The sequence of actions, from initial facility assessment to the completion of remedial action, that are taken to address releases of hazardous wastes at a RCRA-permitted facility.

Ground water
Water that flows under the ground and supplies wells and springs. It can come from rainwater that soaked into the ground or it can flow underground from "uphill" locations. Ground water can flow out into a stream or another "downhill" surface water body. Ground water can carry contaminants from one place to another.

Interim measure
A short-term action that is taken to address a release or threatened release of hazardous substances.

Lead agency
The agency with the authority to make final decisions. At CERCLA sites not on the National Priorities List (NPL), the Navy is the lead agency, with EPA involvement. At CERCLA sites on the NPL, EPA is the lead agency. At RCRA sites, EPA is the lead agency.

Ordnance/Explosives
Ordnance includes military material such as weapons, ammunition, combat vehicles, and the equipment used to maintain them. Explosives can include ammunition, gunpowder, flash cartridges, blasting caps, etc.

RFA
RCRA Facility Assessment. The first step towards a RCRA corrective action. Records review, visual site inspection and limited sampling, looking for evidence that hazardous wastes might have been (or could be) released to the environment and a corrective action may be needed.

RFI
RCRA Facility Investigation. Detailed study to determine the nature (what substances) and extent (how much, how large an area) of contamination; to assess the possible risk to human health or the environment; to determine whether or not corrective action is needed; and to support the evaluation of remedial alternatives.

SWMU
Solid Waste Management Unit. A designated area that is, or is suspected to be, the source of a release of wastes (hazardous or non-hazardous) into the environment. Requires investigation and possibly corrective action.

TRC
Technical Review Committee. A group of individuals, including Navy, EPA, state and local officials, and community members, who review and comment on technical reports.

WHERE CAN I GET MORE INFORMATION?

Public Information Repositories

US Environmental Protection Agency
Caribbean Environmental
Protection Division
Attention: Daniel Rodriguez
Centro Europa Building, Suite 417
1492 Ponce De Leon Avenue
San Juan, PR 00907
Hours: Monday-Friday, 8:00 a.m.-4:00 p.m.
Telephone: (787) 977-5849
Email: Rodriguez.Daniel@epa.gov

Biblioteca Pública, José Gautier Benitez
Calle Baldorioty de Castro
Vieques Island, PR
Hours: Monday-Friday, 8:00 a.m.-6:00 p.m.
Telephone: 787-741-3706

Files are also available at the Puerto Rico Environmental Quality Board. See point-of-contact information below.

People to call with questions or comments:

U.S. Environmental Protection Agency

Carlos Ramos
Region 2
Office of Regional Administrator
290 Broadway, 26th Floor
New York, NY 10007-1866
Phone: (212) 637-3588
Fax: (212) 637-4943
Email: Ramos.carlos@epa.gov

Timothy Gordon
Region 2
RCRA Programs Branch
290 Broadway, 22nd Floor
New York, NY 10007-1866
Phone: (212) 637-4167
Fax (212) 637-4437
Email: Gordon.Timothy@epa.gov

Puerto Rico Environment Quality Board

Eugene Scott or Yarissa Martinez
National Plaza Building, Office 225
431 Ponce de Leon
Hato Rey, PR 00917
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U.S. Navy

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Hoja de Información Comunitaria

Verano del 2002

Investigacion de Instalacion RCRA

Area Este de Maniobras e Instalación de Entrenamiento de Guerra de la Flota del Atlántico (no el campo de tiro)
Isla de Vieques, Puerto Rico

Introduccion

Aproximadamente 14,600 acres en el lado Este de la Isla de Vieques pertenecen a la Marina de los EEUU. El Area Este de Maniobras (EMA—Eastern Maneuver Area) ocupa unos 11,000 acres en la parte Este del centro de la Isla y la Facilidad de Entrenamiento de Guerra de la Flota del Atlántico (AFWTF—Atlantic Fleet Weapons Training Facility) ocupa aproximadamente 3,600 acres en el extremo Este de la Isla (ver Figura 1).

La AFTWF y la EMA han sido utilizadas para realizar ejercicios de entrenemiento naval. Campo García, localizado dentro de la EMA, contiene las instalaciones de obras públicas para mantención de vehículos, edificios, caminos y los servicios necesarios para las actividades de la Marina en la Isla de Vieques. Estos terrenos contienen áreas potencialmente contaminadas por las actividades pasadas de la Marina, como ejercicios de entrenamiento, mantenimiento, almacenamiento de materiales, y la disposición de desperdicios.

A partir de mayo de 1999, la Marina ha utilizado solamente **artillería/municiones** inertes (no explosivas) en el campo de entrenamiento. Sin embargo, la mayoría de las actividades de entrenamiento anteriores a esta fecha dentro del área de impacto vivo de la AFWTF utilizaron artillería/municiones explosivas. En la Facilidad de Entrenemiento AFWTF, como parte de las operaciones normales, se han eliminado periodicamente artillería/municiones no estalladas (UXO -unexploded ordnance) del campo de entrenamiento por medio de quema abierta/detonación abierta (OB/OD—open burning/open detonation). En esta área se también se han destruido artillería/municiones caducadas o deterioradas.

El Departamento de la Marina de los EEUU está realizando una investigación ambiental de la contaminación potencial en ciertos lugares de su propiedad en el lado Este de la Isla de Vieques, Puerto Rico. La Agencia de Protección Ambiental de los EEUU (la EPA, o Environmental Protection Agency) está supervisando este trabajo bajo una Orden Administrativa de Consentimiento, firmada con la Marina de los EEUU. Esta hoja de información explica el proceso de planificación, ejecución de la investigación ambiental, así como cualquier acción de limpieza u otras acciones necesarias para proteger al público y al medio ambiente, e identifica las oportunidades para la participación pública. Los términos y siglas en negrilla se explican en el Glosario.

Los Terrenos en el Oeste de Vieques

En abril de 2001, la Marina traspasó alrededor de 8,100 acres de terrenos en el lado Oeste de la Isla a la Municipalidad de Vieques, el Fideicomiso de Conservación de Puerto Rico y el Departamento del Interior de los EEUU. La Ley CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act) requiere que la Marina realice todas las actividades de investigación y limpieza necesarias para proteger la salud pública y el medioambiente contra cualquier sustancia peligrosa remanentede las actividades pasadas de la Marina en estos terrenos transferidos. (**CERCLA es la Ley Comprensiva de Respuesta, Compensación y Responsabilidad Ambiental**, la cual es comunmente conocida como "Superfund").

Actualmente se están investigando 17 lugares potencialmente contaminados en el Oeste de la Isla de Vieques para determinar cuales son las acciones de limpieza necesarias. La Marina es la **agencia principal** para realizar este trabajo guiada por la Junta de Calidad Ambiental de Puerto Rico—JCA o el Environmental Quality Board—EQB) y la EPA.

¿Que es la Ley RCRA?

La ley de Conservación y, Recuperación de Recursos (RCRA—Resource Conservation and Recovery Act) es la ley federal a través de la cual se regula y se permite que instalaciones almacenen o dispongan de sustancias sólidas y desperdicios peligrosos. La EPA puede también requerir que aquellas instalaciones que funcionan bajo las regulaciones de un permiso RCRA investiguen y limpien cualquier desperdicio que pudo haber sido descargado en el medioambiente. Este proceso de limpieza se denomina **acción correctiva**. La Figura 2 ilustra el proceso de acción una correctiva RCRA y las oportunidades para la participación pública.

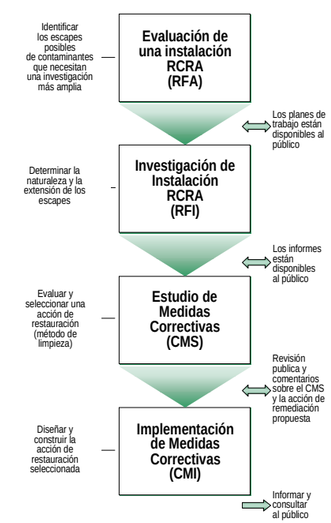

Figura 2
El Proceso RCRA

Master Health and Safety Plan

CH2M HILL HEALTH AND SAFETY PLAN

(REFERENCE CH2M HILL SOP HS-19, *SITE-SPECIFIC WRITTEN SAFETY PLANS*)

This Health and Safety 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: 139322

CLIENT: United States Navy

PROJECT/SITE NAME: Atlantic Fleet Weapons Training Facility

SITE ADDRESS: Vieques Island, Puerto Rico

CH2M HILL PROJECT MANAGER: Martin J. Clasen, P.G.

CH2M HILL OFFICE: Tampa, Florida

DATE HEALTH AND SAFETY PLAN PREPARED: February, 2001

DATE(S) OF SITE WORK: 2nd and 3rd Quarter, 2001

SITE ACCESS: The area of investigation is accessed through the secure Main Gate of Camp Garcia. All subject sites are located on the eastern portion of Vieques Island, Puerto Rico.

SITE SIZE: 11,000 acres

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 terrain mentioned above. These areas contain level terrain primarily made up 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 79°F to 80°F, and

a mean daily temperature range of 15°F to 25°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 occupies approximately 22,600 acres of the roughly 33,000 acres making up Vieques Island. The 22,600 acres include the following: Naval Ammunition Support Detachment (NASD) consists of 8,000 acres along the western most tip of the island; the Eastern Maneuver Area (EMA) consists of 11,000 acres located in the east-central portion of the island; and the Atlantic Fleet Weapons Training Facility (AFWTF) consists of 3,600 acres along the eastern portion of the island (USEPA, Region II). The areas of EMA and AFWTF (LANT) are known as the Inner Range extending to a limit of 3 miles from the shoreline. The area known as the Air Impact Area (AIA) is located within the AFWTF, and is primarily used for gunfire and ordnance delivery training activities. This island lies roughly 7 miles southeast of the U.S. Naval Station Roosevelt Roads (NSRR), Puerto Rico. Figure 1-1 is a facility map depicting the SWMU and AOC locations. The areas mentioned above function under the command of Commander Fleet Air Caribbean and Naval Forces Caribbean, with headquarters located at NSRR. Although the 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 AFWTF.

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 AFWTF 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 waste are treated through open burning/open detonation (OB/OD) processes.

SWMU Descriptions

The following subsection present a general description and history of each solid waste management unit (SWMU). Available information regarding the nature and extent of contamination at the SWMU is also presented. The descriptions of these SWMUs and the potential for releases are based on a Preliminary Review (PR) and a Visual Site Inspection (VSI) provided either in the RCRA Facility Assessment (RFA), or in the Administrative Order On Consent between the U.S. Environmental Protection Agency (EPA) and the Navy.

SWMU 1 - Camp Garcia Landfill

According to the RFA, the Camp Garcia Landfill is located in the EMA approximately 4,000 feet north-northwest of Blue Beach. The actual landfill is located roughly 2 miles east of Camp Garcia. 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, when it became inactive. When this SWMU was operational, this landfill disposed paper, corrugated containers, cans and food packaging material, rags, scrap metal, and yard waste. The municipal waste from both Camp Garcia and the Inner Range was disposed here. This particular landfill was not lined. It serviced approximately 150 individuals, depending on military exercises. One 5-ton dump truck was used every day, 5 days a week, to dispose waste to this site. Approximately 1,800 to 3,120 tons of waste was distributed over the 100 to 200-acre area. When this SWMU became inactive, a cap was installed.

The landfill today is vegetated with dense grasses, and a gravel road was constructed down its center in the mid-1980s. During the VSI, no signs of erosion or stresses on vegetation were observed. No documentation was discovered regarding releases at this SWMU (Vargas, 1995).

SWMU 2 - Fuels Off-Loading Site

This site is located at Camp Garcia, and is the former location of four aboveground storage fuel tanks (ASTs). 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 a barge pumping fuel through an 8-inch submarine line to each of these tanks. Prior to initiating this refueling process, seawater had to be flushed from the submarine line. During this process, approximately 1,000 gallons of fuel was discharged into the ocean and onto the land. According to the NACIP IAS study, this refueling process took place for approximately 25 years; therefore, approximately 100,000 gallons of fuel was potentially discharged during this time. Diesel fuel, unleaded gasoline, AVGAS, and JP-5 fuel were stored at this site during the operational period. The sludge that developed in these tanks was removed by a private contractor to be disposed of on the main island.

The site today is overgrown with grass and small shrubs, with only minimal signs of previous activity. During the VSI, no signs of previous releases to either the soil or the water were apparent, and no release controls were identified.

SWMU 4 - Waste Areas of Building 303 (Camp Garcia)

According to the RFA, the waste areas are located in Building 303 at Camp Garcia. These areas include a spent battery accumulation area; a catch basin for hydraulic oil; a cleaning/decreasing basin; and a rags, absorbent, and grease storage area. The last three areas listed were once individual areas of concern (AOCs), but were changed to SWMUs per the Administrative Order On Consent (USEPA, Region II).

The battery accumulation area contains spent batteries and battery acid to be disposed of offsite on NSRR. Once at NSRR, the batteries and acid will then be removed by a contractor. According to the abovementioned RFA, this area in Building 303 was established as a storage area for batteries ever since this building was erected in the 1960s. This unit remains active, and continues to house spent batteries and battery acid. During the VSI, no batteries

or acid were present at this location. This area showed no visible signs of leakage on the concrete floor from previous storage of these materials.

The catch basin for hydraulic oil is an area inside Building 303 designed to catch any hydraulic oil which may drip from the aboveground tanks. This basin in approximately 5 feet long and 6 inches wide. During the VSI, no signs of leakage were apparent on the cement floor under the basin.

The rags, absorbent, and grease storage area contains barrels of grease, rags, and other materials used when a spill develops. According to the RFA, this was also the area where spent batteries were once stored. During the VSI, no signs of spills were visible. No description of the cleaning / degreasing basin was available in the RFA (Vargas, 1995).

SWMU 5 - Spent Battery Accumulation Area (Inner Range)

This particular SWMU is located in the Inner Range portion of this installation. This area is similar to SWMU 4, but the batteries and battery acid stored here are outside on a gravel driveway. According to the RFA, the acid from these batteries is typically emptied into plastic containers and shipped to NSRR.

Although the start up date for this SWMU is unknown, it remains active today. During the VSI, nine batteries were stored at this site on the gravel driveway. There were no signs of any spills or leaks from these batteries. No release controls were identified at this SWMU (Vargas, 1995).

SWMU 6 - Waste Oil and Paint Accumulation Area (Seabees Area at Camp Garcia)

According to the RFA, this area is used by the Seabees as a storage area for waste oil and paint. The waste oil at this location is containerized in 55-gallon drums, and the paint is housed in small containers. Tires as well as a two drums of lubricating oil are present at this site. The waste oil and tires are stored on a grassy area until they are shipped offsite to NSRR. The RFA states that this area became active approximately 10 years ago, and remains active today. During the VSI, signs of oil leakage into the ground from the drums were visible. No release controls are present at this site (Vargas, 1995).

SWMU 7- Waste Oil Accumulation Area (outside building 303 at Camp Garcia)

According to the RFA, this area is located outside Building 303 at Camp Garcia. This area is used by the Marines 3 months per year. During these 3 months, Marines conduct exercises at the EMA, and need a place to dump waste oil from the maintenance of vehicles. This area includes an open-top 55-gallon drum, 25-gallon trash can, and two drums cut in half. According to the RFA, the soil in this area is typically stained with waste oil after maintenance procedures of marine vehicles. Once the Marines complete their training, it is reported that they excavate the soil under the waste oil storage area, and mix it with sand. The excavated soil would then be containerized in 55-gallon drums and shipped to NSRR. Although the start date for this site is unknown, the Marines continue to use this area for training. During the VSI, the drums appeared to be full and signs of waste oil were visible in the soil at this site. There were no release controls identified at this SWMU (Vargas, 1995).

SWMU 8 - Waste Oil Accumulation Area (Inner Range)

This accumulation area is located outside the generator building at the observation post on Cerro Matias. According to the RFA, this area contains drums which store both waste lubricants and oils. These drums are stored on bare soil prior to being shipped offsite to

NSRR. This accumulation area started approximately 10 years ago, and remains active today. During the VSI, minimal spills of lubricating oil were present in the area of the drums. No release controls were visible at this site (Vargas, 1995).

SWMU 10 - Sewage Treatment Lagoons.

According to the RFA, the sewage treatment lagoons for Camp Garcia went into service when the adjacent pump station was installed in the early 1950s. This SWMU is still considered active.

These lagoons were used for two stages for the treatment of domestic waste. Four unlined lagoons were utilized in this process; two received the waste, and two provided polishing treatment. When treatment of the waste is completed in the polishing lagoons, the remaining liquid was discharged onto the land. Because of the small number of Navy Seabees and civilians using the sanitary facilities daily (45 people), the amount of domestic waste generated is small. Although unlikely, the presence of hazardous constituents in the waste has not been determined. No signs of release have been observed at this SWMU, although sampling has not been conducted here (Vargas, 1995).

SWMU 12 - Solid Waste Collection Unit Area

This area was formerly referred to as AOC B but in accordance with the Administrative Order of Consent (USEPA, Region II), it was decided that this area should be a waste management unit identified as SWMU 12.

The collection area contains storage devices used to containerize solid waste prior to its disposal at the Vieques Island landfill. The containers used to store this waste include: wooden boxes, wooden trailers, and metal dumpsters and cans. During the VSI, only a wooden trailer was visible at this site (Vargas, 1995).

AOC Descriptions

The following subsections present a general description and history of each AOC. Available information regarding the nature and extent of contamination at the AOC is also presented. The descriptions of these locations and the potential for releases are based on a PR and a VSI provided either in the RFA (Vargas, 1995), or in the Administrative Order on Consent (USEPA, Region II).

AOC A - Diesel Fuel Fill Pipe Area (Observation Post I)

According to the RFA, this area contains a pipe used to fill the underground storage tank (UST) located at Observation Post I in the Cerro Matias.

The UST and the fill pipe were first put into service approximately 10 years ago. This site includes a 6-foot x 6-foot area of soil in the area of the fill pipe that was found during the VSI to be stained with fuel from spills during previous refueling procedures. Because the tank is located 25 feet southwest and downgradient of the fill pipe, this staining does not appear to be coming from the tank. No release controls were found at this site (Vargas, 1995).

AOC F - Rock Quarry (Camp Garcia)

According to the RFA, this site is located southwest of the former Camp Garcia landfill. This site contains the gravel that the Navy uses for roads and other construction purposes.

During the VSI, however, used tires and some paper waste were also visible at this location (Vargas, 1995).

AOC G - Pump Station and Chlorination Building at Sewage Lagoons (Camp Garcia)

This site, which is located at Camp Garcia, became active in the 1950s. After approximately 30 years of service, this building was shut down because of the decrease in activity at the facility. The main purpose of this building was to pump and chlorinate domestic waste water. This building was constructed using concrete, and built partially below grade. During the VSI, stains were visible on the concrete unit because of previous overflows of the unit. No signs of damage to the grassy area in the building's general vicinity were visible (Vargas, 1995).

Site Map

This page is reserved for a Site Map.

Note locations of Support, Decontamination, and Exclusion Zones; site telephone; first aid station; evacuation routes; and assembly areas.

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1 Tasks to be Performed Under this Plan

1.1 Description of Tasks

(Reference Field Project Start-up Form)

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.

Tasks	Controls
None	Not applicable

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				
Drilling		X								
Heavy equipment	X	X		X					X	X
Working near water					X					
Working from boat				X						
IDW Drum Sampling								X		

2 Hazard Controls

This section provides safe work practices and control measures used to reduce or eliminate potential hazards. These practices and controls are to be implemented by the party in control of either the site or the particular hazard. CH2M HILL employees and subcontractors must remain aware of the hazards affecting them regardless of who is responsible for controlling the hazards. CH2M HILL employees and subcontractors who do not understand any of these provisions should contact the 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.

2.2 General Hazards

2.2.1 General Hazards and Housekeeping

(Reference CH2M HILL SOP HS-20, 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 HS-05, Hazard Communication)

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 HS-29, Manual Lifting)

- 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 HS-22, Fire Prevention)

- Fire extinguishers shall be provided so that the travel distance from any work area to the nearest extinguisher is less than 100 feet. When 5 gallons or more of a flammable or combustible liquid is being used, an extinguisher must be within 50 feet. Extinguishers must:
  - be maintained in a fully charged and operable condition,
  - be visually inspected each month, and
  - undergo a maintenance check each year.
- The area in front of extinguishers must be kept clear.
- Post “Exit” signs over exiting doors, and post “Fire Extinguisher” signs over extinguisher locations.
- Combustible materials stored outside should be at least 10 feet from any building.
- Solvent waste and oily rags must be kept in a fire resistant, covered container until removed from the site.
- Flammable/combustible liquids must be kept in approved containers, and must be stored in an approved storage cabinet.

2.2.7 Electrical

(Reference CH2M HILL SOP HS-23, 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 HS-25, 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 HS-09, 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) (CH2M HILL SOP HS-09).

- ***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 HS-63, 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: Caleb Romero, NSSR, Puerto Rico
Phone: (787) 865-4429, Ext. 4068 / 4268

- 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 HS-17, 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.

2.3.16 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

(Reference CH2M HILL SOP HS-46, Biological Hazards)

2.3.1 Snakes

No poisonous snakes are indigenous to Puerto Rico.

Snakes typically are found in underbrush and tall grassy areas. If you encounter a snake, stay calm and look around; there may be other snakes. Turn around and walk away on the same path you used to approach the area. If a person is bitten by a snake, wash and immobilize the injured area, keeping it lower than the heart if possible. Seek medical attention immediately. **DO NOT** apply ice, cut the wound, or apply a tourniquet. Try to identify the type of snake: note color, size, patterns, and markings.

2.3.2 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.

2.3.5 Bloodborne Pathogens

(Reference CH2M HILL SOP HS-36, Bloodborne Pathogens)

Exposure to bloodborne pathogens may occur when rendering first aid or CPR, or when coming into contact with landfill waste or waste streams containing potentially infectious material. Exposure controls and PPE are required as specified in CH2M HILL SOP HS-36, *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.

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.

Mongeese, rats, and mice have been documented to (potentially) carry rabies. There is some evidence that mongeese 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 mongeese 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.

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 HS-01, Medical Surveillance, and HS-02, Health and Safety 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.

Pregnant employees are to be informed of and are to follow the procedures in CH2M HILL's SOP HS-04, *Reproduction Protection*, including obtaining a physician's statement of the employee's ability to perform hazardous activities before being assigned fieldwork.

Employee Name	Office	Responsibility	SSC/FA-CPR
Marty Clasen	TPA	Project Manager	Level D SSC; FA-CPR
Erik Isern	TPA	Field Team Member	Level D SSC; FA-CPR
Mariana Brown	TPA	Field Team Member	Level D SSC; FA-CPR
Isaas Lynch	GNV	Field Team Leader/SSC	Level D SSC, FA-CPR
Cleone Arfstrom	DEN	Field Team Member	Level D SSC; FA-CPR
Rick Gorsira	TPA	Field Team Leader/SSC	Level D SSC; FA-CPR

3.2 Field Team Chain of Command and Communication Procedures

3.2.1 Client

Contact Name: Madeline Rivera, IRP Manager, NSRR
Phone: (787) 865-5337
Facility Contact Name: N/A
Phone: N/A

3.2.2 CH2M HILL

Project Manager: Marty Clasen/TPA
Health and Safety Manager: Michael Goldman/ATL
Field Team Leader: Fernando Ferreira/TPA
Site Safety Coordinator: Fernando Ferreira/TPA

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 HS-55, Subcontractor, Contractor, and Owner)

Subcontractor: To be determined after bid award 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-55, Subcontractor, Contractor, and Owner)

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 HS-07, Personal Protective Equipment, HS-08, 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.
Test pit excavation 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].
Tasks requiring upgrade	B	**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	Positive-pressure demand self-contained breathing apparatus (SCBA); MSA Ultralite, or equivalent.

Reasons for Upgrading or Downgrading Level of Protection

Upgrade[f]	Downgrade
• Request from individual performing tasks. • Change in work tasks that will increase contact or potential contact with hazardous materials. • Occurrence or likely occurrence of gas or vapor emission. • Known or suspected presence of dermal hazards. • Instrument action levels (Section 5) exceeded.	• New information indicating that situation is less hazardous than originally thought. • Change in site conditions that 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

(Reference CH2M HILL SOP HS-06, Air Monitoring)

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 Stop Work	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 Level B	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 HS-13, 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.

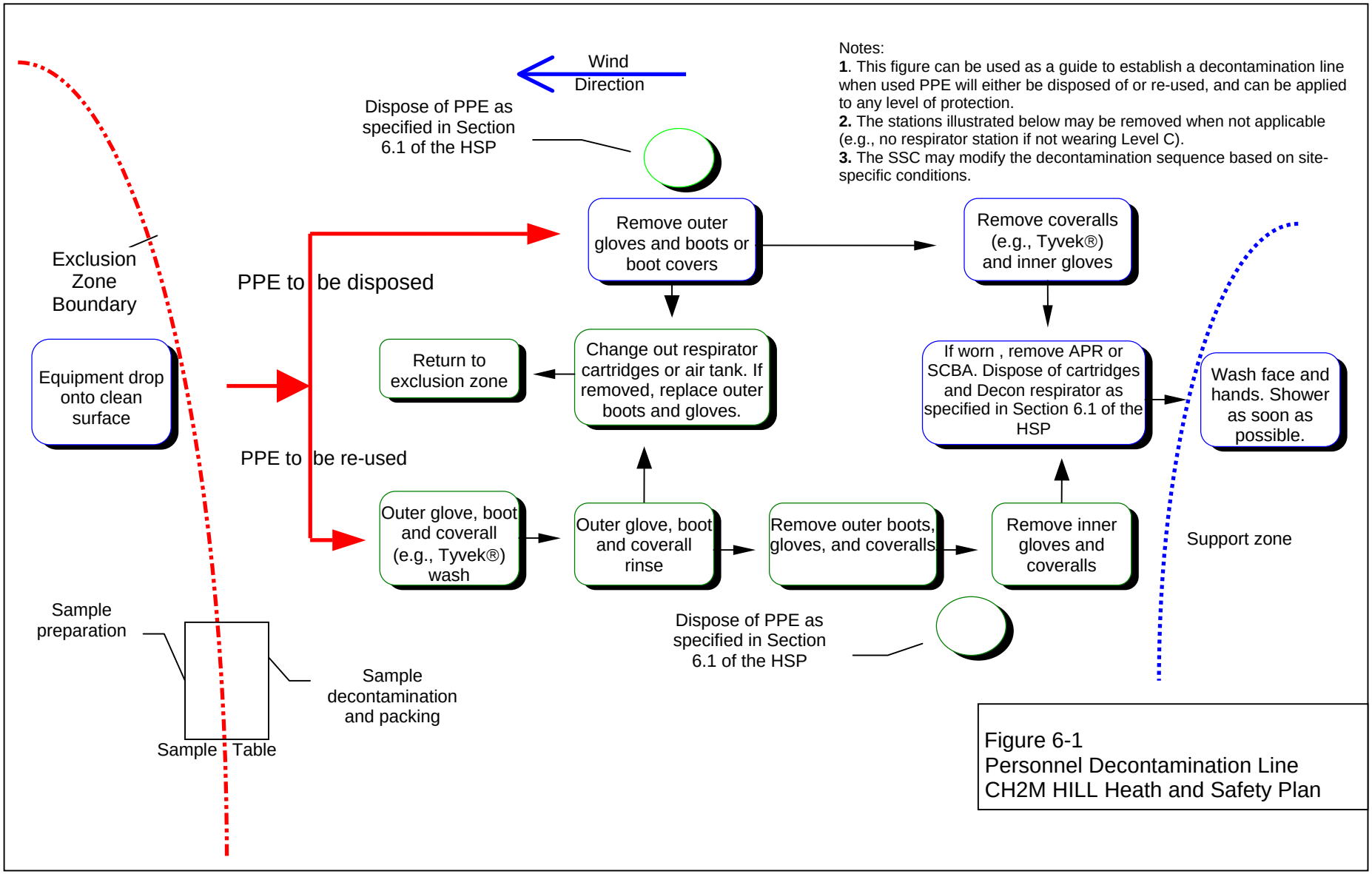

Figure 6-1
Personnel Decontamination Line
CH2M HILL Heath and Safety Plan

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 HS-11, 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 HS-19, Site-Specific Written Safety 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 HS-12, Emergency Response)

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.

- 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.
- 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

- Upon any project incident (fire, spill, injury, near miss, death, etc.), immediately notify the PM and HSM. Call emergency beeper 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 client as required in contract.

9.8 Emergency Contacts (complete during project start-up)

24-hour CH2M HILL Emergency Beeper – 888/444-1226	
Medical Emergency – 911 Facility Medical Response # (787) 741-3992 Local Ambulance #: None (In life threatening emergencies only, call (787) 741-0333.	**CH2M HILL Medical Consultant** Dr. Peter Greaney GMG WorkCare, Orange, CA 800/455-6155 (After hours calls will be returned within 20 minutes)
Fire/Spill Emergency -- 911 Facility Fire Response #: Local Fire Dept #:	**Local Occupational Physician**
Security & Police – 911 Facility Security #: (787) 741-3992 Local Police #:	**Corporate Director Health and Safety** Name: Mollie Netherland/SEA Phone: 206/453-5005 24-hour emergency beeper: 888-444-1226
Utilities Emergency Water: Gas: Electric:	**Health and Safety Manager (HSM)** Name: Michael Goldman Phone: 770/604-9182 (office) ext 396; Home; 404/872-6081 (home)
Site Safety Coordinator (SSC) Name: Erik Isern Phone: (787) 381-0775	**Regional Human Resources Department** Name: Mary Jo Jordan Phone: 352/335-5877
Project Manager Name: Martin Clasen Phone: (813) 874-6522, Ext. 4307	**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** Sterling Administration Services Phone: 800/420-8926 After hours: 800/497-4566 Report fatalities AND report vehicular accidents involving pedestrians, motorcycles, or more than two cars.

Federal Agency / Contact Name:	**Phone:**
State Agency / Contact Name:	**Phone:**
Local Agency / Contact Name:	**Phone:**

Contact the Project Manager. Generally, the Project Manager will contact relevant government agencies.

Facility Alarms:	**Evacuation Assembly Area(s):**
Facility/Site Evacuation Route(s):	
Hospital Name/Address: NSRR	**Hospital Phone #:**

Directions to Hospital

For minor first aid, call the base security at (787) 741-3992. In life threatening conditions only, contact the Seabees Quarter Deck at (787) 741-0333.

10 Approval

This site-specific 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.

10.1 Original Plan

Written By: Martin J. Clasen, P.G. Date: 02/16/01

Approved By: __Michael Goldman_____ Date: June 11, 2003

10.2 Revisions

Revisions Made By_____ Date:_____

Revisions to Plan:_____

Revisions Approved By:_____ Date:_____

11 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: Ordnance Explosives (OE) Standard of Practice HSE-91

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**

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.

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.

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**	**199__**	**199__**	**199__**
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: = $\frac{\text{Number of Lost Work Day Cases x 200,000}}{\text{Number of Hours Worked}}$

[2] The following formula is used for calculating the OSHA Recordable Incident Rate: = $\frac{\text{Number of Recordable Cases x 200,000}}{\text{Number of Hours Worked}}$

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: _____

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):

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	Yes	No	N/A	N/O
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	☐	☐	☐	☐

<u>SECTION 3</u>

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

Material Safety Data Sheets MESSER MG Industries

SECTION 1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MG INDUSTRIES
3 GREAT VALLEY PARKWAY
MALVERN, PENNSYLVANIA 19355
PHONE: 610-695-7400
FAX: 610-695-7596

EMERGENCY CONTACT:
CHEMTREC:
1-800-424-9300

SUBSTANCE: METHANE, COMPRESSED GAS
TRADE NAMES/SYNONYMS:
FIRE DAMP; MARSH GAS; METHYL HYDRIDE; NATURAL GAS; METHANE; STCC 4905755; UN 1971; R50; CH4; MGI14160; RTECS PA1490000
CHEMICAL FAMILY: hydrocarbons, aliphatic
CREATION DATE: May 04 1990
REVISION DATE: Sep 10 1998

SECTION 2 COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: METHANE, COMPRESSED GAS
CAS NUMBER: 74-82-8
EC NUMBER (EINECS): 200-812-7
EC INDEX NUMBER: 601-001-00-4
PERCENTAGE: >99.9
OTHER CONTAMINANTS:
MERCAPTAN MAY BE ADDED AS AN ODORIZER

SECTION 3 HAZARDS IDENTIFICATION

NFPA RATINGS (SCALE 0-4): HEALTH=1 FIRE=4 REACTIVITY=0
EC CLASSIFICATION (ASSIGNED):
F+ Extremely Flammable
R 12
EC Classification may be inconsistent with independently-researched data.
EMERGENCY OVERVIEW:
PHYSICAL DESCRIPTION: Odorless, colorless, tasteless gas.
MAJOR HEALTH HAZARDS: difficulty breathing
PHYSICAL HAZARDS: Flammable gas. May cause flash fire.
POTENTIAL HEALTH EFFECTS:
INHALATION:
SHORT TERM EXPOSURE: nausea, vomiting, dizziness, tingling sensation,

suffocation, convulsions, coma
LONG TERM EXPOSURE: no information on significant adverse effects
SKIN CONTACT:
SHORT TERM EXPOSURE: no information is available
LONG TERM EXPOSURE: no information is available
EYE CONTACT:
SHORT TERM EXPOSURE: no information is available
LONG TERM EXPOSURE: no information is available
INGESTION:
SHORT TERM EXPOSURE: no information is available
LONG TERM EXPOSURE: no information is available
CARCINOGEN STATUS:
OSHA: N
NTP: N
IARC: N

SECTION 4 FIRST AID MEASURES

INHALATION: When safe to enter area, remove from exposure. Use a bag valve mask or similar device to perform artificial respiration (rescue breathing) if needed. Keep warm and at rest. Get medical attention immediately.
SKIN CONTACT: It is unlikely that emergency treatment will be required. If adverse effects occur, wash with soap or mild detergent and large amounts of water. Get medical attention, if needed.
EYE CONTACT: It is unlikely that emergency treatment will be required. Wash with large amounts of water or normal saline until no evidence of chemical remains (at least 15-20 minutes). Get medical attention immediately.
INGESTION: It is unlikely that emergency treatment will be required. Get medical attention, if needed.
NOTE TO PHYSICIAN: For inhalation, consider oxygen.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Severe fire hazard. Severe explosion hazard. Containers may rupture or explode if exposed to heat. Vapor/air mixtures are explosive above flash point. Electrostatic discharges may be generated by flow or agitation resulting in ignition or explosion.
EXTINGUISHING MEDIA: carbon dioxide, regular dry chemical
Large fires: Use regular foam or flood with fine water spray.
FIRE FIGHTING: Move container from fire area if it can be done without risk. For fires in cargo or storage area: Cool containers with water from unmanned hose holder or monitor nozzles until well after fire is out. If this is impossible then take the following precautions: Keep unnecessary people away, isolate hazard area and deny entry. Let the fire burn. Withdraw

immediately in case of rising sound from venting safety device or any discoloration of tanks due to fire. For tank, rail car or tank truck: Stop leak if possible without personal risk. Let burn unless leak can be stopped immediately. For smaller tanks or cylinders, extinguish and isolate from other flammables. Evacuation radius: 800 meters (1/2 mile). Stop flow of gas.
FLASH POINT: -369 F (-223 C)
LOWER FLAMMABLE LIMIT: 5.0%
UPPER FLAMMABLE LIMIT: 15%
AUTOIGNITION: 999 F (537 C)

SECTION 6 ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL RELEASE:
Avoid heat, flames, sparks and other sources of ignition. Stop leak if possible without personal risk. Reduce vapors with water spray. Keep unnecessary people away, isolate hazard area and deny entry. Remove sources of ignition. Ventilate closed spaces before entering.

SECTION 7 HANDLING AND STORAGE

Store and handle in accordance with all current regulations and standards. Subject to storage regulations: U.S. OSHA 29 CFR 1910.106. Grounding and bonding required. Keep separated from incompatible substances.

SECTION 8 EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
METHANE, COMPRESSED GAS:
No occupational exposure limits established.
VENTILATION: Based on available information, additional ventilation is not required. Ensure compliance with applicable exposure limits.
EYE PROTECTION: Eye protection not required, but recommended.
CLOTHING: Protective clothing is not required.
GLOVES: Wear appropriate chemical resistant gloves.

RESPIRATOR: Under conditions of frequent use or heavy exposure, respiratory protection may be needed. Respiratory protection is ranked in order from minimum to maximum. Consider warning properties before use.
For Unknown Concentrations or Immediately Dangerous to Life or Health -
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Any self-contained breathing apparatus with a full facepiece.

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SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL DESCRIPTION: Odorless, colorless, tasteless gas.
MOLECULAR WEIGHT: 16.04
MOLECULAR FORMULA: C-H4
BOILING POINT: -260 F (-162 C)
FREEZING POINT: -297 F (-183 C)
VAPOR PRESSURE: 760 mmHg @ -161 C
VAPOR DENSITY (air=1): 0.555
SPECIFIC GRAVITY: Not applicable
DENSITY: 0.717 g/L @ 0 C
WATER SOLUBILITY: 3.5% @ 17 C
PH: Not applicable
VOLATILITY: Not applicable
ODOR THRESHOLD: Not available
EVAPORATION RATE: Not applicable
VISCOSITY: 0.01118 cP @ 27 C
COEFFICIENT OF WATER/OIL DISTRIBUTION: Not applicable
SOLVENT SOLUBILITY:
Soluble: alcohol, ether, benzene, organic solvents

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY: Stable at normal temperatures and pressure.
CONDITIONS TO AVOID: Avoid heat, flames, sparks and other sources of ignition. Containers may rupture or explode if exposed to heat.
INCOMPATIBILITIES: halogens, oxidizing materials, combustible materials
METHANE:
BROMINE: Explosive reaction.
CHLORINE: Explosive reaction, particularly in the presence of light or catalysts.
CHLORINE DIOXIDE: Spontaneous explosion.
DIOXYGEN DIFLUORIDE: Explosive interaction.
DIOXYGENYL TETRAFLUOROBORATE: Explosive interaction.
FLUORINE: Ignition.
INTERHALOGENS: Contact will result in fire or explosion.
NITROGEN TRIFLUORIDE: Explosive reaction on ignition.
OXIDIZERS (STRONG): Fire and explosion hazard.
OXYGEN: Mixtures of the liquids are explosive.
OXYGEN DIFLUORIDE: Explodes when sparked.
TRIOXYGEN DIFLUORIDE: Explodes violently with the liquid.
HAZARDOUS DECOMPOSITION:
Thermal decomposition products: oxides of carbon
POLYMERIZATION: Will not polymerize.

MGI14160 Page 005 of 007

SECTION 11 TOXICOLOGICAL INFORMATION

HEALTH EFFECTS:
INHALATION:
METHANE: Pregnant mice were exposed for one hour to fuel gas, containing 85% methane. Resultant abnormalities of the fetal brain produced brain hernias and hydrocephalus. See information on simple asphyxiants.
ACUTE EXPOSURE:

SIMPLE ASPHYXIANTS: The symptoms of asphyxia depend on the rapidity with which the oxygen deficiency develops and how long it continues. In sudden acute asphyxia, unconsciousness may be immediate. With slow development there may be rapid respiration and pulse, air hunger, dizziness, reduced awareness, tightness in the head, tingling sensations, incoordination, faulty judgement, emotional instability, and rapid fatigue. As the asphyxia progresses, nausea, vomiting, collapse, unconsciousness, convulsions, deep coma and death are possible.

CHRONIC EXPOSURE:

SIMPLE ASPHYXIANTS: No data available.

SKIN CONTACT:

ACUTE EXPOSURE:

METHANE: No adverse effects have been reported from the gas.

CHRONIC EXPOSURE:

METHANE: No data available.

EYE CONTACT:

ACUTE EXPOSURE:

METHANE: No adverse effects have been reported from the gas.

CHRONIC EXPOSURE:

METHANE: No data available.

INGESTION:

ACUTE EXPOSURE:

METHANE: Ingestion of a gas is unlikely.

CHRONIC EXPOSURE:

METHANE: No data available.

SECTION 12 ECOLOGICAL INFORMATION

Not available

SECTION 13 DISPOSAL CONSIDERATIONS

Subject to disposal regulations: U.S. EPA 40 CFR 262. Hazardous Waste

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Number(s): D001. Dispose in accordance with all applicable regulations.

SECTION 14 TRANSPORT INFORMATION

U.S. DOT 49 CFR 172.101 SHIPPING NAME-UN NUMBER:
Methane, compressed-UN1971
U.S. DOT 49 CFR 172.101 HAZARD CLASS OR DIVISION:
2.1
U.S. DOT 49 CFR 172.101 AND SUBPART E LABELING REQUIREMENTS:
Flammable gas
U.S. DOT 49 CFR 172.101 PACKAGING AUTHORIZATIONS:
EXCEPTIONS: 49 CFR 173.306
NON-BULK PACKAGING: 49 CFR 173.302
BULK PACKAGING: 49 CFR 173.302
U.S. DOT 49 CFR 172.101 QUANTITY LIMITATIONS:
PASSENGER AIRCRAFT OR RAILCAR: Forbidden
CARGO AIRCRAFT ONLY: 150 kg
LAND TRANSPORT ADR/RID:

SUBSTANCE NAME: Natural gas, compressed/Methane, compressed or Natural gas, compressed

UN NUMBER: UN1971

ADR/RID CLASS: 2

ITEM NUMBER: 2(b)/1F

WARNING SIGN/LABEL: 3/3; 13

HAZARD ID NUMBER: 23

AIR TRANSPORT IATA/ICAO: No classification assigned.
MARITIME TRANSPORT IMDG: No classification assigned.

SECTION 15 REGULATORY INFORMATION

U.S. REGULATIONS:
TSCA INVENTORY STATUS: Y
TSCA 12(b) EXPORT NOTIFICATION: Not listed.
CERCLA SECTION 103 (40CFR302.4): N
SARA SECTION 302 (40CFR355.30): N
SARA SECTION 304 (40CFR355.40): N
SARA SECTION 313 (40CFR372.65): N
SARA HAZARD CATEGORIES, SARA SECTIONS 311/312 (40CFR370.21):
ACUTE: Y
CHRONIC: N
FIRE: Y
REACTIVE: N
SUDDEN RELEASE: Y

OSHA PROCESS SAFETY (29CFR1910.119): N
STATE REGULATIONS:
California Proposition 65: N
EUROPEAN REGULATIONS:
EC NUMBER (EINECS): 200-812-7
EC RISK AND SAFETY PHRASES:

R 12	Extremely flammable.
S 2	Keep out of reach of children.
S 9	Keep container in a well-ventilated place.
S 16	Keep away from sources of ignition - No smoking.
S 33	Take precautionary measures against static discharges.

GERMAN REGULATIONS:
WATER HAZARD CLASS (WGK): 0 (Official German Classification)

SECTION 16 OTHER INFORMATION

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New Jersey Department of Health and Senior Services

HAZARDOUS SUBSTANCE FACT SHEET

Common Name: **METHANE**

CAS Number: 74-82-8
DOT Number: UN 1971 (compressed gas)
UN 1972 (liquefied)

RTK Substance number: 1202
Date: February 1989 Revision: October 1996

HAZARD SUMMARY

* **Methane** can affect you when breathed in.
* Very high levels can cause suffocation from lack of *oxygen*.
* Skin contact with liquid **Methane** can cause frostbite.
* **Methane** is a HIGHLY FLAMMABLE GAS and a DANGEROUS FIRE and EXPLOSION HAZARD.

IDENTIFICATION

Methane is an odorless, colorless gas, or liquid under pressure. It is used as a fuel and in the manufacture of organic chemicals. *Acetylene, Hydrogen Cyanide, and Hydrogen.*

REASON FOR CITATION

* **Methane** is on the Hazardous Substance List because it is cited by ACGIH, DOT and NFPA.
* This chemical is on the Special Health Hazard Substance List because it is **FLAMMABLE**.
* Definitions are provided on page 5.

HOW TO DETERMINE IF YOU ARE BEING EXPOSED

The New Jersey Right to Know Act requires most employers to label chemicals in the workplace and requires public employers to provide their employees with information and training concerning chemical hazards and controls. The federal OSHA Hazard Communication Standard, 1910.1200, requires private employers to provide similar training and information to their employees.

* Exposure to hazardous substances should be routinely evaluated. This may include collecting personal and area air samples. You can obtain copies of sampling results from your employer. You have a legal right to this information under OSHA 1910.20.
* If you think you are experiencing any work-related health problems, see a doctor trained to recognize occupational diseases. Take this Fact Sheet with you.

WORKPLACE EXPOSURE LIMITS

No exposure limits have been determined for **Methane**.

The health effects caused by exposure to **Methane** are much less serious than its fire and explosion risk.

Large amounts of **Methane** will decrease the amount of available *oxygen*. *Oxygen* content should be tested to ensure that it is at least 19% by volume.

WAYS OF REDUCING EXPOSURE

* Where possible, enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, respirators should be worn.
* Wear protective gloves and clothing to avoid contact with cold, liquid **Methane**.
* Wear protective clothing made of material that does not generate static electricity.
* Permanently installed analyzers can be used to monitor for dangerous release of **Methane** gas.
* Post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, communicate all information on the health and safety hazards of **Methane** to potentially exposed workers.

This Fact Sheet is a summary source of information of all potential and most severe health hazards that may result from exposure. Duration of exposure, concentration of the substance and other factors will affect your susceptibility to any of the potential effects described below.

HEALTH HAZARD INFORMATION

Acute Health Effects

The following acute (short-term) health effects may occur immediately or shortly after exposure to **Methane**:

* Very high levels can cause suffocation from lack of *oxygen*.
* Skin contact with liquid **Methane** can cause frostbite.

Chronic Health Effects

The following chronic (long-term) health effects can occur at some time after exposure to **Methane** and can last for months or years:

Cancer Hazard

* According to the information presently available to the New Jersey Department of Health and Senior Services, **Methane** has not been tested for its ability to cause cancer in animals.

Reproductive Hazard

* According to the information presently available to the New Jersey Department of Health and Senior Services, **Methane** has not been tested for its ability to affect reproduction.

Other Long-Term Effects

* **Methane** has not been tested for other chronic (long-term) health effects.

MEDICAL

Medical Testing

There is no special test for this chemical. However, if illness occurs or overexposure is suspected, medical attention is recommended.

Any evaluation should include a careful history of past and present symptoms with an exam. Medical tests that look for damage already done are not a substitute for controlling exposure.

Request copies of your medical testing. You have a legal right to this information under OSHA 1910.20.

WORKPLACE CONTROLS AND PRACTICES

Unless a less toxic chemical can be substituted for a hazardous substance, **ENGINEERING CONTROLS** are the most effective way of reducing exposure. The best protection is to enclose operations and/or provide local exhaust ventilation at the site of chemical release. Isolating operations can also reduce exposure. Using respirators or protective equipment is less effective than the controls mentioned above, but is sometimes necessary.

In evaluating the controls present in your workplace, consider: (1) how hazardous the substance is, (2) how much of the substance is released into the workplace and (3) whether harmful skin or eye contact could occur. Special controls should be in place for highly toxic chemicals or when significant skin, eye, or breathing exposures are possible.

In addition, the following controls are recommended:

* Before entering a confined space where **Methane** is present, check to make sure that sufficient *oxygen* (19%) exists.
* Before entering a confined space where **Methane** may be present, check to make sure that an explosive concentration does not exist.

PERSONAL PROTECTIVE EQUIPMENT

WORKPLACE CONTROLS ARE BETTER THAN PERSONAL PROTECTIVE EQUIPMENT. However, for some jobs (such as outside work, confined space entry, jobs done only once in a while, or jobs done while workplace controls are being installed), personal protective equipment may be appropriate.

The following recommendations are only guidelines and may not apply to every situation.

Clothing

* All protective clothing (suits, gloves, footwear, headgear) should be clean, available each day, and put on before work.
* Where exposure to cold equipment, vapors, or liquid may occur, employees should be equipped with special clothing designed to prevent freezing of body tissues.

Eye Protection

* Wear gas-proof goggles, unless full facepiece respiratory protection is worn.

Respiratory Protection

IMPROPER USE OF RESPIRATORS IS DANGEROUS. Such equipment should only be used if the employer has a written program that takes into account workplace conditions, requirements for worker training, respirator fit testing and medical exams, as described in OSHA 1910.134.

* DO NOT USE CHEMICAL CARTRIDGE OR CANISTER RESPIRATORS.
* Exposure to **Methane** is dangerous because it can replace *oxygen* and lead to suffocation. Only MSHA/NIOSH approved self-contained breathing apparatus with a full facepiece operated in positive pressure mode should be used in *oxygen* deficient environments.

HANDLING AND STORAGE

* Prior to working with **Methane** you should be trained on its proper handling and storage.
* Procedures for handling, use, and storage of **Methane** cylinders should be in compliance with OSHA 1910.101 (Compressed gases) and Subpart M-Compressed Gas and Compressed Air Equipment (1910.169 to 171) and follow the recommendations of the Compressed Gas Association.
* **Methane** must be stored to avoid contact with OXIDIZERS (such as OXYGEN, CHLORINE, BROMINE, PERCHLORATES, PEROXIDES, NITRATES and PERMANGANATES) since violent reactions occur.
* Sources of ignition such as smoking and open flames are prohibited where **Methane** is handled, used, or stored.
* Use only non-sparking tools and equipment, especially when opening and closing containers of **Methane**.
* Wherever **Methane** is used, handled, manufactured, or stored, use explosion-proof electrical equipment and fittings.

QUESTIONS AND ANSWERS

Q: If I have acute health effects, will I later get chronic health effects?

A: Not always. Most chronic (long-term) effects result from repeated exposures to a chemical.

Q: Can I get long-term effects without ever having short-term effects?

A: Yes, because long-term effects can occur from repeated exposures to a chemical at levels not high enough to make you immediately sick.

Q: What are my chances of getting sick when I have been exposed to chemicals?

A: The likelihood of becoming sick from chemicals is increased as the amount of exposure increases. This is determined by the length of time and the amount of material to which someone is exposed.

Q: When are higher exposures more likely?

A: Conditions which increase risk of exposure include physical and mechanical processes (heating, pouring, spraying, spills and evaporation from large surface areas such as open containers), and "confined space" exposures (working inside vats, reactors, boilers, small rooms, etc.).

Q: Is the risk of getting sick higher for workers than fo community residents?

A: Yes. Exposures in the community, except possibly in cases of fires or spills, are usually much lower than those found in the workplace. However, people in the community may be exposed to contaminated water as well as to chemicals in the air over long periods. Because of this, and because of exposure of children or people who are already ill, community exposures may cause health problems.

The following information is available from:

New Jersey Department of Health and
Senior Services
Occupational Disease and Injury Services
Trenton, NJ 08625-0360
(609) 984-1863

Industrial Hygiene Information

Industrial hygienists are available to answer your questions regarding the control of chemical exposures using exhaust ventilation, special work practices, good housekeeping, good hygiene practices, and personal protective equipment including respirators. In addition, they can help to interpret the results of industrial hygiene survey data.

Medical Evaluation

If you think you are becoming sick because of exposure to chemicals at your workplace, you may call a Department of Health and Senior Services physician who can help you find the services you need.

Public Presentations

Presentations and educational programs on occupational health or the Right to Know Act can be organized for labor unions, trade associations and other groups.

Right to Know Information Resources

The Right to Know Infoline (609) 984-2202 can answer questions about the identity and potential health effects of chemicals, list of educational materials in occupational health, references used to prepare the Fact Sheets, preparation of the Right to Know survey, education and training programs, labeling requirements, and general information regarding the Right to Know Act. Violations of the law should be reported to (609) 984-2202.

DEFINITIONS

ACGIH is the American Conference of Governmental Industrial Hygienists. It recommends upper limits (called TLVs) for exposure to workplace chemicals.

A **carcinogen** is a substance that causes cancer.

The **CAS number** is assigned by the Chemical Abstracts Service to identify a specific chemical.

A **combustible** substance is a solid, liquid or gas that will burn.

A **corrosive** substance is a gas, liquid or solid that causes irreversible damage to human tissue or containers.

DEP is the New Jersey Department of Environmental Protection.

DOT is the Department of Transportation, the federal agency that regulates the transportation of chemicals.

EPA is the Environmental Protection Agency, the federal agency responsible for regulating environmental hazards.

A **fetus** is an unborn human or animal.

A **flammable** substance is a solid, liquid, vapor or gas that will ignite easily and burn rapidly.

The flash point is the temperature at which a liquid or solid gives off vapor that can form a flammable mixture with air.

HHAG is the Human Health Assessment Group of the federal EPA.

IARC is the International Agency for Research on Cancer, a scientific group that classifies chemicals according to their cancer-causing potential.

A **miscible** substance is a liquid or gas that will evenly dissolve in another.

mg/m^3 means milligrams of a chemical in a cubic meter of air. It is a measure of concentration (weight/volume).

MSHA is the Mine Safety and Health Administration, the federal agency that regulates mining. It also evaluates and approves respirators.

A **mutagen** is a substance that causes mutations. A **mutation** is a change in the genetic material in a body cell. Mutation can lead to birth defects, miscarriages, or cancer.

NAERG is the North American Emergency Response Guidebook. It was jointly developed by Transport Canada, the United States Department of Transportation and the Secretariat of Communications and Transportation of Mexico. It is a guide for first responders to quickly identify the specific or generic hazards of material involved in a transportation incident, and to protect themselves and the general public during the initial response phase of the incident.

NCI is the National Cancer Institute, a federal agency that determines the cancer-causing potential of chemicals.

NFPA is the National Fire Protection Association. It classifies substances according to their fire and explosion hazard.

NIOSH is the National Institute for Occupational Safety and Health. It tests equipment, evaluates and approves respirators, conducts studies of workplace hazards, and proposes standards to OSHA.

NTP is the National Toxicology Program which tests chemicals and reviews evidence for cancer.

OSHA is the Occupational Safety and Health Administration, which adopts and enforces health and safety standards.

PEOSHA is the Public Employees Occupational Safety and Health Act, a state law which sets PELs for New Jersey public employees.

ppm means parts of a substance per million parts of air. It is a measure of concentration by volume in air.

A **reactive** substance is a solid, liquid or gas that releases energy under certain conditions.

A **teratogen** is a substance that causes birth defects by damaging the fetus.

TLV is the Threshold Limit Value, the workplace exposure limit recommended by ACGIH.

The **vapor pressure** is a measure of how readily a liquid or a solid mixes with air at its surface. A higher vapor pressure indicates a higher concentration of the substance in air and therefore increases the likelihood of breathing it in.

>>>>>>>>>>>>>>>>>> EMERGENCY INFORMATION <<<<<<<<<<<<<<<<<

Common Name: **METHANE**
DOT Number: **UN 1971 (compressed gas)**
UN 1972 (liquefied)
ERG Code: : **115**
CAS Number: **74-82-8**

Hazard rating	NJ DOH	NFPA
FLAMMABILITY	-	4
REACTIVITY	-	0
CONTAINERS MAY EXPLODE IN FIRE		

Hazard Rating Key: 0=minimal; 1=slight; 2=moderate; 3=serious; 4=severe

FIRE HAZARDS

* **Methane** is a FLAMMABLE GAS.
* CONTAINERS MAY EXPLODE IN FIRE.
* THE FLAME MAY BE INVISIBLE.
* Stop the flow of gas.
* Use water spray to disperse the vapors.
* For small fires use dry chemical or *carbon dioxide* extinguishers.
* For large fires use water spray, fog or foam.
* If employees are expected to fight fires, they must be trained and equipped as stated in OSHA 1910.156.

ILLS AND EMERGENCIES

If **Methane** is leaked, take the following steps:

* Restrict persons not wearing protective equipment from area of leak until clean-up is complete.
* Remove all ignition sources.
* Ventilate area of leak to disperse the gas.
* Stop flow of gas. If source of leak is a cylinder and the leak cannot be stopped in place, remove the leaking cylinder to a safe place in the open air, and repair leak or allow cylinder to empty.
* Use water spray to reduce vapor.
* It may be necessary to contain and dispose of **Methane** as a HAZARDOUS WASTE. Contact your Department of Environmental Protection (DEP) or your regional office of the federal Environmental Protection Agency (EPA) for specific recommendations.
* If employees are required to clean-up spills, they must be properly trained and equipped. OSHA 1910.120(q) may be applicable.

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FOR LARGE SPILLS AND FIRES immediately call your fire department. You can request emergency information from the following:

CHEMTREC: (800) 424-9300
NJDEP HOTLINE: (609) 292-7172

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HANDLING AND STORAGE (See page 3)

FIRST AID

In NJ, POISON INFORMATION 1-800-962-1253

Skin Contact

* Immerse affected part in warm (not hot) water. Seek medical attention.

Breathing

* Remove the person from exposure.
* Begin rescue breathing if breathing has stopped and CPR if heart action has stopped.
* Transfer promptly to a medical facility.

PHYSICAL DATA

Flash Point: -306°F (-188°C)
Water Solubility: Slightly soluble

OTHER COMMONLY USED NAMES

Chemical Name:
Methyl Hydride
Other Names:
Natural Gas; Marsh Gas; Biogas

Not intended to be copied and sold for commercial purposes.

NEW JERSEY DEPARTMENT OF HEALTH AND SENIOR SERVICES
Right to Know Program
CN 368, Trenton, NJ 08625-0368
(609) 984-2202

Material Safety Data Sheets MESSER MG Industries

SECTION 1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MG INDUSTRIES
3 GREAT VALLEY PARKWAY
MALVERN, PENNSYLVANIA 19355
PHONE: 610-695-7400
FAX: 610-695-7596

EMERGENCY CONTACT:
CHEMTREC:
1-800-424-9300

SUBSTANCE: ISOBUTENE
TRADE NAMES/SYNONYMS:
2-METHYLPROPENE; ISOBUTYLENE; LIQUIFIED PETROLEUM GAS; 2-METHYL-1-PROPENE; L.P.G.; GAMMA-BUTYLENE; ASYM-DIMETHYL ETHYLENE; UN 1055; MGI11610; RTECS UD0890000
CHEMICAL FAMILY: hydrocarbons, aliphatic
CREATION DATE: May 04 1990
REVISION DATE: Sep 10 1998

SECTION 2 COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: ISOBUTENE
CAS NUMBER: 115-11-7
EC NUMBER (EINECS): 204-066-3
EC INDEX NUMBER: 601-012-00-4
PERCENTAGE: 100

SECTION 3 HAZARDS IDENTIFICATION

NFPA RATINGS (SCALE 0-4): HEALTH=0 FIRE=4 REACTIVITY=0
EC CLASSIFICATION (ASSIGNED):
F+ Extremely Flammable
R 12
EC Classification may be inconsistent with independently-researched data.
EMERGENCY OVERVIEW:
PHYSICAL DESCRIPTION: Colorless, volatile liquid or easily liquified gas with coal gas odor
MAJOR HEALTH HAZARDS: central nervous system depression, difficulty breathing
PHYSICAL HAZARDS: Flammable gas. May cause flash fire.
POTENTIAL HEALTH EFFECTS:
INHALATION:
SHORT TERM EXPOSURE: irritation, nausea, vomiting, headache, symptoms of drunkenness, disorientation, tingling sensation, suffocation, convulsions,

coma
LONG TERM EXPOSURE: no information on significant adverse effects
SKIN CONTACT:
SHORT TERM EXPOSURE: irritation (possibly severe)
LONG TERM EXPOSURE: no information is available
EYE CONTACT:
SHORT TERM EXPOSURE: irritation, blurred vision
LONG TERM EXPOSURE: no information on significant adverse effects
INGESTION:
SHORT TERM EXPOSURE: frostbite
LONG TERM EXPOSURE: no information is available
CARCINOGEN STATUS:
OSHA: N
NTP: N
IARC: N

SECTION 4 FIRST AID MEASURES

INHALATION: When safe to enter area, remove from exposure. Use a bag valve mask or similar device to perform artificial respiration (rescue breathing) if needed. Keep warm and at rest. Get medical attention immediately.
SKIN CONTACT: Wash if needed. If frostbite, freezing, or cryogenic burns occur, warm affected area in warm water. If this is not available, gently wrap affected parts in blankets. Allow circulation to return naturally. Get medical attention immediately.
EYE CONTACT: Wash eyes immediately with large amounts of water, occasionally lifting upper and lower lids, until no evidence of chemical remains. Continue irrigating with normal saline until ready to transport to hospital. Cover with sterile bandages. Get medical attention immediately.
INGESTION: If vomiting occurs, keep head lower than hips to help prevent aspiration. Get medical attention, if needed.
NOTE TO PHYSICIAN: For inhalation, consider oxygen.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Severe fire hazard. The vapor is heavier than air. Vapors or gases may ignite at distant ignition sources and flash back. Vapor/air mixtures are explosive above flash point.
EXTINGUISHING MEDIA: carbon dioxide, regular dry chemical
Large fires: Flood with fine water spray.
FIRE FIGHTING: Move container from fire area if it can be done without risk. Cool containers with water spray until well after the fire is out. Stay away from the ends of tanks. For fires in cargo or storage area: Cool containers with water from unmanned hose holder or monitor nozzles until well after

fire is out. If this is impossible then take the following precautions: Keep unnecessary people away, isolate hazard area and deny entry. Let the fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of tanks due to fire. For tank, rail car or tank truck: Stop leak if possible without personal risk. Let burn unless leak can be stopped immediately. For smaller tanks or cylinders, extinguish and isolate from other flammables. Evacuation radius: 800 meters (1/2 mile). Do not attempt to extinguish fire unless flow of material can be stopped first. Flood with fine water spray. Cool containers with water spray until well after the fire is out. Apply water from a protected location or from a safe distance. Avoid inhalation of material or combustion by-products. Stay upwind and keep out of low areas. Evacuate if fire gets out of control or containers are directly exposed to fire. Evacuation radius: 500 meters (1/3 mile). Consider downwind evacuation if material is leaking. Stop flow of gas.
FLASH POINT: -105 F (-76 C)
AUTOIGNITION: 869 F (465 C)

SECTION 6 ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL RELEASE:
Avoid heat, flames, sparks and other sources of ignition. Do not touch spilled material. Stop leak if possible without personal risk. Reduce vapors with water spray. Keep unnecessary people away, isolate hazard area and deny entry. Remove sources of ignition. Ventilate closed spaces before entering.

SECTION 7 HANDLING AND STORAGE

Store and handle in accordance with all current regulations and standards.

SECTION 8 EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
ISOBUTENE:

No occupational exposure limits established.
VENTILATION: Provide local exhaust ventilation system. Ventilation equipment should be explosion-resistant if explosive concentrations of material are present. Ensure compliance with applicable exposure limits.
EYE PROTECTION: Wear splash resistant safety goggles with a faceshield. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.
CLOTHING: For the gas: Protective clothing is not required. For the liquid: Wear appropriate protective, cold insulating clothing.
GLOVES: Wear insulated gloves.

RESPIRATOR: Under conditions of frequent use or heavy exposure, respiratory protection may be needed. Respiratory protection is ranked in order from minimum to maximum. Consider warning properties before use.
Any supplied-air respirator with a full facepiece that is operated in a pressure-demand or other positive-pressure mode.
Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.
For Unknown Concentrations or Immediately Dangerous to Life or Health -
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Any self-contained breathing apparatus with a full facepiece.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL DESCRIPTION: Colorless, volatile liquid or easily liquified gas with coal gas odor
MOLECULAR WEIGHT: 56.12
MOLECULAR FORMULA: C4-H8
BOILING POINT: 19 F (-7 C)
FREEZING POINT: -220 F (-140 C)
VAPOR PRESSURE: 1.96 mmHg @ 20 C
VAPOR DENSITY (air=1): 1.9
SPECIFIC GRAVITY (water=1): 0.5879 @ 25 C
WATER SOLUBILITY: almost insoluble
PH: Not applicable
VOLATILITY: Not applicable
ODOR THRESHOLD: Not available
EVAPORATION RATE: Not applicable
COEFFICIENT OF WATER/OIL DISTRIBUTION: Not applicable
SOLVENT SOLUBILITY:
Soluble: organic solvents, alcohol, ether, sulfuric acid

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY: Stable at normal temperatures and pressure.
CONDITIONS TO AVOID: Avoid heat, flames, sparks and other sources of ignition. Minimize contact with material. Containers may rupture or explode if exposed to heat.
INCOMPATIBILITIES: oxidizing materials
ISOBUTENE:
OXIDIZING MATERIAL: May react.
HAZARDOUS DECOMPOSITION:
Thermal decomposition products: oxides of carbon
POLYMERIZATION: Will not polymerize.

SECTION 11 TOXICOLOGICAL INFORMATION

ISOBUTENE:
TOXICITY DATA:
620 gm/m3/4 hour(s) inhalation-rat LC50; 415 gm/m3/2 hour(s) inhalation-mouse LC50

ACUTE TOXICITY LEVEL:
Relatively Non-toxic: inhalation
TARGET ORGANS: central nervous system
HEALTH EFFECTS:
INHALATION:
ISOBUTENE: May cause irritation of the mucous membranes. Isobutene is a mild anesthetic and may cause at large concentrations symptoms of dizziness, dullness, shortness of breath, disorientation, excitation, headaches, and vomiting. Severe exposure may cause loss of consciousness, convulsions, coma, and possible death. See information on simple asphyxiants.
ACUTE EXPOSURE:
SIMPLE ASPHYXIANTS: The symptoms of asphyxia depend on the rapidity with which the oxygen deficiency develops and how long it continues. In sudden acute asphyxia, unconsciousness may be immediate. With slow development there may be rapid respiration and pulse, air hunger, dizziness, reduced awareness, tightness in the head, tingling sensations, incoordination, faulty judgement, emotional instability, and rapid fatigue. As the asphyxia progresses, nausea, vomiting, collapse, unconsciousness, convulsions, deep coma and death are possible.
CHRONIC EXPOSURE:
SIMPLE ASPHYXIANTS: No data available.
SKIN CONTACT:
ACUTE EXPOSURE:
ISOBUTENE: Contact with liquified gas may cause frostbite, redness, pain and burns.
CHRONIC EXPOSURE:
ISOBUTENE: No data available.
EYE CONTACT:
ACUTE EXPOSURE:
ISOBUTENE: Contact with the vapor may cause irritation of the eyes. Eye contact with liquified gas may cause frostbite, redness, pain and blurred vision.
CHRONIC EXPOSURE:
ISOBUTENE: No effects reported in humans.
INGESTION:
ACUTE EXPOSURE:
ISOBUTENE: Ingestion of a gas is unlikely. If liquid is swallowed, frostbite damage of the lips, mouth and mucous membranes may occur.

CHRONIC EXPOSURE:
ISOBUTENE: No data available.

SECTION 12 ECOLOGICAL INFORMATION

Not available

SECTION 13 DISPOSAL CONSIDERATIONS

Dispose in accordance with all applicable regulations.

SECTION 14 TRANSPORT INFORMATION

U.S. DOT 49 CFR 172.101 SHIPPING NAME-UN NUMBER:
Isobutylene-UN1055
U.S. DOT 49 CFR 172.101 HAZARD CLASS OR DIVISION:
2.1
U.S. DOT 49 CFR 172.101 AND SUBPART E LABELING REQUIREMENTS:
Flammable gas
U.S. DOT 49 CFR 172.101 PACKAGING AUTHORIZATIONS:
EXCEPTIONS: 49 CFR 173.306
NON-BULK PACKAGING: 49 CFR 173.304
BULK PACKAGING: 49 CFR 173.314, 315
U.S. DOT 49 CFR 172.101 QUANTITY LIMITATIONS:
PASSENGER AIRCRAFT OR RAILCAR: Forbidden

CARGO AIRCRAFT ONLY: 150 kg
LAND TRANSPORT ADR/RID:
SUBSTANCE NAME: Isobutylene/Isobutene
UN NUMBER: UN1055
ADR/RID CLASS: 2
ITEM NUMBER: 3(b)/2F
WARNING SIGN/LABEL: 3/3; 13
HAZARD ID NUMBER: 23
AIR TRANSPORT IATA/ICAO:
CORRECT TECHNICAL NAME: Isobutylene
UN/ID NUMBER: UN1055
IATA/ICAO CLASS: 2.1
LABEL: Flammable gas
MARITIME TRANSPORT IMDG: No classification assigned.

SECTION 15 REGULATORY INFORMATION

U.S. REGULATIONS:
TSCA INVENTORY STATUS: Y
TSCA 12(b) EXPORT NOTIFICATION: Not listed.
CERCLA SECTION 103 (40CFR302.4): N
SARA SECTION 302 (40CFR355.30): N
SARA SECTION 304 (40CFR355.40): N
SARA SECTION 313 (40CFR372.65): N
SARA HAZARD CATEGORIES, SARA SECTIONS 311/312 (40CFR370.21):
ACUTE: Y
CHRONIC: N
FIRE: Y
REACTIVE: N
SUDDEN RELEASE: Y
OSHA PROCESS SAFETY (29CFR1910.119): N
STATE REGULATIONS:
California Proposition 65: N
EUROPEAN REGULATIONS:
EC NUMBER (EINECS): 204-066-3
EC RISK AND SAFETY PHRASES:

R 12	Extremely flammable.
S 2	Keep out of reach of children.
S 9	Keep container in a well-ventilated place.
S 16	Keep away from sources of ignition - No smoking.
S 33	Take precautionary measures against static discharges.

GERMAN REGULATIONS:
WATER HAZARD CLASS (WGK): 0 (Official German Classification)

SECTION 16 OTHER INFORMATION

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New Jersey Department of Health and Senior Services

HAZARDOUS SUBSTANCE FACT SHEET

Common Name: **PENTANE-2,4-DIONE**

CAS Number: 123-54-6
DOT Number: UN 2310

RTK Substance number: 1477
Date: August 1999

HAZARD SUMMARY

* **Pentane-2,4-Dione** can affect you when breathed in and may be absorbed through the skin.
* Contact can irritate the skin and eyes.
* Breathing **Pentane-2,4-Dione** can irritate the nose and throat causing coughing and wheezing.
* **Pentane-2,4-Dione** can cause nausea, vomiting, diarrhea and abdominal pain.
* Exposure to **Pentane-2,4-Dione** can cause headache, weakness, dizziness, convulsions, unconsciousness and even death.
* **Pentane-2,4-Dione** may cause a skin allergy. If allergy develops, very low future exposure can cause itching and a skin rash.
* High exposure may affect the brain.

IDENTIFICATION

Pentane-2,4-Dione is a colorless to slightly yellow liquid with a pleasant odor. It is used in the manufacture of colors, paints, varnishes, resins, inks, dyes, pharmaceuticals, and other chemicals, as a pesticide, and as an additive to gasoline.

REASON FOR CITATION

* **Pentane-2,4-Dione** is on the Hazardous Substance List because it is cited by DOT and NFPA.
* Definitions are provided on page 5.

HOW TO DETERMINE IF YOU ARE BEING EXPOSED

The New Jersey Right to Know Act requires most employers to label chemicals in the workplace and requires public employers to provide their employees with information and training concerning chemical hazards and controls. The federal OSHA Hazard Communication Standard, 1910.1200, requires private employers to provide similar training and information to their employees.

* Exposure to hazardous substances should be routinely evaluated. This may include collecting personal and area air samples. You can obtain copies of sampling results from your employer. You have a legal right to this information under OSHA 1910.1020.
* If you think you are experiencing any work-related health problems, see a doctor trained to recognize occupational diseases. Take this Fact Sheet with you.

WORKPLACE EXPOSURE LIMITS

No occupational exposure limits have been established for **Pentane-2,4-Dione**. This does not mean that this substance is not harmful. Safe work practices should always be followed.

* It should be recognized that **Pentane-2,4-Dione** may be absorbed through your skin, thereby increasing your exposure.

WAYS OF REDUCING EXPOSURE

* Where possible, enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, respirators should be worn.
* Wear protective work clothing.
* Wash thoroughly immediately after exposure to **Pentane-2,4-Dione** and at the end of the workshift.
* Post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, communicate all information on the health and safety hazards of **Pentane-2,4-Dione** to potentially exposed workers.

This Fact Sheet is a summary source of information of all potential and most severe health hazards that may result from exposure. Duration of exposure, concentration of the substance and other factors will affect your susceptibility to any of the potential effects described below.

HEALTH HAZARD INFORMATION

Acute Health Effects

The following acute (short-term) health effects may occur immediately or shortly after exposure to **Pentane-2,4-Dione**:

* Contact can irritate the skin and eyes.
* Breathing **Pentane-2,4-Dione** can irritate the nose and throat causing coughing and wheezing.
* **Pentane-2,4-Dione** can cause nausea, vomiting, diarrhea and abdominal pain.
* Exposure to **Pentane-2,4-Dione** can cause headache, weakness, dizziness, convulsions, unconsciousness and even death.

Chronic Health Effects

The following chronic (long-term) health effects can occur at some time after exposure to **Pentane-2,4-Dione** and can last for months or years:

Cancer Hazard

There is limited evidence that **Pentane-2,4-Dione** may cause mutations.

Reproductive Hazard

* There is limited evidence that **Pentane-2,4-Dione** may cause reproductive damage.

Other Long-Term Effects

* **Pentane-2,4-Dione** may cause a skin allergy. If allergy develops, very low future exposure can cause itching and a skin rash.
* High exposure may affect the brain.

MEDICAL

Medical Testing

If symptoms develop or overexposure is suspected, the following are recommended:

* Evaluation by a qualified allergist, including careful exposure history and special testing, may help diagnose skin allergy.
* Evaluate for brain effects such as changes in memory, concentration, sleeping patterns and mood (especially irritability and social withdrawal), as well as headaches and fatigue. Consider evaluations of the cerebellar, autonomic and peripheral nervous systems. Positive and borderline individuals should be referred for neuropsychological testing.

Any evaluation should include a careful history of past and present symptoms with an exam. Medical tests that look for damage already done are not a substitute for controlling exposure.

Request copies of your medical testing. You have a legal right to this information under OSHA 1910.1020.

WORKPLACE CONTROLS AND PRACTICES

Unless a less toxic chemical can be substituted for a hazardous substance, **ENGINEERING CONTROLS** are the most effective way of reducing exposure. The best protection is to enclose operations and/or provide local exhaust ventilation at the site of chemical release. Isolating operations can also reduce exposure. Using respirators or protective equipment is less effective than the controls mentioned above, but is sometimes necessary.

In evaluating the controls present in your workplace, consider: (1) how hazardous the substance is, (2) how much of the substance is released into the workplace and (3) whether harmful skin or eye contact could occur. Special controls should be in place for highly toxic chemicals or when significant skin, eye, or breathing exposures are possible.

In addition, the following control is recommended:

* Where possible, automatically pump liquid **Pentane-2,4-Dione** from drums or other storage containers to process containers.

Good **WORK PRACTICES** can help to reduce hazardous exposures. The following work practices are recommended:

* Workers whose clothing has been contaminated by **Pentane-2,4-Dione** should change into clean clothing promptly.
* Contaminated work clothes should be laundered by individuals who have been informed of the hazards of exposure to **Pentane-2,4-Dione**.
* Eye wash fountains should be provided in the immediate work area for emergency use.
* If there is the possibility of skin exposure, emergency shower facilities should be provided.
* On skin contact with **Pentane-2,4-Dione**, immediately wash or shower to remove the chemical. At the end of the workshift, wash any areas of the body that may have contacted **Pentane-2,4-Dione**, whether or not known skin contact has occurred.
* Do not eat, smoke, or drink where **Pentane-2,4-Dione** is handled, processed, or stored, since the chemical can be swallowed. Wash hands carefully before eating, drinking, smoking, or using the toilet.

PERSONAL PROTECTIVE EQUIPMENT

WORKPLACE CONTROLS ARE BETTER THAN PERSONAL PROTECTIVE EQUIPMENT. However, for some jobs (such as outside work, confined space entry, jobs done only once in a while, or jobs done while workplace controls are being installed), personal protective equipment may be appropriate.

OSHA 1910.132 requires employers to determine the appropriate personal protective equipment for each hazard and to train employees on how and when to use protective equipment.

The following recommendations are only guidelines and may not apply to every situation.

Clothing

* Avoid skin contact with **Pentane-2,4-Dione**. Wear solvent-resistant gloves and clothing. Safety equipment suppliers/manufacturers can provide recommendations on the most protective glove/clothing material for your operation.
* All protective clothing (suits, gloves, footwear, headgear) should be clean, available each day, and put on before work.

Eye Protection

* Wear indirect-vent, impact and splash resistant goggles when working with liquids.
* All protective clothing (suits, gloves, footwear, headgear) should be clean, available each day, and put on before work.

Respiratory Protection

IMPROPER USE OF RESPIRATORS IS DANGEROUS. Such equipment should only be used if the employer has a written program that takes into account workplace conditions, requirements for worker training, respirator fit testing and medical exams, as described in OSHA 1910.134.

* Where the potential for overexposure exists, use a MSHA/NIOSH approved supplied-air respirator with a full facepiece operated in a pressure-demand or other positive-pressure mode. For increased protection use in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive-pressure mode.

HANDLING AND STORAGE

* Prior to working with **Pentane-2,4-Dione** you should be trained on its proper handling and storage.
* **Pentane-2,4-Dione** is not compatible with ORGANIC ACIDS; ISOCYANATES; AMINES; OXIDIZING AGENTS (such as PERCHLORATES, PEROXIDES, PERMANGANATES, CHLORATES, NITRATES, CHLORINE, BROMINE and FLUORINE); HALOGENS; REDUCING AGENTS; STRONG BASES (such as SODIUM HYDROXIDE and POTASSIUM HYDROXIDE); and ALKANOLAMINES.
* Store in tightly closed containers in a cool, well-ventilated area away from PLASTICS.
* Sources of ignition, such as smoking and open flames, are prohibited where **Pentane-2,4-Dione** is used, handled, or stored in a manner that could create a potential fire or explosion hazard.

QUESTIONS AND ANSWERS

Q: If I have acute health effects, will I later get chronic health effects?

A: Not always. Most chronic (long-term) effects result from repeated exposures to a chemical.

Q: Can I get long-term effects without ever having short-term effects?

A: Yes, because long-term effects can occur from repeated exposures to a chemical at levels not high enough to make you immediately sick.

Q: What are my chances of getting sick when I have been exposed to chemicals?

A: The likelihood of becoming sick from chemicals is increased as the amount of exposure increases. This is determined by the length of time and the amount of material to which someone is exposed.

Q: When are higher exposures more likely?

A: Conditions which increase risk of exposure include physical and mechanical processes (heating, pouring, spraying, spills and evaporation from large surface areas such as open containers), and "confined space" exposures (working inside vats, reactors, boilers, small rooms, etc.).

Q: Is the risk of getting sick higher for workers than for community residents?

A: Yes. Exposures in the community, except possibly in cases of fires or spills, are usually much lower than those found in the workplace. However, people in the community may be exposed to contaminated water as well as to chemicals in the air over long periods. This may be a problem for children or people who are already ill.

Q: Can men as well as women be affected by chemicals that cause reproductive system damage?

A: Yes. Some chemicals reduce potency or fertility in both men and women. Some damage sperm and eggs, possibly leading to birth defects.

Q: Who is at the greatest risk from reproductive hazards?

A: Pregnant women are at greatest risk from chemicals that harm the developing fetus. However, chemicals may affect the ability to have children, so both men and women of childbearing age are at high risk.

Q: What are the likely health problems from chemicals which cause mutations?

A: There are two primary health concerns associated with mutagens: (1) cancers can result from changes induced in cells and, (2) adverse reproductive and developmental outcomes can result from damage to the egg and sperm cells.

The following information is available from:

New Jersey Department of Health and Senior Services
Occupational Health Service
PO Box 360
Trenton, NJ 08625-0360
(609) 984-1863
(609) 292-5677 (fax)

Web address: http://www.state.nj.us/health/eoh/odisweb/

Industrial Hygiene Information

Industrial hygienists are available to answer your questions regarding the control of chemical exposures using exhaust ventilation, special work practices, good housekeeping, good hygiene practices, and personal protective equipment including respirators. In addition, they can help to interpret the results of industrial hygiene survey data.

Medical Evaluation

If you think you are becoming sick because of exposure to chemicals at your workplace, you may call personnel at the Department of Health and Senior Services, Occupational Health Service, who can help you find the information you need.

Public Presentations

Presentations and educational programs on occupational health or the Right to Know Act can be organized for labor unions, trade associations and other groups.

Right to Know Information Resources

The Right to Know Infoline (609) 984-2202 can answer questions about the identity and potential health effects of chemicals, list of educational materials in occupational health, references used to prepare the Fact Sheets, preparation of the Right to Know survey, education and training programs, labeling requirements, and general information regarding the Right to Know Act. Violations of the law should be reported to (609) 984-2202.

DEFINITIONS

ACGIH is the American Conference of Governmental Industrial Hygienists. It recommends upper limits (called TLVs) for exposure to workplace chemicals.

A **carcinogen** is a substance that causes cancer.

The **CAS number** is assigned by the Chemical Abstracts Service to identify a specific chemical.

A **combustible** substance is a solid, liquid or gas that will burn.

A **corrosive** substance is a gas, liquid or solid that causes irreversible damage to human tissue or containers.

DEP is the New Jersey Department of Environmental Protection.

DOT is the Department of Transportation, the federal agency that regulates the transportation of chemicals.

EPA is the Environmental Protection Agency, the federal agency responsible for regulating environmental hazards.

A **fetus** is an unborn human or animal.

A **flammable** substance is a solid, liquid, vapor or gas that will ignite easily and burn rapidly.

The **flash point** is the temperature at which a liquid or solid gives off vapor that can form a flammable mixture with air.

HHAG is the Human Health Assessment Group of the federal EPA.

IARC is the International Agency for Research on Cancer, a scientific group that classifies chemicals according to their cancer-causing potential.

A **miscible** substance is a liquid or gas that will evenly dissolve in another.

mg/m^3 means milligrams of a chemical in a cubic meter of air. It is a measure of concentration (weight/volume).

MSHA is the Mine Safety and Health Administration, the federal agency that regulates mining. It also evaluates and approves respirators.

A **mutagen** is a substance that causes mutations. A **mutation** is a change in the genetic material in a body cell. Mutations can lead to birth defects, miscarriages, or cancer.

NAERG is the North American Emergency Response Guidebook. It was jointly developed by Transport Canada, the United States Department of Transportation and the Secretariat of Communications and Transportation of Mexico. It is a guide for first responders to quickly identify the specific or generic hazards of material involved in a transportation incident, and to protect themselves and the general public during the initial response phase of the incident.

NCI is the National Cancer Institute, a federal agency that determines the cancer-causing potential of chemicals.

NFPA is the National Fire Protection Association. It classifies substances according to their fire and explosion hazard.

NIOSH is the National Institute for Occupational Safety and Health. It tests equipment, evaluates and approves respirators, conducts studies of workplace hazards, and proposes standards to OSHA.

NTP is the National Toxicology Program which tests chemicals and reviews evidence for cancer.

OSHA is the Occupational Safety and Health Administration which adopts and enforces health and safety standards.

PEOSHA is the Public Employees Occupational Safety and Health Act, a state law which sets PELs for New Jersey public employees.

ppm means parts of a substance per million parts of air. It is a measure of concentration by volume in air.

A **reactive** substance is a solid, liquid or gas that releases energy under certain conditions.

A **teratogen** is a substance that causes birth defects by damaging the fetus.

TLV is the Threshold Limit Value, the workplace exposure limit recommended by ACGIH.

The **vapor pressure** is a measure of how readily a liquid or a solid mixes with air at its surface. A higher vapor pressure indicates a higher concentration of the substance in air and therefore increases the likelihood of breathing it in.

>>>>>>>>>>>>>>>>>> EMERGENCY INFORMATION <<<<<<<<<<<<<<<<<<

Common Name: **PENTANE-2,4-DIONE**
DOT Number: **UN 2310**
ERG Code: **127**
CAS Number: **123-54-6**

Hazard rating	NJDHSS	NFPA
FLAMMABILITY	-	2
REACTIVITY	-	0
COMBUSTIBLE POISONOUS GASES ARE PRODUCED IN FIRE CONTAINERS MAY EXPLODE IN FIRE		

Hazard Rating Key: 0=minimal; 1=slight; 2=moderate; 3=serious; 4=severe

FIRE HAZARDS

* **Pentane-2,4-Dione** is a COMBUSTIBLE LIQUID.
* Use dry chemical, CO_2, alcohol or polymer foam extinguishers.
* POISONOUS GASES ARE PRODUCED IN FIRE.
* CONTAINERS MAY EXPLODE IN FIRE.
* Use water spray to keep fire-exposed containers cool.
* Vapors may travel to a source of ignition and flash back.
* If employees are expected to fight fires, they must be trained and equipped as stated in OSHA 1910.156.

SPILLS AND EMERGENCIES

If **Pentane-2,4-Dione** is spilled or leaked, take the following steps:

* Evacuate persons not wearing protective equipment from area of spill or leak until clean-up is complete.
* Remove all ignition sources.
* Cover with an activated charcoal adsorbent and place in covered containers for disposal.
* Ventilate and wash area after clean-up is complete.
* It may be necessary to contain and dispose of **Pentane-2,4-Dione** as a HAZARDOUS WASTE. Contact your Department of Environmental Protection (DEP) or your regional office of the federal Environmental Protection Agency (EPA) for specific recommendations.
* If employees are required to clean-up spills, they must be properly trained and equipped. OSHA 1910.120(q) may be applicable.

FOR LARGE SPILLS AND FIRES immediately call your fire department. You can request emergency information from the following:

CHEMTREC: (800) 424-9300
NJDEP HOTLINE: (609) 292-7172

HANDLING AND STORAGE (See page 3)

FIRST AID

In NJ, POISON INFORMATION 1-800-764-7661

Eye Contact

* Immediately flush with large amounts of water for at least 15 minutes, occasionally lifting upper and lower lids.

Skin Contact

* Remove contaminated clothing. Wash contaminated skin with soap and water.

Breathing

* Remove the person from exposure.
* Begin rescue breathing (using universal precautions) if breathing has stopped and CPR if heart action has stopped.
* Transfer promptly to a medical facility.

PHYSICAL DATA

Vapor Pressure: 7 mm Hg at 77°F (25°C)
Flash Point: 105°F (40.6°C)
Water Solubility: Soluble

OTHER COMMONLY USED NAMES

Chemical Name:
2,4-Pentanedione
Other Names:
2-Propanone, Acetyl; Diacetylmethane; Acetyl Acetone; Acetoacetone

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Not intended to be copied and sold for commercial purposes.

NEW JERSEY DEPARTMENT OF HEALTH AND SENIOR SERVICES
Right to Know Program
PO Box 368, Trenton, NJ 08625-0368
(609) 984-2202

Material Safety Data Sheets MESSER MG Industries

SECTION 1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MG INDUSTRIES
3 GREAT VALLEY PARKWAY
MALVERN, PENNSYLVANIA 19355
PHONE: 610-695-7400
FAX: 610-695-7596

EMERGENCY CONTACT:
CHEMTREC:
1-800-424-9300

SUBSTANCE: HYDROGEN CHLORIDE, ANHYDROUS
TRADE NAMES/SYNONYMS:
HYDROCHLORIC ACID, ANHYDROUS; HYDROGEN CHLORIDE; SPIRITS OF SALT; MURIATIC ACID; HYDROCHLORIC ACID; HYDROCHLORIC ACID GAS; ANHYDROUS HYDROCHLORIC ACID; HYDROGEN CHLORIDE (HCL); STCC 4904270; UN 1050; CLH; MGI11150; RTECS MW4025000
CHEMICAL FAMILY: acids, inorganic
CREATION DATE: May 04 1990
REVISION DATE: Jun 02 1999

SECTION 2 COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: HYDROGEN CHLORIDE, ANHYDROUS
CAS NUMBER: 7647-01-0
EC NUMBER (EINECS): 231-595-7
EC INDEX NUMBER: 017-002-00-2
PERCENTAGE: 100

SECTION 3 HAZARDS IDENTIFICATION

NFPA RATINGS (SCALE 0-4): HEALTH=3 FIRE=0 REACTIVITY=1
EC CLASSIFICATION (ASSIGNED):
T Toxic
C Corrosive
R 23-35
EC Classification may be inconsistent with independently-researched data.
EMERGENCY OVERVIEW:
PHYSICAL DESCRIPTION: Colorless gas or fuming liquid with a suffocating odor.
MAJOR HEALTH HAZARDS: skin burns, mucous membrane burns, respiratory irritation (possibly severe), eye irritation (possibly severe)
PHYSICAL HAZARDS: Containers may rupture or explode if exposed to heat. May react on contact with water.
POTENTIAL HEALTH EFFECTS:
INHALATION:

SHORT TERM EXPOSURE: irritation (possibly severe), headache, lung congestion, lung damage
LONG TERM EXPOSURE: digestive disorders
SKIN CONTACT:
SHORT TERM EXPOSURE: irritation (possibly severe), frostbite
LONG TERM EXPOSURE: same as effects reported in short term exposure
EYE CONTACT:
SHORT TERM EXPOSURE: irritation (possibly severe), frostbite, blindness
LONG TERM EXPOSURE: same as effects reported in short term exposure
INGESTION:
SHORT TERM EXPOSURE: burns, nausea, vomiting, diarrhea
LONG TERM EXPOSURE: same as effects reported in short term exposure
CARCINOGEN STATUS:
OSHA: N
NTP: N

IARC: N

SECTION 4 FIRST AID MEASURES

INHALATION: When safe to enter area, remove from exposure. Use a bag valve mask or similar device to perform artificial respiration (rescue breathing) if needed. Keep warm and at rest. Get medical attention immediately.
SKIN CONTACT: Remove contaminated clothing, jewelry, and shoes immediately. Wash with soap or mild detergent and large amounts of water until no evidence of chemical remains (at least 15-20 minutes). For burns, cover affected area securely with sterile, dry, loose-fitting dressing. Get medical attention immediately.
EYE CONTACT: Wash eyes immediately with large amounts of water, occasionally lifting upper and lower lids, until no evidence of chemical remains. Continue irrigating with normal saline until ready to transport to hospital. Cover with sterile bandages. Get medical attention immediately.
INGESTION: Contact local poison control center or physician immediately. Never make an unconscious person vomit or drink fluids. Give large amounts of water or milk. Allow vomiting to occur. When vomiting occurs, keep head lower than hips to help prevent aspiration. If person is unconscious, turn head to side. Get medical attention immediately.
NOTE TO PHYSICIAN: For inhalation, consider oxygen. Avoid gastric lavage or emesis.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Negligible fire hazard. Containers may rupture or explode if exposed to heat.
EXTINGUISHING MEDIA: carbon dioxide, regular dry chemical
Large fires: Use regular foam or flood with fine water spray.

FIRE FIGHTING: Do not get water inside container. Move container from fire area if it can be done without risk. Cool containers with water spray until well after the fire is out. Stay away from the ends of tanks. Keep unnecessary people away, isolate hazard area and deny entry.

SECTION 6 ACCIDENTAL RELEASE MEASURES

AIR RELEASE:
Reduce vapors with water spray. Stay upwind and keep out of low areas. Collect runoff for disposal as potential hazardous waste.
SOIL RELEASE:
Dig holding area such as lagoon, pond or pit for containment. Dike for later disposal. Absorb with sand or other non-combustible material. Add an alkaline material (lime, crushed limestone, sodium bicarbonate, or soda ash).
WATER RELEASE:
Add an alkaline material (lime, crushed limestone, sodium bicarbonate, or soda ash).
OCCUPATIONAL RELEASE:
Stop leak if possible without personal risk. Reduce vapors with water spray. Do not get water directly on material. Do not get water inside container. Keep unnecessary people away, isolate hazard area and deny entry. Small spills: Flood with water. Large spills: Dike for later disposal. Stay upwind and keep out of low areas. Ventilate closed spaces before entering. Evacuation radius: 150 feet. Notify Local Emergency Planning Committee and State Emergency Response Commission for release greater than or equal to RQ (U.S. SARA Section 304). If release occurs in the U.S. and is reportable under CERCLA Section 103, notify the National Response Center at (800)424-8802 (USA) or (202)426-2675 (USA).

SECTION 7 HANDLING AND STORAGE

Store and handle in accordance with all current regulations and standards. Subject to storage regulations: U.S. OSHA 29 CFR 1910.101. Protect from

physical damage. Store in a cool, dry place. Store in a well-ventilated area. Keep separated from incompatible substances. Keep separated from incompatible substances. Notify State Emergency Response Commission for storage or use at amounts greater than or equal to the TPQ (U.S. EPA SARA Section 302). SARA Section 303 requires facilities storing a material with a TPQ to participate in local emergency response planning (U.S. EPA 40 CFR 355.30).

SECTION 8 EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
HYDROGEN CHLORIDE, ANHYDROUS:
HYDROGEN CHLORIDE (HYDROCHLORIC ACID):

5 ppm (7.6 mg/m3) OSHA ceiling
5 ppm (7.6 mg/m3) ACGIH ceiling
5 ppm (7.6 mg/m3) NIOSH recommended ceiling
7 mg/m3 (5 ml/m3) DFG MAK 1 times/shift
10 ppm (15 mg/m3) EC MAK STEL
5 ppm (8 mg/m3) EC MAK TWA
5 ppm (7.6 mg/m3) UK OES STEL
MEASUREMENT METHOD: Silica gel tube; Sodium bicarbonate/Sodium carbonate; Ion chromotography; NIOSH III # 7903, Inorganic Acids
VENTILATION: Provide local exhaust or process enclosure ventilation system. Ensure compliance with applicable exposure limits.
EYE PROTECTION: Wear splash resistant safety goggles with a faceshield. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.
CLOTHING: Wear appropriate chemical resistant clothing.
GLOVES: Wear appropriate chemical resistant gloves.
RESPIRATOR: The following respirators and maximum use concentrations are drawn from NIOSH and/or OSHA.
50 ppm
Any chemical cartridge respirator with cartridge(s) providing protection against this substance.
Any air-purifying respirator with a full facepiece and a canister providing protection against this substance.
Any powered, air-purifying respirator with cartridge(s) providing protection against this substance.
Any supplied-air respirator.
Any self-contained breathing apparatus with a full facepiece.
Escape -
Any air-purifying respirator with a full facepiece and an acid gas canister.
Any appropriate escape-type, self-contained breathing apparatus.
For Unknown Concentrations or Immediately Dangerous to Life or Health -
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Any self-contained breathing apparatus with a full facepiece.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL DESCRIPTION: Colorless gas or fuming liquid with a suffocating odor.
MOLECULAR WEIGHT: 36.46
MOLECULAR FORMULA: H-CL
BOILING POINT: -121 F (-85 C)
FREEZING POINT: -175 F (-115 C)
VAPOR PRESSURE: 3040 mmHg @ 17.8 C
VAPOR DENSITY (air=1): 1.268
SPECIFIC GRAVITY (water=1): 1.187 @ -85 C
WATER SOLUBILITY: 82.3% @ 0 C

PH: acidic in solution
VOLATILITY: Not applicable
ODOR THRESHOLD: 1-5 ppm

EVAPORATION RATE: Not applicable
COEFFICIENT OF WATER/OIL DISTRIBUTION: Not applicable
SOLVENT SOLUBILITY:
Soluble: alcohol, ether, benzene, methanol

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY: May react with evolution of heat on contact with water.
CONDITIONS TO AVOID: Minimize contact with material. Avoid inhalation of material or combustion by-products. Containers may rupture or explode if exposed to heat.
INCOMPATIBILITIES: cyanides, metals, amines, bases, metal carbide, oxidizing materials, acids, halo carbons, combustible materials, halogens, metal salts
HYDROGEN CHLORIDE (HYDROCHLORIC ACID):
ACETIC ANHYDRIDE: Violent reaction.
ALCOHOLIC HYDROGEN CYANIDE: Explosive reaction.
ALUMINUM: Explosion.
ALUMINUM-TITANIUM ALLOYS: Ignites or incandesces when heated.
2-AMINOETHANOL: Violent reaction.
AMMONIUM HYDROXIDE: Violent reaction.
BASES: Violent reaction.
BRASS: Corrodes.
BRONZE: Corrodes.
CALCIUM CARBIDE: Reacts with incandescence.
CALCIUM HYPOCHLORITE: Ignition.
CESIUM ACETYLIDE: Ignites on contact.
CHLORINE + DINITROANILINES: Vigorous reaction with release of flammable hydrogen gas fumes.
CHLOROSULFONIC ACID: Violent reaction.
1,1-DIFLUOROETHYLENE: Extremely exothermic decomposition reaction.
DOWICIL 100: Decomposes.
ETHYLENE DIAMINE: Violent reaction.
ETHYLENE IMINE: Violent reaction.
FLUORINE: Ignites on contact.
HEXALITHIUM DISILICIDE: Incandescesent.
IRON: Corrodes with evolution of flammable hydrogen gas.
MAGNESIUM BORIDE: Produces a spontaneously flammable gas.
MERCURIC SULFATE: Violent reaction at 125 C.
METAL ACETYLIDES: Violent reaction.
METALS: Severe corrosion with evolution of flammable hydrogen gas.
OLEUM: Violent reaction.
OXIDIZERS (STRONG): Violent reaction.
OXYGEN + PLATINUM: Ignites on contact.
PERCHLORIC ACID: Violent reaction.
PLASTICS, RUBBER, COATINGS: Attacks.
POTASSIUM PERMANGANATE: Explosion hazard.
BETA-PROPIOLACTONE: Violent reaction.

PROPYLENE OXIDE: Violent reaction.
RUBIDIUM ACETYLIDE: Ignites on contact.
SILICA (GEL): Incompatible.
SODIUM: Vigorous or explosive reaction.
SULFURIC ACID: Explosive reaction with release of toxic hydrogen chloride gas.
TETRASELENIUM TETRANITRIDE: Explodes on contact.
VINYL ACETATE: Violent reaction.
HAZARDOUS DECOMPOSITION:
Thermal decomposition products: chlorine
POLYMERIZATION: Will not polymerize.

SECTION 11 TOXICOLOGICAL INFORMATION

HYDROGEN CHLORIDE, ANHYDROUS:
IRRITATION DATA:

5 mg/30 second(s) rinsed eyes-rabbit mild
TOXICITY DATA:
1300 ppm/30 minute(s) inhalation-human LCLo; 3000 ppm/5 minute(s) inhalation-human LCLo; 81 mg/kg unreported-man LDLo; 3124 ppm/1 hour(s) inhalation-rat LC50; 1108 ppm/1 hour(s) inhalation-mouse LC50; 40142 ug/kg intraperitoneal-mouse LD50; 900 mg/kg oral-rabbit LD50; 4413 ppm/30 minute(s) inhalation-rabbit LCLo; 4413 ppm/30 minute(s) inhalation-guinea pig LCLo; 685 ug/m3/24 hour(s)-84 day(s) continuous inhalation-rat TCLo
CARCINOGEN STATUS: IARC: Human Inadequate Evidence, Animal Inadequate Evidence, Group 3
LOCAL EFFECTS:
Corrosive: inhalation, skin, eye, ingestion
ACUTE TOXICITY LEVEL:
Moderately Toxic: inhalation, ingestion
MUTAGENIC DATA:
DNA repair - Escherichia coli 25 ug/well; sex chromosone loss and non disjunction - Drosophila melanogaster inhalation 100 ppm 24 hour(s); sex chromosone loss and non disjunction - Drosophila melanogaster oral 100 ppm; cytogenetic analysis - grasshopper parenteral 20 mg; cytogenetic analysis - hamster lung 30 mmol/L; cytogenetic analysis - hamster ovary 8 mmol/L
REPRODUCTIVE EFFECTS DATA:
450 mg/m3 inhalation-rat TCLo/1 hour(s) 1 day(s) pre pregnancy continuous
HEALTH EFFECTS:
INHALATION:
ACUTE EXPOSURE:
HYDROGEN CHLORIDE (HYDROCHLORIC ACID): Inhalation of gas or fumes at levels of 5-35 ppm may cause irritation and burning of the throat, coughing and choking; 50-100 ppm may be barely tolerable for 1 hour. High levels may cause inflammation and occasionally ulceration of the nose, throat or larynx, bronchitis, pneumonia, palpitations and headache. Higher concentrations may cause necrosis of the tracheal and bronchial epithelium, nasoseptal perforation, atelectasis, emphysema, damage to pulmonary blood vessels and lesions of the liver and other organs. Death may be due to laryngeal spasm, bronchopneumonia or pulmonary edema.

1300-2000 ppm may be dangerous, even on brief exposures. An environmental exposure to hydrochloric acid has resulted in chronic neurobehavioral dysfunction. Reproductive effects have been reported in animals.
CHRONIC EXPOSURE:
HYDROGEN CHLORIDE (HYDROCHLORIC ACID): Repeated or prolonged exposure may cause erosion and discoloration of exposed teeth, chronic bronchitis and gastritis.
SKIN CONTACT:
ACUTE EXPOSURE:
HYDROGEN CHLORIDE (HYDROCHLORIC ACID): Contact may cause severe irritation, inflammation, ulceration, necrosis and chemical burns. Shock symptoms may develop including rapid pulse, sweating and collapse. Photosensitization reactions may occur in persons previously exposed. Contact with a compressed gas may cause frostbite.
CHRONIC EXPOSURE:
HYDROGEN CHLORIDE (HYDROCHLORIC ACID): Repeated or prolonged contact with vapors or dilute solutions may cause dermatitis. Photosensitization may occur.
EYE CONTACT:
ACUTE EXPOSURE:
HYDROGEN CHLORIDE (HYDROCHLORIC ACID): Contact may cause severe irritation, conjunctivitis, corneal necrosis and burns with impairment or permanent loss of vision. A drop of hydrochloric acid splashed in the eye and immediately washed out has produced a white coagulation of the corneal and conjunctival epithelium. Animals exposed to vapor concentrations of 1350 ppm for one and a half hours showed clouding of the cornea and 300 ppm for 6 hours showed slight erosion of the corneal epithelium. Contact with a compressed gas may cause frostbite.
CHRONIC EXPOSURE:

HYDROGEN CHLORIDE (HYDROCHLORIC ACID): Animals exposed to vapor at 100 ppm for 6 hours daily for 50 days showed only slight unrest and irritation of the eyes, but no ocular injury. Effects are dependent upon concentration and duration of exposure. Conjunctivitis or effects similar to those for acute exposure may occur.

INGESTION:

ACUTE EXPOSURE:

HYDROGEN CHLORIDE (HYDROCHLORIC ACID): Ingestion of the acid may cause burns of the mouth, throat, esophagus and stomach with consequent pain, uneasiness, nausea, salivation, vomiting, diarrhea, chills, shock and intense thirst. Nephritis, fever and perforation of the intestinal tract, and circulatory collapse may occur. Death may be due to esophageal or gastric necrosis.

CHRONIC EXPOSURE:

HYDROGEN CHLORIDE (HYDROCHLORIC ACID): No data available.

SECTION 12 ECOLOGICAL INFORMATION

ECOTOXICITY DATA:

FISH TOXICITY: 21900 ug/L 96 hour(s) LC50 (Mortality) Fathead minnow (Pimephales promelas)

INVERTEBRATE TOXICITY: 560 ug/L 48 hour(s) EC50 (Immobilization) Water flea (Daphnia magna)

ALGAL TOXICITY: 800 ug/L 1600 week(s) EC50 (Population Size Reduction) Green algae (Chlorella pyrenoidosa)

PHYTOTOXICITY: 1000 ug/L 4-48 week(s) (Residue) Water-hyacinth (Eichhornia crassipes)

FATE AND TRANSPORT:

BIOCONCENTRATION: 1000 M 24 week(s) BCF (Residue) Blue-green algae (Coccochloris sp) 1E-6.5 M

SECTION 13 DISPOSAL CONSIDERATIONS

Subject to disposal regulations: U.S. EPA 40 CFR 262. Hazardous Waste Number(s): D002. Dispose in accordance with all applicable regulations.

SECTION 14 TRANSPORT INFORMATION

U.S. DOT 49 CFR 172.101 SHIPPING NAME-UN NUMBER:

Hydrogen chloride, refrigerated liquid-UN2186

U.S. DOT 49 CFR 172.101 HAZARD CLASS OR DIVISION:

2.3

U.S. DOT 49 CFR 172.101 AND SUBPART E LABELING REQUIREMENTS:

Poison gas; Corrosive

U.S. DOT 49 CFR 172.101 PACKAGING AUTHORIZATIONS:

EXCEPTIONS: None

NON-BULK PACKAGING: None

BULK PACKAGING: 49 CFR 173.314, 315

U.S. DOT 49 CFR 172.101 QUANTITY LIMITATIONS:

PASSENGER AIRCRAFT OR RAILCAR: Forbidden

CARGO AIRCRAFT ONLY: Forbidden

LAND TRANSPORT ADR/RID:

SUBSTANCE NAME: Hydrogen chloride, refrigerated liquid: Not to be accepted for carriage

UN NUMBER: UN2186

ADR/RID CLASS: 2

ITEM NUMBER: 3TC, Note

AIR TRANSPORT IATA/ICAO:

CORRECT TECHNICAL NAME: Hydrogen chloride, refrigerated liquid

UN/ID NUMBER: UN2186

IATA/ICAO CLASS: 2.3

MARITIME TRANSPORT IMDG: No classification assigned.

SECTION 15 REGULATORY INFORMATION

U.S. REGULATIONS:
TSCA INVENTORY STATUS: Y
TSCA 12(b) EXPORT NOTIFICATION: Not listed.
CERCLA SECTION 103 (40CFR302.4): Y
HYDROGEN CHLORIDE (HYDROCHLORIC ACID): 5000 LBS RQ
(liquid)
SARA SECTION 302 (40CFR355.30): Y
HYDROGEN CHLORIDE (HYDROCHLORIC ACID): 500 LBS TPQ
(gas)
SARA SECTION 304 (40CFR355.40): Y
HYDROGEN CHLORIDE (HYDROCHLORIC ACID): 5000 LBS RQ
(gas)
SARA SECTION 313 (40CFR372.65): Y
HYDROGEN CHLORIDE (HYDROCHLORIC ACID)
(except non-aerosol forms)
SARA HAZARD CATEGORIES, SARA SECTIONS 311/312 (40CFR370.21):
ACUTE: Y
CHRONIC: N
FIRE: N
REACTIVE: Y
SUDDEN RELEASE: Y
OSHA PROCESS SAFETY (29CFR1910.119): Y
HYDROGEN CHLORIDE (HYDROCHLORIC ACID): 5000 LBS TQ
(gas)
STATE REGULATIONS:
California Proposition 65: N
EUROPEAN REGULATIONS:
EC NUMBER (EINECS): 231-595-7
EC RISK AND SAFETY PHRASES:

R 23	Toxic by inhalation.
R 35	Causes severe burns.
S 1/2	Keep locked-up and out of reach of children.
S 9	Keep container in a well-ventilated place.
S 26	In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S 36/37/39	Wear suitable protective clothing, gloves and eye/face protection.
S 45	In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

CONCENTRATION LIMITS:

C>=5%	T; C	R 23-35
1%<=C<5%	C	R 20-35
0.5%<=C<1%	C	R 20-34
0.2%<=C<0.5%	C	R 34
0.02%<=C<0.2%	Xi	R 36/37/38

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GERMAN REGULATIONS:
WATER HAZARD CLASS (WGK): 1 (Official German Classification)

SECTION 16 OTHER INFORMATION

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New Jersey Department of Health and Senior Services

HAZARDOUS SUBSTANCE FACT SHEET

Common Name: **NITRIC ACID**

CAS Number: 7697-37-2
DOT Number: UN 2031 (more than 40% acid)
UN 1760 (40% or less acid)
UN 2032 (fuming)

RTK Substance number: 1356
Date: October 1985 Revision: March 1995

HAZARD SUMMARY

* **Nitric Acid** can affect you when breathed in and by passing through your skin.
* **Nitric Acid** is a CORROSIVE CHEMICAL and contact can cause severe eye and skin irritation and burns with possible permanent eye damage.
* Breathing **Nitric Acid** can irritate the nose and throat.
* Breathing **Nitric Acid** can irritate the lungs causing coughing and/or shortness of breath. Higher exposures can cause a build-up of fluid in the lungs (pulmonary edema), a medical emergency, with severe shortness of breath.
* Exposure to the vapor may cause erosion of the teeth.

IDENTIFICATION

Nitric Acid is a colorless, yellow or red fuming (smoking) liquid with a strong odor. It is used in making fertilizers, dyes, explosives, and other chemicals.

REASON FOR CITATION

* **Nitric Acid** is on the Hazardous Substance List because it is regulated by OSHA and cited by ACGIH, NIOSH, DEP, DOT, NFPA, and EPA.
* This chemical is on the Special Health Hazard Substance List because it is **CORROSIVE**.
* Definitions are provided on page 5.

HOW TO DETERMINE IF YOU ARE BEING EXPOSED

The New Jersey Right to Know Act requires most employers to label chemicals in the workplace and requires public employers to provide their employees with information and training concerning chemical hazards and controls. The federal OSHA Hazard Communication Standard, 1910.1200, requires private employers to provide similar training and information to their employees.

* Exposure to hazardous substances should be routinely evaluated. This may include collecting personal and area air samples. You can obtain copies of sampling results from your employer. You have a legal right to this information under OSHA 1910.20.
* If you think you are experiencing any work-related health problems, see a doctor trained to recognize occupational diseases. Take this Fact Sheet with you.

WORKPLACE EXPOSURE LIMITS

OSHA: The legal airborne permissible exposure limit (PEL) is **2 ppm** averaged over an 8-hour workshift.

NIOSH: The recommended airborne exposure limit is **2 ppm** averaged over a 10-hour workshift.

ACGIH: The recommended airborne exposure limit is **2 ppm** averaged over an 8-hour workshift and **4 ppm** as a STEL (short term exposure limit).

WAYS OF REDUCING EXPOSURE

* Where possible, enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, respirators should be worn.
* Wear protective work clothing.
* Wash thoroughly immediately after exposure to **Nitric Acid** and at the end of the workshift.
* Post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, communicate all information on the health and safety hazards of **Nitric Acid** to potentially exposed workers.

This Fact Sheet is a summary source of information of all potential and most severe health hazards that may result from exposure. Duration of exposure, concentration of the substance and other factors will affect your susceptibility to any of the potential effects described below.

HEALTH HAZARD INFORMATION

Acute Health Effects

The following acute (short-term) health effects may occur immediately or shortly after exposure to **Nitric Acid**:

* Contact can cause severe eye and skin irritation and burns with possible permanent eye damage.
* Breathing **Nitric Acid** can irritate the nose and throat.
* Breathing **Nitric Acid** can irritate the lungs causing coughing and/or shortness of breath. Higher exposures can cause a build-up of fluid in the lungs (pulmonary edema), a medical emergency, with severe shortness of breath.

Chronic Health Effects

The following chronic (long-term) health effects can occur at some time after exposure to **Nitric Acid** and can last for months or years:

Cancer Hazard

According to the information presently available to the New Jersey Department of Health and Senior Services, **Nitric Acid** has not been tested for its ability to cause cancer in animals.

Reproductive Hazard

* According to the information presently available to the New Jersey Department of Health and Senior Services, **Nitric Acid** has not been tested for its ability to affect reproduction.

Other Long-Term Effects

* Exposure to the vapor may cause erosion of the teeth.

MEDICAL

Medical Testing

Before beginning employment and at regular times after that, for those with frequent or potentially high exposures, the following are recommended:

* Lung function tests.

If symptoms develop or overexposure is suspected, the following may be useful:

* Consider chest x-ray after acute overexposure.

Any evaluation should include a careful history of past and present symptoms with an exam. Medical tests that look for damage already done are not a substitute for controlling exposure.

Request copies of your medical testing. You have a legal right to this information under OSHA 1910.20.

Mixed Exposures

Because smoking can cause heart disease, as well as lung cancer, emphysema, and other respiratory problems, it may worsen respiratory conditions caused by chemical exposure. Even if you have smoked for a long time, stopping now will reduce your risk of developing health problems.

WORKPLACE CONTROLS AND PRACTICES

Unless a less toxic chemical can be substituted for a hazardous substance, **ENGINEERING CONTROLS** are the most effective way of reducing exposure. The best protection is to enclose operations and/or provide local exhaust ventilation at the site of chemical release. Isolating operations can also reduce exposure. Using respirators or protective equipment is less effective than the controls mentioned above, but is sometimes necessary.

In evaluating the controls present in your workplace, consider: (1) how hazardous the substance is, (2) how much of the substance is released into the workplace and (3) whether harmful skin or eye contact could occur. Special controls should be in place for highly toxic chemicals or when significant skin, eye, or breathing exposures are possible.

In addition, the following controls are recommended:

* Where possible, automatically pump liquid **Nitric Acid** from drums or other storage containers to process containers.
* Specific engineering controls are recommended for this chemical by NIOSH. Refer to the NIOSH criteria document: *Occupational Exposure to Nitric Acid #76-141*.

Good **WORK PRACTICES** can help to reduce hazardous exposures. The following work practices are recommended:

* Workers whose clothing has been contaminated by Nitric **Acid** should change into clean clothing promptly.
* Contaminated work clothes should be laundered by individuals who have been informed of the hazards of exposure to **Nitric Acid**.
* Eye wash fountains should be provided in the immediate work area for emergency use.
* If there is the possibility of skin exposure, emergency shower facilities should be provided.
* On skin contact with **Nitric Acid**, immediately wash or shower to remove the chemical. At the end of the workshift, wash any areas of the body that may have contacted **Nitric Acid**, whether or not known skin contact has occurred.
* Do not eat, smoke, or drink where **Nitric Acid** is handled, processed, or stored, since the chemical can be swallowed. Wash hands carefully before eating or smoking.

PERSONAL PROTECTIVE EQUIPMENT

WORKPLACE CONTROLS ARE BETTER THAN PERSONAL PROTECTIVE EQUIPMENT. However, for some jobs (such as outside work, confined space entry, jobs done only once in a while, or jobs done while workplace controls are being installed), personal protective equipment may be appropriate.

The following recommendations are only guidelines and may not apply to every situation.

Clothing

* Avoid skin contact with **Nitric Acid**. Wear acid-resistant gloves and clothing. Safety equipment suppliers/ manufacturers can provide recommendations on the most protective glove/clothing material for your operation.
* All protective clothing (suits, gloves, footwear, headgear) should be clean, available each day, and put on before work.
* Safety equipment manufacturers recommend *Butyl, Butyl/Neoprene, Natural Rubber* and *Natural Rubber/Neoprene Mix* as protective materials.

Eye Protection

* Wear splash-proof chemical goggles and face shield when working with liquid, unless full facepiece respiratory protection is worn.

Respiratory Protection

IMPROPER USE OF RESPIRATORS IS DANGEROUS. Such equipment should only be used if the employer has a written program that takes into account workplace conditions, requirements for worker training, respirator fit testing and medical exams, as described in OSHA 1910.134.

* Where the potential exists for exposures over **2 ppm**, use a MSHA/NIOSH approved supplied-air respirator with a full facepiece operated in the positive pressure mode or with a full facepiece, hood, or helmet in the continuous flow mode, or use a MSHA/NIOSH approved self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
* Exposure to **100 ppm** is immediately dangerous to life and health. If the possibility of exposures above **100 ppm** exists, use a MSHA/NIOSH approved self contained breathing apparatus with a full facepiece operated in continuous flow or other positive pressure mode.

HANDLING AND STORAGE

* Prior to working with **Nitric Acid** you should be trained on its proper handling and storage.
* **Nitric Acid** is not compatible with METALLIC POWDERS, HYDROGEN SULFIDE, CARBIDES, ALCOHOLS, REDUCING AGENTS, ALKALI METALS, BRASS, COPPER, COPPER ALLOYS GALVANIZED IRON, ALUMINUM, AMINES, and ORGANIC MATERIALS.
* Store in tightly closed containers in a cool, well-ventilated area away from WATER, HEAT and COMBUSTIBLES.

QUESTIONS AND ANSWERS

Q: If I have acute health effects, will I later get chronic health effects?

A: Not always. Most chronic (long-term) effects result from repeated exposures to a chemical.

Q: Can I get long-term effects without ever having short-term effects?

A: Yes, because long-term effects can occur from repeated exposures to a chemical at levels not high enough to make you immediately sick.

Q: What are my chances of getting sick when I have been exposed to chemicals?

A: The likelihood of becoming sick from chemicals is increased as the amount of exposure increases. This is determined by the length of time and the amount of material to which someone is exposed.

Q: When are higher exposures more likely?

A: Conditions which increase risk of exposure include physical and mechanical processes (heating, pouring, spraying, spills and evaporation from large surface areas such as open containers), and "confined space" exposures (working inside vats, reactors, boilers, small rooms, etc.).

Q: Is the risk of getting sick higher for workers than for community residents?

A: Yes. Exposures in the community, except possibly in cases of fires or spills, are usually much lower than those found in the workplace. However, people in the community may be exposed to contaminated water as well as to chemicals in the air over long periods. Because of this, and because of exposure of children or people who are already ill, community exposures may cause health problems.

The following information is available from:

New Jersey Department of Health and
Senior Services
Occupational Disease and Injury Services
Trenton, NJ 08625-0360
(609) 984-1863

Industrial Hygiene Information

Industrial hygienists are available to answer your questions regarding the control of chemical exposures using exhaust ventilation, special work practices, good housekeeping, good hygiene practices, and personal protective equipment including respirators. In addition, they can help to interpret the results of industrial hygiene survey data.

Medical Evaluation

If you think you are becoming sick because of exposure to chemicals at your workplace, you may call a Department of Health and Senior Services physician who can help you find the services you need.

Public Presentations

Presentations and educational programs on occupational health or the Right to Know Act can be organized for labor unions, trade associations and other groups.

Right to Know Information Resources

The Right to Know Infoline (609) 984-2202 can answer questions about the identity and potential health effects of chemicals, list of educational materials in occupational health, references used to prepare the Fact Sheets, preparation of the Right to Know survey, education and training programs, labeling requirements, and general information regarding the Right to Know Act. Violations of the law should be reported to (609) 984-2202.

DEFINITIONS

ACGIH is the American Conference of Governmental Industrial Hygienists. It recommends upper limits (called TLVs) for exposure to workplace chemicals.

A **carcinogen** is a substance that causes cancer.

The **CAS number** is assigned by the Chemical Abstracts Service to identify a specific chemical.

A **combustible** substance is a solid, liquid or gas that will burn.

A **corrosive** substance is a gas, liquid or solid that causes irreversible damage to human tissue or containers.

DEP is the New Jersey Department of Environmental Protection.

DOT is the Department of Transportation, the federal agency that regulates the transportation of chemicals.

EPA is the Environmental Protection Agency, the federal agency responsible for regulating environmental hazards.

A **fetus** is an unborn human or animal.

A **flammable** substance is a solid, liquid, vapor or gas that will ignite easily and burn rapidly.

The **flash point** is the temperature at which a liquid or solid gives off vapor that can form a flammable mixture with air.

HHAG is the Human Health Assessment Group of the federal EPA.

IARC is the International Agency for Research on Cancer, a scientific group that classifies chemicals according to their cancer-causing potential.

A **miscible** substance is a liquid or gas that will evenly dissolve in another.

mg/m^3 means milligrams of a chemical in a cubic meter of air. It is a measure of concentration (weight/volume).

MSHA is the Mine Safety and Health Administration, the federal agency that regulates mining. It also evaluates and approves respirators.

A **mutagen** is a substance that causes mutations. A **mutation** is a change in the genetic material in a body cell. Mutation can lead to birth defects, miscarriages, or cancer.

NAERG is the North American Emergency Response Guidebook. It was jointly developed by Transport Canada, the United States Department of Transportation and the Secretariat of Communications and Transportation of Mexico. It is a guide for first responders to quickly identify the specific or generic hazards of material involved in a transportation incident, and to protect themselves and the general public during the initial response phase of the incident.

NCI is the National Cancer Institute, a federal agency that determines the cancer-causing potential of chemicals.

NFPA is the National Fire Protection Association. It classifies substances according to their fire and explosion hazard.

NIOSH is the National Institute for Occupational Safety and Health. It tests equipment, evaluates and approves respirators, conducts studies of workplace hazards, and proposes standards to OSHA.

NTP is the National Toxicology Program which tests chemicals and reviews evidence for cancer.

OSHA is the Occupational Safety and Health Administration, which adopts and enforces health and safety standards.

PEOSHA is the Public Employees Occupational Safety and Health Act, a state law which sets PELs for New Jersey public employees.

ppm means parts of a substance per million parts of air. It is a measure of concentration by volume in air.

A **reactive** substance is a solid, liquid or gas that releases energy under certain conditions.

A **teratogen** is a substance that causes birth defects by damaging the fetus.

TLV is the Threshold Limit Value, the workplace exposure limit recommended by ACGIH.

The **vapor pressure** is a measure of how readily a liquid or a solid mixes with air at its surface. A higher vapor pressure indicates a higher concentration of the substance in air and therefore increases the likelihood of breathing it in.

>>>>>>>>>>>>>>>>>> EMERGENCY INFORMATION <<<<<<<<<<<<<<<<<

Common Name: **NITRIC ACID**
DOT Number: **UN 2031 (more than 40% acid)**
UN 1760 (40% or less acid)
UN 2032 (fuming)
NAERG Code: **157**
CAS Number: **7697-37-2**

Hazard rating	NJDHSS	NFPA
FLAMMABILITY	-	0
REACTIVITY	-	1
CORROSIVE MAY IGNITE COMBUSTIBLE MATERIALS POISONOUS GASES ARE PRODUCED IN FIRE		

Hazard Rating Key: 0=minimal; 1=slight; 2=moderate; 3=serious; 4=severe

FIRE HAZARDS

* **Nitric Acid** is non-combustible. However, it can increase the flammability of combustible, organic, and readily oxidizable materials, or cause ignition of some of these materials.
* Extinguish fire using an agent suitable for type of surrounding fire. **Nitric Acid** itself does not burn.
* POISONOUS GASES ARE PRODUCED IN FIRE, including *Nitrogen Oxides*.
  If employees are expected to fight fires, they must be trained and equipped as stated in OSHA 1910.156.

SPILLS AND EMERGENCIES

If **Nitric Acid** is spilled or leaked, take the following steps:

* Restrict persons not wearing protective equipment from areas of spill or leak until cleanup is complete.
* Absorb liquids in vermiculite, dry sand, earth, or a similar material and deposit in sealed containers.
* Ventilate and wash area of spill or leak after clean-up is complete.
* It may be necessary to contain and dispose of **Nitric Acid** as a HAZARDOUS WASTE. Contact your Department of Environmental Protection (DEP) or your regional office of the federal Environmental Protection Agency (EPA) for specific recommendations.
* If employees are required to clean-up spills, they must be properly trained and equipped. OSHA 1910.120(q) may be applicable.

FOR LARGE SPILLS AND FIRES immediately call your fire department. You can request emergency information from the following:

CHEMTREC: (800) 424-9300
NJDEP HOTLINE: (609) 292-7172

HANDLING AND STORAGE (See page 3)

FIRST AID

In NJ, POISON INFORMATION 1-800-962-1253

Eye Contact

* Immediately flush with large amounts of water. Continue without stopping for at least 30 minutes, occasionally lifting upper and lower lids. Seek medical attention immediately.

Skin Contact

* Quickly remove contaminated clothing. Immediately wash area with large amounts of water. Seek medical attention immediately.

Breathing

* Remove the person from exposure.
* Begin rescue breathing if breathing has stopped and CPR if heart action has stopped.
* Transfer promptly to a medical facility.
* Medical observation is recommended for 24 to 48 hours after breathing overexposure, as pulmonary edema may be delayed.

PHYSICAL DATA

Vapor Pressure: 2.6 to 103 mm Hg at 68°F (20°C)
Water Solubility: Miscible

OTHER COMMONLY USED NAMES

Chemical Name:
Nitric Acid
Other Names:
Hydrogen Nitrate; Azotic Acid

Not intended to be copied and sold for commercial purposes.

NEW JERSEY DEPARTMENT OF HEALTH AND SENIOR SERVICES
Right to Know Program
PO Box 368, Trenton, NJ 08625-0368
(609) 984-2202

New Jersey Department of Health and Senior Services

HAZARDOUS SUBSTANCE FACT SHEET

Common Name: **SULFURIC ACID**

CAS Number: 7664-93-9
DOT Number: UN 1830
UN 1831 (fuming)
UN 1832 (spent)

RTK Substance number: 1761
Date: January 1986 Revision: March 1995

HAZARD SUMMARY

* **Sulfuric Acid** can affect you when breathed in.
* **Sulfuric Acid** is a CORROSIVE CHEMICAL and can severely irritate and burn the skin and eyes causing permanent damage.
* Breathing **Sulfuric Acid** can irritate the lungs causing coughing and/or shortness of breath. Higher exposures can cause a build-up of fluid in the lungs (pulmonary edema), a medical emergency, with severe shortness of breath.
* Repeated exposure can cause permanent lung damage, damage to teeth and stomach upset.
* **Sulfuric Acid** is a REACTIVE CHEMICAL and is an EXPLOSION HAZARD.

IDENTIFICATION

Sulfuric Acid is an oily liquid. It is used in fertilizers, chemicals, dyes, petroleum refining, etching and analytical chemistry, and in making iron, steel and industrial explosives.

REASON FOR CITATION

* **Sulfuric Acid** is on the Hazardous Substance List because it is regulated by OSHA and cited by ACGIH, DOT, NIOSH, DEP, NFPA and EPA.
* This chemical is on the Special Health Hazard Substance List because it is **REACTIVE** and **CORROSIVE**.
* Definitions are provided on page 5.

HOW TO DETERMINE IF YOU ARE BEING EXPOSED

The New Jersey Right to Know Act requires most employers to label chemicals in the workplace and requires public employers to provide their employees with information and training concerning chemical hazards and controls. The federal OSHA Hazard Communication Standard, 1910.1200, requires private employers to provide similar training and information to their employees.

* Exposure to hazardous substances should be routinely evaluated. This may include collecting personal and area air samples. You can obtain copies of sampling results from your employer. You have a legal right to this information under OSHA 1910.20.
* If you think you are experiencing any work-related health problems, see a doctor trained to recognize occupational diseases. Take this Fact Sheet with you.

WORKPLACE EXPOSURE LIMITS

OSHA: The legal airborne permissible exposure limit (PEL) is **1 mg/m^3** averaged over an 8-hour workshift.

NIOSH: The recommended airborne exposure limit is **1 mg/m^3** averaged over a 10-hour workshift.

ACGIH: The recommended airborne exposure limit is **1 mg/m^3** averaged over an 8-hour workshift.

WAYS OF REDUCING EXPOSURE

* Where possible, enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, respirators should be worn.
* Wear protective work clothing.
* Wash thoroughly immediately after exposure to **Sulfuric Acid** and at the end of the workshift.
* Post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, communicate all information on the health and safety hazards of **Sulfuric Acid** to potentially exposed workers.

This Fact Sheet is a summary source of information of all potential and most severe health hazards that may result from exposure. Duration of exposure, concentration of the substance and other factors will affect your susceptibility to any of the potential effects described below.

HEALTH HAZARD INFORMATION

Acute Health Effects

The following acute (short-term) health effects may occur immediately or shortly after exposure to **Sulfuric Acid**:

* **Sulfuric Acid** can severely irritate and burn the skin and eyes causing third-degree burns and blindness on contact.
* Breathing **Sulfuric Acid** can irritate the lungs causing coughing and/or shortness of breath. Higher exposures can cause a build-up of fluid in the lungs (pulmonary edema), a medical emergency, with severe shortness of breath.

Chronic Health Effects

The following chronic (long-term) health effects can occur at some time after exposure to **Sulfuric Acid** and can last for months or years:

Cancer Hazard

* There is limited evidence that **Sulfuric Acid** causes lung cancer in refinery workers.

Reproductive Hazard

* According to the information presently available to the New Jersey Department of Health and Senior Services, **Sulfuric Acid** has been tested and has not been shown to affect reproduction.

Other Long-Term Effects

* Repeated exposure can cause bronchitis, with cough, phlegm, and shortness of breath, and may cause emphysema.
* **Sulfuric Acid** can cause chronic runny nose, tearing of the eyes, nose bleeds and stomach upset.
* Repeated exposure can cause erosion and pitting of the teeth.

MEDICAL

Medical Testing

For those with frequent or potentially high exposure (half the TLV or greater), the following are recommended before beginning work and at regular times after that:

* Lung function tests.
* Exam of the teeth.

If symptoms develop or overexposure is suspected, the following may be useful:

* Consider chest x-ray after acute overexposure.

Any evaluation should include a careful history of past and present symptoms with an exam. Medical tests that look for damage already done are not a substitute for controlling exposure.

Request copies of your medical testing. You have a legal right to this information under OSHA 1910.20.

WORKPLACE CONTROLS AND PRACTICES

Unless a less toxic chemical can be substituted for a hazardous substance, **ENGINEERING CONTROLS** are the most effective way of reducing exposure. The best protection is to enclose operations and/or provide local exhaust ventilation at the site of chemical release. Isolating operations can also reduce exposure. Using respirators or protective equipment is less effective than the controls mentioned above, but is sometimes necessary.

In evaluating the controls present in your workplace, consider: (1) how hazardous the substance is, (2) how much of the substance is released into the workplace and (3) whether harmful skin or eye contact could occur. Special controls should be in place for highly toxic chemicals or when significant skin, eye, or breathing exposures are possible.

In addition, the following controls are recommended:

* Where possible, automatically pump liquid **Sulfuric Acid** from drums or other storage containers to process containers.
* Specific engineering controls are recommended for this chemical by NIOSH. Refer to the NIOSH criteria document: *Occupational Exposure to Sulfuric Acid #74-128*
* Before entering a confined space where **Sulfuric Acid** may be present, check to make sure that an explosive concentration does not exist.

Good **WORK PRACTICES** can help to reduce hazardous exposures. The following work practices are recommended:

* Workers whose clothing has been contaminated by **Sulfuric Acid** should change into clean clothing promptly.
* Do not take contaminated work clothes home. Family members could be exposed.
* Contaminated work clothes should be laundered by individuals who have been informed of the hazards of exposure to **Sulfuric Acid**.

* Eye wash fountains should be provided in the immediate work area for emergency use.
* If there is the possibility of skin exposure, emergency shower facilities should be provided.
* On skin contact with **Sulfuric Acid**, immediately wash or shower to remove the chemical. A specially formulated emolient soap can be used.
* At the end of workshift, after washing, you should be provided with and use a skin cream which will help prevent excessive drying and a loss of elasticity of your skin.
* Do not eat, smoke, or drink where **Sulfuric Acid** is handled, processed, or stored, since the chemical can be swallowed. Wash hands carefully before eating or smoking.

PERSONAL PROTECTIVE EQUIPMENT

WORKPLACE CONTROLS ARE BETTER THAN PERSONAL PROTECTIVE EQUIPMENT. However, for some jobs (such as outside work, confined space entry, jobs done only once in a while, or jobs done while workplace controls are being installed), personal protective equipment may be appropriate.

The following recommendations are only guidelines and may not apply to every situation.

Clothing

* Avoid skin contact with **Sulfuric Acid**. Wear acid-resistant gloves and clothing. Safety equipment suppliers/ manufacturers can provide recommendations on the most protective glove/clothing material for your operation.
* All protective clothing (suits, gloves, footwear, headgear) should be clean, available each day, and put on before work.
* ACGIH recommends *Neoprene, Nitrile, Polyvinyl Chloride* or *Saranex* as protective materials.

Eye Protection

* Wear splash-proof chemical goggles and face shield when working with liquid, unless full facepiece respiratory protection is worn.
* For highly concentrated **Sulfuric Acid**, wear gas-proof goggles and face shield unless full facepiece respiratory protection is worn.

Respiratory Protection

IMPROPER USE OF RESPIRATORS IS DANGEROUS. Such equipment should only be used if the employer has a written program that takes into account workplace conditions, requirements for worker training, respirator fit testing and medical exams, as described in OSHA 1910.134.

* Where the potential exists for exposures over **1 mg/m^3**, use a MSHA/NIOSH approved full facepiece respirator with an acid gas canister and high efficiency particulate prefilters. Increased protection is obtained from full facepiece powered-air purifying respirators.
* If while wearing a filter, cartridge or canister respirator you can smell, taste, or otherwise detect **Sulfuric Acid**, or in the case of a full facepiece respirator you experience eye irritation, leave the area immediately. Check to make sure the respirator-to-face seal is still good. If it is, replace the filter, cartridge, or canister. If the seal is no longer good, you may need a new respirator.
* Be sure to consider all potential exposures in your workplace. You may need a combination of filters, prefilters, cartridges, or canisters, to protect against different forms of a chemical (such as vapor and mist) or against a mixture of chemicals.
* Where the potential for high exposures exists, use a MSHA/NIOSH approved supplied-air respirator with a full facepiece operated in the positive pressure mode or with a full facepiece, hood, or helmet in the continuous flow mode, or use a MSHA/NIOSH approved self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
* Exposure to **80 mg/m^3** is immediately dangerous to life and health. If the possibility of exposures above **80 mg/m^3** exists, use a MSHA/NIOSH approved self contained breathing apparatus with a full facepiece operated in continuous flow or other positive pressure mode.

HANDLING AND STORAGE

* Prior to working with **Sulfuric Acid** you should be trained on its proper handling and storage.
* **Sulfuric Acid** must be stored to avoid contact with WATER, CYCLOPENTADIENE, CYCLOPENTA-NONE OXIME, NITROARYL AMINES, HEXA-LITHIUM DISILICIDE, and PHOSPHORUS III OXIDES since violent reactions occur.
* **Sulfuric Acid** is not compatible with CHLORATES, CHROMATES, CARBIDES, FULMINATES, NITRATES, PICRATES, CYANIDES, HALIDES, and POWDERED METALS.
* Store in tightly closed containers in a cool, dry, well-ventilated area away from SUNLIGHT, COMBUSTIBLES and ORGANIC MATERIALS in an area with an acid resistant cement floor.
* Always add acid to water, never the reverse.
* **Sulfuric Acid** is extremely corrosive - HANDLE WITH CARE and use proper equipment and practices.
* Wherever **Sulfuric Acid** is used, handled, manufactured, or stored, use explosion-proof electrical equipment and fittings.
* Contact of **Sulfuric Acid** with metal drums may cause the release of *flammable and explosive Hydrogen gas*, therefore, storage drums should be coated with acid resistant material.

QUESTIONS AND ANSWERS

Q: If I have acute health effects, will I later get chronic health effects?

A: Not always. Most chronic (long-term) effects result from repeated exposures to a chemical.

Q: Can I get long-term effects without ever having short-term effects?

A: Yes, because long-term effects can occur from repeated exposures to a chemical at levels not high enough to make you immediately sick.

Q: What are my chances of getting sick when I have been exposed to chemicals?

A: The likelihood of becoming sick from chemicals is increased as the amount of exposure increases. This is determined by the length of time and the amount of material to which someone is exposed.

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EPA is the Environmental Protection Agency, the federal agency responsible for regulating environmental hazards.

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The **flash point** is the temperature at which a liquid or solid gives off vapor that can form a flammable mixture with air.

HHAG is the Human Health Assessment Group of the federal EPA.

IARC is the International Agency for Research on Cancer, a scientific group that classifies chemicals according to their cancer-causing potential.

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NIOSH is the National Institute for Occupational Safety and Health. It tests equipment, evaluates and approves respirators, conducts studies of workplace hazards, and proposes standards to OSHA.

NTP is the National Toxicology Program which test chemicals and reviews evidence for cancer.

OSHA is the Occupational Safety and Health Administration, which adopts and enforces health and safety standards.

PEOSHA is the Public Employees Occupational Safety and Health Act, a state law which sets PELs for New Jersey public employees.

ppm means parts of a substance per million parts of air. It is a measure of concentration by volume in air.

A **reactive** substance is a solid, liquid or gas that releases energy under certain conditions.

A **teratogen** is a substance that causes birth defects by damaging the fetus.

TLV is the Threshold Limit Value, the workplace exposure limit recommended by ACGIH.

The **vapor pressure** is a measure of how readily a liquid or a solid mixes with air at its surface. A higher vapor pressure indicates a higher concentration of the substance in air and therefore increases the likelihood of breathing it in.

>>>>>>>>>>>>>>>>>> EMERGENCY INFORMATION <<<<<<<<<<<<<<<<<<

Common Name: **SULFURIC ACID**
DOT Number: **UN 1830**
UN 1831 (fuming)
UN 1832 (spent)
AERG Code: **157**
CAS Number: **7664-93-9**

Hazard rating	NJDHSS	NFPA
FLAMMABILITY	-	0
REACTIVITY	-	2
CORROSIVE AND REACTIVE DO NOT USE WATER POISONOUS GASES ARE PRODUCED IN FIRE OR ON CONTACT WITH WATER OR STEAM		

Hazard Rating Key: 0=minimal; 1=slight; 2=moderate; 3=serious; 4=severe

FIRE HAZARDS

* Extinguish fire using an agent suitable for type of surrounding fire. **Sulfuric Acid** itself does not burn.
* DO NOT USE WATER.
* **Sulfuric Acid** may ignite other combustible materials.
* POISONOUS GASES ARE PRODUCED IN FIRE or ON CONTACT WITH WATER or STEAM, including *Oxides of Sulfur*.

Use water spray only to keep fire-exposed containers cool.
If employees are expected to fight fires, they must be trained and equipped as stated in OSHA 1910.156.

SPILLS AND EMERGENCIES

If **Sulfuric Acid** is spilled or leaked, take the following steps:

* Restrict persons not wearing protective equipment from area of spill or leak until cleanup is complete.
* Cover spills with dry sand, soda ash or cement powder. DO NOT use organic materials like sawdust and DO NOT wash down a spill of **Sulfuric Acid** with water.
* Collect spilled material in the most convenient and safe manner and deposit in sealed containers.
* Ventilate and wash area after clean-up is complete.
* Keep **Sulfuric Acid** out of a confined space, such as a sewer, because of the possibility of an explosion, unless the sewer is designed to prevent the build-up of explosive concentrations.
* It may be necessary to contain and dispose of **Sulfuric Acid** as a HAZARDOUS WASTE. Contact your Department of Environmental Protection (DEP) or your regional office of the federal Environmental Protection Agency (EPA) for specific recommendations.

If employees are required to clean-up spills, they must be properly trained and equipped. OSHA 1910.120(q) may be applicable.

FOR LARGE SPILLS AND FIRES immediately call your fire department. You can request emergency information from the following:

CHEMTREC: (800) 424-9300
NJDEP HOTLINE: (609) 292-7172

HANDLING AND STORAGE (See page 3)

FIRST AID

In NJ, POISON INFORMATION 1-800-962-1253

Eye Contact

* INSTANTLY flush eyes with large amounts of water. Continue without stopping for at least 30 minutes, occasionally lifting upper and lower lids. Seek medical attention immediately.

Skin Contact

* Quickly remove contaminated clothing. Immediately wash area with large amounts of water. Seek medical attention immediately.

Breathing

* Remove the person from exposure.
* Begin rescue breathing if breathing has stopped and CPR if heart action has stopped.
* Transfer promptly to a medical facility.
* Medical observation is recommended for 24 to 48 hours after breathing overexposure, as pulmonary edema may be delayed.

PHYSICAL DATA

Flash Point: None
Vapor Pressure: 73 mm Hg at 68°F (20°C)
Water Solubility: Miscible/Reactive

OTHER NAMES:

BOV; Dipping Acid; Oil of Vitriol; Vitriol Brown Oil;

Not intended to be copied and sold for commercial purposes.

NEW JERSEY DEPARTMENT OF HEALTH AND SENIOR SERVICES
Right to Know Program
PO Box 368, Trenton, NJ 08625-0368
(609) 984-2202

New Jersey Department of Health and Senior Services

HAZARDOUS SUBSTANCE FACT SHEET

Common Name: **SODIUM HYDROXIDE**

CAS Number: 1310-73-2
DOT Number: UN 1823 (solid)
UN 1824 (solution)

RTK Substance number: 1706
Date: September 1985 Revision: March 1995

HAZARD SUMMARY

* **Sodium Hydroxide** can affect you when breathed in.
* Breathing **Sodium Hydroxide** can irritate the lungs causing coughing and/or shortness of breath. Higher exposures can cause a build-up of fluid in the lungs (pulmonary edema), a medical emergency, with severe shortness of breath.
* Contact can cause severe skin irritation and burns.
* **Sodium Hydroxide** can cause severe irritation and burns of the eyes with possible permanent damage.
* Breathing **Sodium Hydroxide** can irritate the mouth, nose and throat.
* **Sodium Hydroxide** is a CORROSIVE SOLID or LIQUID.

IDENTIFICATION

Sodium Hydroxide is a white, odorless pellet or solid which is often used in water solutions. It is used in making other chemicals, petroleum refining, paper making, cleaning compounds and many other uses.

REASON FOR CITATION

* **Sodium Hydroxide** is on the Hazardous Substance List because it is regulated by OSHA and cited by ACGIH, DOT, NIOSH, NFPA and EPA.
* This chemical is on the Special Health Hazard Substance List because it is **CORROSIVE**.
* Definitions are provided on page 5.

HOW TO DETERMINE IF YOU ARE BEING EXPOSED

The New Jersey Right to Know Act requires most employers to label chemicals in the workplace and requires public employers to provide their employees with information and training concerning chemical hazards and controls. The federal OSHA Hazard Communication Standard, 1910.1200, requires private employers to provide similar training and information to their employees.

* Exposure to hazardous substances should be routinely evaluated. This may include collecting personal and area air samples. You can obtain copies of sampling results from your employer. You have a legal right to this information under OSHA 1910.20.
* If you think you are experiencing any work-related health problems, see a doctor trained to recognize occupational diseases. Take this Fact Sheet with you.

WORKPLACE EXPOSURE LIMITS

OSHA: The legal airborne permissible exposure limit (PEL) is **2 mg/m^3** averaged over an 8-hour workshift.

NIOSH: The recommended airborne exposure limit . **2 mg/m^3**, which should not be exceeded during any 15 minute work period.

ACGIH: The recommended airborne exposure limit is **2 mg/m^3**, which should not be exceeded at any time.

WAYS OF REDUCING EXPOSURE

* Where possible, enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, respirators should be worn.
* Wear protective work clothing.
* Wash thoroughly immediately after exposure to **Sodium Hydroxide**.
* Post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, communicate all information on the health and safety hazards of **Sodium Hydroxide** to potentially exposed workers.

This Fact Sheet is a summary source of information of all potential and most severe health hazards that may result from exposure. Duration of exposure, concentration of the substance and other factors will affect your susceptibility to any of the potential effects described below.

HEALTH HAZARD INFORMATION

Acute Health Effects

The following acute (short-term) health effects may occur immediately or shortly after exposure to **Sodium Hydroxide**:

* **Sodium Hydroxide** can cause severe irritation and burns of the eyes with possible permanent damage.
* Contact can cause severe skin irritation and burns.
* Breathing **Sodium Hydroxide** can irritate the mouth, nose and throat.
* Breathing **Sodium Hydroxide** can irritate the lungs causing coughing and/or shortness of breath. Higher exposures can cause a build-up of fluid in the lungs (pulmonary edema), a medical emergency, with severe shortness of breath.

Chronic Health Effects

The following chronic (long-term) health effects can occur at some time after exposure to **Sodium Hydroxide** and can last for months or years:

Cancer Hazard

* According to the information presently available to the New Jersey Department of Health and Senior Services, **Sodium Hydroxide** has not been tested for its ability to cause cancer in animals.

Reproductive Hazard

* According to the information presently available to the New Jersey Department of Health and Senior Services, **Sodium Hydroxide** has been tested and has not been shown to affect reproduction.

Other Long-Term Effects

* Very irritating substances may affect the lungs. It is not known whether **Sodium Hydroxide** causes lung damage.

MEDICAL

Medical Testing

For those with frequent or potentially high exposure (half the TLV or greater) the following are recommended before beginning work and at regular times after that:

* Lung function tests.

If symptoms develop or overexposure is suspected, the following may be useful:

* Consider chest x-ray after acute overexposure.

Any evaluation should include a careful history of past and present symptoms with an exam. Medical tests that look for damage already done are not a substitute for controlling exposure.

Request copies of your medical testing. You have a legal right to this information under OSHA 1910.20.

Mixed Exposures

Because smoking can cause heart disease, as well as lung cancer, emphysema, and other respiratory problems, it may worsen respiratory conditions caused by chemical exposure. Even if you have smoked for a long time, stopping now will reduce your risk of developing health problems.

WORKPLACE CONTROLS AND PRACTICES

Unless a less toxic chemical can be substituted for a hazardous substance, **ENGINEERING CONTROLS** are the most effective way of reducing exposure. The best protection is to enclose operations and/or provide local exhaust ventilation at the site of chemical release. Isolating operations can also reduce exposure. Using respirators or protective equipment is less effective than the controls mentioned above, but is sometimes necessary.

In evaluating the controls present in your workplace, consider: (1) how hazardous the substance is, (2) how much of the substance is released into the workplace and (3) whether harmful skin or eye contact could occur. Special controls should be in place for highly toxic chemicals or when significant skin, eye, or breathing exposures are possible.

In addition, the following controls are recommended:

* Where possible, automatically pump liquid **Sodium Hydroxide** from drums or other storage containers to process containers.
* Specific engineering controls are recommended for this chemical by NIOSH. Refer to the NIOSH criteria document: *Occupational Exposure to Sodium Hydroxide #76-105*.

Good **WORK PRACTICES** can help to reduce hazardous exposures. The following work practices are recommended:

* Workers whose clothing has been contaminated by **Sodium Hydroxide** should change into clean clothing immediately.

* Contaminated work clothes should be laundered by individuals who have been informed of the hazards of exposure to **Sodium Hydroxide**.
* Eye wash fountains should be provided in the immediate work area for emergency use.
* If there is the possibility of skin exposure, emergency shower facilities should be provided.
* On skin contact with **Sodium Hydroxide**, immediately wash or shower to remove the chemical. At the end of the workshift, wash any areas of the body that may have contacted **Sodium Hydroxide**, whether or not known skin contact has occurred.
* Do not eat, smoke, or drink where **Sodium Hydroxide** is handled, processed, or stored, since the chemical can be swallowed. Wash hands carefully before eating or smoking.
* Do not dry sweep for clean-up. Use a vacuum or a wet method to reduce dust during clean-up.

PERSONAL PROTECTIVE EQUIPMENT

WORKPLACE CONTROLS ARE BETTER THAN PERSONAL PROTECTIVE EQUIPMENT. However, for some jobs (such as outside work, confined space entry, jobs done only once in a while, or jobs done while workplace controls are being installed), personal protective equipment may be appropriate.

The following recommendations are only guidelines and may not apply to every situation.

Clothing

* Avoid skin contact with **Sodium Hydroxide**. Wear protective gloves and clothing. Safety equipment suppliers/manufacturers can provide recommendations on the most protective glove/clothing material for your operation.
* All protective clothing (suits, gloves, footwear, headgear) should be clean, available each day, and put on before work.
* Safety equipment manufacturers recommend *Neoprene* or *Polyvinyl Chloride* as protective materials.

Eye Protection

* Wear splash-proof chemical goggles and face shield when working with liquid, or wear dust-proof goggles and face shield when working with powders or dust, unless full facepiece respiratory protection is worn.

Respiratory Protection

IMPROPER USE OF RESPIRATORS IS DANGEROUS. Such equipment should only be used if the employer has a written program that takes into account workplace conditions, requirements for worker training, respirator fit testing and medical exams, as described in OSHA 1910.134.

* Where the potential exists for exposures over **2 mg/m^3**, use a MSHA/NIOSH approved full facepiece respirator with a high efficiency particulate filter. Greater protection is provided by a powered-air purifying respirator. Particulate filters must be checked every day before work for physical damage, such as rips or tears, and replaced as needed.
* If while wearing a filter, cartridge or canister respirator, you can smell, taste, or otherwise detect **Sodium Hydroxide**, or in the case of a full facepiece respirator you experience eye irritation, leave the area immediately. Check to make sure the respirator-to-face seal is still good. If it is, replace the filter, cartridge, or canister. If the seal is no longer good, you may need a new respirator.
* Be sure to consider all potential exposures in your workplace. You may need a combination of filters, prefilters, cartridges, or canisters, to protect against different forms of a chemical (such as vapor and mist) or against a mixture of chemicals.
* Where the potential for high exposures exists, use a MSHA/NIOSH approved supplied-air respirator with a full facepiece operated in the positive pressure mode or with a full facepiece, hood, or helmet in the continuous flow mode, or use a MSHA/NIOSH approved self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
* Exposure to **250 mg/m^3** is immediately dangerous to life and health. If the possibility of exposures above **200 mg/m^3** exists, use an MSHA/NIOSH approved self contained breathing apparatus with a full facepiece operated in continuous flow or other positive pressure mode.

HANDLING AND STORAGE

* Prior to working with **Sodium Hydroxide** you should be trained on its proper handling and storage.

* **Sodium Hydroxide** is not compatible with OXIDIZING AGENTS (such as PERCHLORATES, PEROXIDES, PERMANGANATES, CHLORATES, NITRATES, CHLORINE, BROMINE and FLUORINE), STRONG ACIDS (such as HYDROCHLORIC, SULFURIC and NITRIC), ORGANIC MATERIALS (such as WOOD), CHLORINATED SOLVENTS, NITROMETHANE, and FLAMMABLE LIQUIDS.
* **Sodium Hydroxide** is corrosive to METALS (such as ALUMINUM, TIN and ZINC).
* Store in tightly closed containers in a cool well-ventilated area away from WATER and MOISTURE.

QUESTIONS AND ANSWERS

Q: If I have acute health effects, will I later get chronic health effects?

A: Not always. Most chronic (long-term) effects result from repeated exposures to a chemical.

Q: Can I get long-term effects without ever having short-term effects?

A: Yes, because long-term effects can occur from repeated exposures to a chemical at levels not high enough to make you immediately sick.

Q: What are my chances of getting sick when I have been exposed to chemicals?

A: The likelihood of becoming sick from chemicals is increased as the amount of exposure increases. This is determined by the length of time and the amount of material to which someone is exposed.

Q: When are higher exposures more likely?

A: Conditions which increase risk of exposure include dust releasing operations (grinding, mixing, blasting, dumping, etc.), other physical and mechanical processes (heating, pouring, spraying, spills and evaporation from large surface areas such as open containers), and "confined space" exposures (working inside vats, reactors, boilers, small rooms, etc.).

Q: Is the risk of getting sick higher for workers than for community residents?

A: Yes. Exposures in the community, except possibly in cases of fires or spills, are usually much lower than those found in the workplace. However, people in the community may be exposed to contaminated water as well as to chemicals in the air over long periods. Because of this, and because of exposure of children or people who are already ill, community exposures may cause health problems.

The following information is available from:

New Jersey Department of Health and
Senior Services
Occupational Disease and Injury Services
Trenton, NJ 08625-0360
(609) 984-1863

Industrial Hygiene Information

Industrial hygienists are available to answer your questions regarding the control of chemical exposures using exhaust ventilation, special work practices, good housekeeping, good hygiene practices, and personal protective equipment including respirators. In addition, they can help to interpret the results of industrial hygiene survey data.

Medical Evaluation

If you think you are becoming sick because of exposure to chemicals at your workplace, you may call a Department of Health and Senior Services physician who can help you find the services you need.

Public Presentations

Presentations and educational programs on occupational health or the Right to Know Act can be organized for labor unions, trade associations and other groups.

Right to Know Information Resources

The Right to Know Infoline (609) 984-2202 can answer questions about the identity and potential health effects of chemicals, list of educational materials in occupational health, references used to prepare the Fact Sheets, preparation of the Right to Know survey, education and training programs, labeling requirements, and general information regarding the Right to Know Act. Violations of the law should be reported to (609) 984-2202.

DEFINITIONS

ACGIH is the American Conference of Governmental Industrial Hygienists. It recommends upper limits (called TLVs) for exposure to workplace chemicals.

A **carcinogen** is a substance that causes cancer.

The **CAS number** is assigned by the Chemical Abstracts Service to identify a specific chemical.

A **combustible** substance is a solid, liquid or gas that will burn.

A **corrosive** substance is a gas, liquid or solid that causes irreversible damage to human tissue or containers.

DEP is the New Jersey Department of Environmental Protection.

DOT is the Department of Transportation, the federal agency that regulates the transportation of chemicals.

EPA is the Environmental Protection Agency, the federal agency responsible for regulating environmental hazards.

A **fetus** is an unborn human or animal.

A **flammable** substance is a solid, liquid, vapor or gas that will ignite easily and burn rapidly.

The **flash point** is the temperature at which a liquid or solid gives off vapor that can form a flammable mixture with air.

HHAG is the Human Health Assessment Group of the federal EPA.

IARC is the International Agency for Research on Cancer, a scientific group that classifies chemicals according to their cancer-causing potential.

A **miscible** substance is a liquid or gas that will evenly dissolve in another.

mg/m^3 means milligrams of a chemical in a cubic meter of air. It is a measure of concentration (weight/volume).

MSHA is the Mine Safety and Health Administration, the federal agency that regulates mining. It also evaluates and approves respirators.

A **mutagen** is a substance that causes mutations. A **mutation** is a change in the genetic material in a body cell. Mutatic can lead to birth defects, miscarriages, or cancer.

NAERG is the North American Emergency Response Guidebook. It was jointly developed by Transport Canada, the United States Department of Transportation and the Secretariat of Communications and Transportation of Mexico. It is a guide for first responders to quickly identify the specific or generic hazards of material involved in a transportation incident, and to protect themselves and the general public during the initial response phase of the incident.

NCI is the National Cancer Institute, a federal agency that determines the cancer-causing potential of chemicals.

NFPA is the National Fire Protection Association. It classifies substances according to their fire and explosion hazard.

NIOSH is the National Institute for Occupational Safety and Health. It tests equipment, evaluates and approves respirators, conducts studies of workplace hazards, and proposes standards to OSHA.

NTP is the National Toxicology Program which tes chemicals and reviews evidence for cancer.

OSHA is the Occupational Safety and Health Administration, which adopts and enforces health and safety standards.

PEOSHA is the Public Employees Occupational Safety and Health Act, a state law which sets PELs for New Jersey public employees.

ppm means parts of a substance per million parts of air. It is a measure of concentration by volume in air.

A **reactive** substance is a solid, liquid or gas that releases energy under certain conditions.

A **teratogen** is a substance that causes birth defects by damaging the fetus.

TLV is the Threshold Limit Value, the workplace exposure limit recommended by ACGIH.

The **vapor pressure** is a measure of how readily a liquid or a solid mixes with air at its surface. A higher vapor pressure indicates a higher concentration of the substance in air an therefore increases the likelihood of breathing it in.

>>>>>>>>>>>>>>>>>> EMERGENCY INFORMATION <<<<<<<<<<<<<<<<<<

Common Name: **SODIUM HYDROXIDE**
DOT Number: **UN 1823 (solid)**
UN 1824 (solution)
ERG Code: **138**
CAS Number: **1310-73-2**

Hazard rating	NJDHSS	NFPA
FLAMMABILITY	-	0
REACTIVITY	-	1
CORROSIVE LIQUID OR SOLID POISONOUS GASES ARE PRODUCED IN FIRE		

Hazard Rating Key: 0=minimal; 1=slight; 2=moderate; 3=serious; 4=severe

FIRE HAZARDS

* Extinguish fire using an agent suitable for type of surrounding fire. **Sodium Hydroxide** itself does not burn.
* POISONOUS GASES ARE PRODUCED IN FIRE.
* **Sodium Hydroxide** may ignite combustibles (wood, paper, oil, etc.).
* Use water spray to keep fire-exposed containers cool.
* If employees are expected to fight fires, they must be trained and equipped as stated in OSHA 1910.156.

SPILLS AND EMERGENCIES

If **Sodium Hydroxide** is spilled or leaked, take the following steps:

* Restrict persons not wearing protective equipment from area of spill or leak until cleanup is complete.
* Absorb liquid spills with fly ash or cement powder and deposit in sealed containers.
* Collect powdered material in the most convenient and safe manner and deposit in sealed containers.
* Ventilate and wash area after clean-up is complete.
* It may be necessary to contain and dispose of **Sodium Hydroxide as a HAZARDOUS WASTE.** Contact your Department of Environmental Protection (DEP) or your regional office of the federal Environmental Protection Agency (EPA) for specific recommendations.
* If employees are required to clean-up spills, they must be properly trained and equipped. OSHA 1910.120(q) may be applicable.

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FOR LARGE SPILLS AND FIRES immediately call your fire department. You can request emergency information from the following:

EMTREC: (800) 424-9300
DEP HOTLINE: (609) 292-7172

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HANDLING AND STORAGE (See page 3)

FIRST AID

In NJ, POISON INFORMATION 1-800-962-1253

Eye Contact

* Instantly flush with large amounts of water. Continue without stopping for at least 30 minutes, occasionally lifting upper and lower lids. Seek medical attention immediately.

Skin Contact

* Quickly remove contaminated clothing. Immediately wash area with large amounts of water. Seek medical attention immediately.

Breathing

* Remove the person from exposure.
* Begin rescue breathing if breathing has stopped and CPR if heart action has stopped.
* Transfer promptly to a medical facility.
* Medical observation is recommended for 24 to 48 hours after breathing overexposure, as pulmonary edema may be delayed.

PHYSICAL DATA

Water Solubility: Highly soluble

OTHER COMMONLY USED NAMES

Chemical Name:
Sodium Hydroxide
Other Names:
Lye; Caustic Soda; White Caustic

Not intended to be copied and sold for commercial purposes.

NEW JERSEY DEPARTMENT OF HEALTH AND SENIOR SERVICES
Right to Know Program
PO Box 368, Trenton, NJ 08625-0368
(609) 984-2202

MSDS - METHANOL

1 - PRODUCT IDENTIFICATION

PRODUCT NAME: METHANOL
FORMULA: CH3OH
FORMULA WT: 32.04
CAS NO.: 67-56-1
NIOSH/RTECS NO.: PC1400000
COMMON SYNONYMS: METHYL ALCOHOL; WOOD ALCOHOL; CARBINOL; METHYLOL; WOOD SPIRIT
PRODUCT CODES: 9049,9072,9075,9076,9071,5217,5370,9074,P704,9093,5536,9068 9073,9091,9263,9069,9070

EFFECTIVE: 09/26/86
REVISION #04

PRECAUTIONARY LABELLING

BAKER SAF-T-DATA(TM) SYSTEM

HEALTH	-	3	SEVERE (POISON)
FLAMMABILITY	-	3	SEVERE (FLAMMABLE)
REACTIVITY	-	1	SLIGHT
CONTACT	-	1	SLIGHT

HAZARD RATINGS ARE 0 TO 4 (0 = NO HAZARD; 4 = EXTREME HAZARD).

LABORATORY PROTECTIVE EQUIPMENT

GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES; CLASS B EXTINGUISHER

PRECAUTIONARY LABEL STATEMENTS

POISON DANGER
FLAMMABLE
HARMFUL IF INHALED
CANNOT BE MADE NON-POISONOUS
MAY BE FATAL OR CAUSE BLINDNESS IF SWALLOWED

KEEP AWAY FROM HEAT, SPARKS, FLAME. DO NOT GET IN EYES, ON SKIN, ON CLOTHING. AVOID BREATHING VAPOR. KEEP IN TIGHTLY CLOSED CONTAINER. USE WITH ADEQUATE VENTILATION. WASH THOROUGHLY AFTER HANDLING. IN CASE OF FIRE, USE ALCOHOL FOAM, DRY CHEMICAL, CARBON DIOXIDE - WATER MAY BE INEFFECTIVE. FLUSH SPILL AREA WITH WATER SPRAY.

SAF-T-DATA(TM) STORAGE COLOR CODE: RED (FLAMMABLE)

2 - HAZARDOUS COMPONENTS

COMPONENT	%	CAS NO.
METHANOL	90-100	67-56-1

3 - PHYSICAL DATA

BOILING POINT: 65 C (149 F)
MELTING POINT: -98 C (-144 F)
VAPOR PRESSURE(MM HG): 96
VAPOR DENSITY(AIR=1): 1.11

SPECIFIC GRAVITY: 0.79 (H2O=1)

EVAPORATION RATE: 4.6 (BUTYL ACETATE=1)

SOLUBILITY(H2O): COMPLETE (IN ALL PROPORTIONS) % VOLATILES BY VOLUME: 100

APPEARANCE & ODOR: CLEAR, COLORLESS LIQUID WITH CHARACTERISTIC PUNGENT ODOR.

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4 - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (CLOSED CUP 12 C (54 F) NFPA 704M RATING: 1-3-0

FLAMMABLE LIMITS: UPPER - 36.0 % LOWER - 6.0 %

FIRE EXTINGUISHING MEDIA
USE ALCOHOL FOAM, DRY CHEMICAL OR CARBON DIOXIDE.
(WATER MAY BE INEFFECTIVE.)

SPECIAL FIRE-FIGHTING PROCEDURES
FIREFIGHTERS SHOULD WEAR PROPER PROTECTIVE EQUIPMENT AND SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN POSITIVE PRESSURE MODE. MOVE CONTAINERS FROM FIRE AREA IF IT CAN BE DONE WITHOUT RISK. USE WATER TO KEEP FIRE-EXPOSED CONTAINERS COOL.

UNUSUAL FIRE & EXPLOSION HAZARDS
VAPORS MAY FLOW ALONG SURFACES TO DISTANT IGNITION SOURCES AND FLASH BACK.
CLOSED CONTAINERS EXPOSED TO HEAT MAY EXPLODE. CONTACT WITH STRONG OXIDIZERS MAY CAUSE FIRE.
BURNS WITH A CLEAR, ALMOST INVISIBLE FLAME.

TOXIC GASES PRODUCED
CARBON MONOXIDE, CARBON DIOXIDE, FORMALDEHYDE

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5 - HEALTH HAZARD DATA

TLV LISTED DENOTES (TLV-SKIN).

THRESHOLD LIMIT VALUE (TLV/TWA): 260 MG/M3 (200 PPM)

SHORT-TERM EXPOSURE LIMIT (STEL): 310 MG/M3 (250 PPM)

PERMISSIBLE EXPOSURE LIMIT (PEL): 260 MG/M3 (200 PPM)

TOXICITY:	LD50 (ORAL-RAT)(MG/KG)	- 5628
	LD50 (IPR-RAT)(MG/KG)	- 9540
	LD50 (SCU-MOUSE)(MG/KG)	- 9800
	LD50 (SKN-RABBIT) (G/KG)	- 20

CARCINOGENICITY: NTP: NO IARC: NO Z LIST: NO OSHA REG: NO

EFFECTS OF OVEREXPOSURE
INHALATION AND INGESTION ARE HARMFUL AND MAY BE FATAL.
INHALATION MAY CAUSE HEADACHE, NAUSEA, VOMITING, DIZZINESS, NARCOSIS, SUFFOCATION, LOWER BLOOD PRESSURE, CENTRAL NERVOUS SYSTEM DEPRESSION.
LIQUID MAY BE IRRITATING TO SKIN AND EYES. PROLONGED SKIN CONTACT MAY RESULT IN DERMATITIS. EYE CONTACT MAY RESULT IN TEMPORARY CORNEAL DAMAGE.
INGESTION MAY CAUSE BLINDNESS.
INGESTION MAY CAUSE NAUSEA, VOMITING, HEADACHES, DIZZINESS, GASTROINTESTINAL IRRITATION.
CHRONIC EFFECTS OF OVEREXPOSURE MAY INCLUDE KIDNEY AND/OR LIVER DAMAGE.

TARGET ORGANS
EYES, SKIN, CENTRAL NERVOUS SYSTEM

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE
NONE IDENTIFIED

ROUTES OF ENTRY
INHALATION, INGESTION, EYE CONTACT, SKIN CONTACT

EMERGENCY AND FIRST AID PROCEDURES
CALL A PHYSICIAN.
IF SWALLOWED, IF CONSCIOUS, IMMEDIATELY INDUCE VOMITING.
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 WHILE REMOVING CONTAMINATED CLOTHING AND SHOES.
WASH CLOTHING BEFORE RE-USE.

6 - REACTIVITY DATA

STABILITY: STABLE HAZARDOUS POLYMERIZATION: WILL NOT OCCUR

CONDITIONS TO AVOID: HEAT, FLAME, OTHER SOURCES OF IGNITION

INCOMPATIBLES: STRONG OXIDIZING AGENTS, STRONG ACIDS, ALUMINUM

DECOMPOSITION PRODUCTS: CARBON MONOXIDE, CARBON DIOXIDE, FORMALDEHYDE

7 - SPILL AND DISPOSAL PROCEDURES

STEPS TO BE TAKEN IN THE EVENT OF A SPILL OR DISCHARGE
WEAR SELF-CONTAINED BREATHING APPARATUS AND FULL PROTECTIVE CLOTHING.
SHUT OFF IGNITION SOURCES; NO FLARES, SMOKING OR FLAMES IN AREA. STOP LEAK IF YOU CAN DO SO WITHOUT RISK. USE WATER SPRAY TO REDUCE VAPORS. TAKE UP WITH SAND OR OTHER NON-COMBUSTIBLE ABSORBENT MATERIAL AND PLACE INTO CONTAINER FOR LATER DISPOSAL. FLUSH AREA WITH WATER.

J. T. BAKER SOLUSORB(R) SOLVENT ADSORBENT IS RECOMMENDED FOR SPILLS OF THIS PRODUCT.

DISPOSAL PROCEDURE
DISPOSE IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE, AND LOCAL ENVIRONMENTAL REGULATIONS.

EPA HAZARDOUS WASTE NUMBER: U154 (TOXIC WASTE)

8 - PROTECTIVE EQUIPMENT

VENTILATION: USE GENERAL OR LOCAL EXHAUST VENTILATION TO MEET TLV REQUIREMENTS.

RESPIRATORY PROTECTION: RESPIRATORY PROTECTION REQUIRED IF AIRBORNE CONCENTRATION EXCEEDS TLV. AT CONCENTRATIONS ABOVE 200 PPM, A SELF-CONTAINED BREATHING APPARATUS IS ADVISED.

EYE/SKIN PROTECTION: SAFETY GOGGLES AND FACE SHIELD, UNIFORM, PROTECTIVE SUIT, RUBBER GLOVES ARE RECOMMENDED.

9 - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA(TM) STORAGE COLOR CODE: RED (FLAMMABLE)

SPECIAL PRECAUTIONS
BOND AND GROUND CONTAINERS WHEN TRANSFERRING LIQUID. KEEP CONTAINER TIGHTLY CLOSED. STORE IN A COOL, DRY, WELL-VENTILATED, FLAMMABLE LIQUID STORAGE AREA.

10 - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

PROPER SHIPPING NAME	METHANOL
HAZARD CLASS	FLAMMABLE LIQUID
UN/NA	UN1230
LABELS	FLAMMABLE LIQUID
REPORTABLE QUANTITY	5000 LBS.

INTERNATIONAL (I.M.O.)

PROPER SHIPPING NAME	METHANOL
HAZARD CLASS	3.2, 6.1
UN/NA	UN1230
LABELS	FLAMMABLE LIQUID, POISON

Material Safety Data Sheets

MESSER MG Industries

SECTION 1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MG INDUSTRIES
3 GREAT VALLEY PARKWAY
MALVERN, PENNSYLVANIA 19355
PHONE: 610-695-7400
FAX: 610-695-7596

EMERGENCY CONTACT:
CHEMTREC:
1-800-424-9300

SUBSTANCE: N-HEXANE
TRADE NAMES/SYNONYMS:
HEXANE; HEXYL HYDRIDE; NORMAL HEXANE; SKELLYSOLVE B; COLUMBIA RUBBER CEMENT THINNER (COLUMBIA CEMENT CO., INC.); CAPROYL HYDRIDE; BESTINE SOLVENT AND THINNER (UNION RUBBER INC); UN 1208; STCC 4908183; C6H14; MGI10950; RTECS MN9275000
CHEMICAL FAMILY: hydrocarbons, aliphatic
CREATION DATE: May 07 1990
REVISION DATE: Dec 07 1999

SECTION 2 COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: N-HEXANE
CAS NUMBER: 110-54-3
EC NUMBER (EINECS): 203-777-6
EC INDEX NUMBER: 601-037-00-0
PERCENTAGE: 100.0

SECTION 3 HAZARDS IDENTIFICATION

NFPA RATINGS (SCALE 0-4): HEALTH=2 FIRE=3 REACTIVITY=0
EC CLASSIFICATION (ASSIGNED):
F Highly Flammable
Xn Harmful
R 11-48/20
EC Classification may be inconsistent with independently-researched data.
EMERGENCY OVERVIEW:
PHYSICAL DESCRIPTION: Clear, colorless mobile liquid with a mild gasoline-like odor.
MAJOR HEALTH HAZARDS: respiratory tract irritation, skin irritation, eye irritation, central nervous system depression
PHYSICAL HAZARDS: Flammable liquid and vapor. Vapor may cause flash fire.
POTENTIAL HEALTH EFFECTS:

INHALATION:
SHORT TERM EXPOSURE: irritation, nausea, irregular heartbeat, headache, symptoms of drunkenness, lung congestion, nerve damage, brain damage, convulsions
LONG TERM EXPOSURE: same as effects reported in short term exposure, blurred vision, impotence, paralysis
SKIN CONTACT:
SHORT TERM EXPOSURE: irritation
LONG TERM EXPOSURE: blisters, itching
EYE CONTACT:
SHORT TERM EXPOSURE: irritation
LONG TERM EXPOSURE: same as effects reported in short term exposure
INGESTION:
SHORT TERM EXPOSURE: nausea, vomiting, headache, symptoms of drunkenness, brain damage

LONG TERM EXPOSURE: no information on significant adverse effects
CARCINOGEN STATUS:
OSHA: N
NTP: N
IARC: N

SECTION 4 FIRST AID MEASURES

INHALATION: Remove from exposure immediately. Use a bag valve mask or similar device to perform artificial respiration (rescue breathing) if needed. Get medical attention.
SKIN CONTACT: Remove contaminated clothing, jewelry, and shoes immediately. Wash with soap or mild detergent and large amounts of water until no evidence of chemical remains (at least 15-20 minutes). Get medical attention, if needed.
EYE CONTACT: Wash eyes immediately with large amounts of water or normal saline, occasionally lifting upper and lower lids, until no evidence of chemical remains. Get medical attention immediately.
INGESTION: If person is unconscious, turn head to side. Never make an unconscious person vomit or drink fluids. When vomiting occurs, keep head lower than hips to help prevent aspiration. Contact local poison control center or physician immediately. Get medical attention.
NOTE TO PHYSICIAN: For ingestion, consider gastric lavage and activated charcoal slurry.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Severe fire hazard. The vapor is heavier than air. Vapors or gases may ignite at distant ignition sources and flash back. Vapor/air mixtures are explosive. Electrostatic discharges may be generated by flow or agitation resulting in ignition or explosion.

EXTINGUISHING MEDIA: regular dry chemical, carbon dioxide, water, regular foam
Large fires: Use regular foam or flood with fine water spray.
FIRE FIGHTING: Move container from fire area if it can be done without risk. Cool containers with water spray until well after the fire is out. Stay away from the ends of tanks. For fires in cargo or storage area: Cool containers with water from unmanned hose holder or monitor nozzles until well after fire is out. If this is impossible then take the following precautions: Keep unnecessary people away, isolate hazard area and deny entry. Let the fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of tanks due to fire. For tank, rail car or tank truck: Evacuation radius: 800 meters (1/2 mile). Water may be ineffective.
FLASH POINT: -8 F (-22 C) (CC)
LOWER FLAMMABLE LIMIT: 1.1%
UPPER FLAMMABLE LIMIT: 7.5%
AUTOIGNITION: 437 F (225 C)
FLAMMABILITY CLASS (OSHA): IB

SECTION 6 ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL RELEASE:
Avoid heat, flames, sparks and other sources of ignition. Stop leak if possible without personal risk. Reduce vapors with water spray. Small spills: Absorb with sand or other non-combustible material. Collect spilled material in appropriate container for disposal. Large spills: Dike for later disposal. Remove sources of ignition. Keep unnecessary people away, isolate hazard area and deny entry. Notify Local Emergency Planning Committee and State Emergency Response Commission for release greater than or equal to RQ (U.S. SARA Section 304). If release occurs in the U.S. and is reportable under CERCLA Section 103, notify the National Response Center at (800)424-8802 (USA) or (202)426-2675 (USA).

SECTION 7 HANDLING AND STORAGE

Store and handle in accordance with all current regulations and standards. Subject to storage regulations: U.S. OSHA 29 CFR 1910.106. Grounding and bonding required. Keep separated from incompatible substances. Store in a tightly closed container. Store in a well-ventilated area. Store in a cool, dry place. Keep in the dark.

SECTION 8 EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
N-HEXANE:
500 ppm (1800 mg/m3) OSHA TWA
50 ppm (180 mg/m3) OSHA TWA (vacated by 58 FR 35338, June 30, 1993)
50 ppm ACGIH TWA (skin)

50 ppm (180 mg/m3) NIOSH recommended TWA 10 hour(s)
180 mg/m3 (50 ml/m3) DFG MAK 4 times/shift
20 ppm (72 mg/m3) UK OES TWA
1 mg/m3 UK OES TWA (dust)
5 ppm (23 mg/m3) UK OES TWA (vapor)
3 mg/m3 UK OES STEL (dust)
10 ppm (47 mg/m3) UK OES STEL (vapor)
MEASUREMENT METHOD: Charcoal tube; Carbon disulfide; Gas chromatography with flame ionization detection; NIOSH III # 1500, Hydrocarbons
VENTILATION: Provide local exhaust ventilation system. Ventilation equipment should be explosion-resistant if explosive concentrations of material are present. Ensure compliance with applicable exposure limits.
EYE PROTECTION: Wear splash resistant safety goggles. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.
CLOTHING: Wear appropriate chemical resistant clothing.
GLOVES: Wear appropriate chemical resistant gloves.
RESPIRATOR: The following respirators and maximum use concentrations are drawn from NIOSH and/or OSHA.
500 ppm
Any supplied-air respirator.
1100 ppm
Any supplied-air respirator.
Any self-contained breathing apparatus with a full facepiece.
Any supplied-air respirator with a full facepiece.
Escape -
Any air-purifying respirator with a full facepiece and an organic vapor canister.
Any appropriate escape-type, self-contained breathing apparatus.
For Unknown Concentrations or Immediately Dangerous to Life or Health -
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Any self-contained breathing apparatus with a full facepiece.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL DESCRIPTION: Clear, colorless mobile liquid with a mild gasoline-like odor.
MOLECULAR WEIGHT: 86.18
MOLECULAR FORMULA: C-H3-(C-H2)4-C-H3
BOILING POINT: 156 F (69 C)
FREEZING POINT: -139 F (-95 C)
VAPOR PRESSURE: 124 mmHg @ 20 C
VAPOR DENSITY (air=1): 3.0
SPECIFIC GRAVITY (water=1): 0.6603
WATER SOLUBILITY: 0.014% @ 20 C
PH: neutral

VOLATILITY: 100%

ODOR THRESHOLD: 64-244 ppm
EVAPORATION RATE: 15.8 (butyl acetate=1)
VISCOSITY: 0.32 cP @ 25 C
COEFFICIENT OF WATER/OIL DISTRIBUTION: Not available
SOLVENT SOLUBILITY:
Soluble: alcohol, ether, chloroform, acetone, organic solvents

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SECTION 10 STABILITY AND REACTIVITY

REACTIVITY: Stable at normal temperatures and pressure.
CONDITIONS TO AVOID: Avoid heat, flames, sparks and other sources of ignition. Containers may rupture or explode if exposed to heat. Keep out of water supplies and sewers.
INCOMPATIBILITIES: oxidizing materials, halogens, combustible materials
N-HEXANE:
CALCIUM HYPOCHLORITE: Fire and explosion hazard.
CHLORINE (LIQUID): Fire and explosion hazard.
DINITROGEN TETRAOXIDE: Possible explosion hazard.
FLUORINE: Incompatible.
MAGNESIUM PERCHLORATE: Incompatible.
OXIDIZERS (STRONG): Fire and explosion hazard.
OXYGEN (CONCENTRATED): Fire and explosion hazard.
PLASTICS, RUBBER, AND COATINGS: May be attacked.
SODIUM HYPOCHLORITE: Fire and explosion hazard.
HAZARDOUS DECOMPOSITION:
Thermal decomposition products: oxides of carbon
POLYMERIZATION: Will not polymerize.

SECTION 11 TOXICOLOGICAL INFORMATION

N-HEXANE:
IRRITATION DATA:
10 mg eyes-rabbit mild
TOXICITY DATA:
>3367 ppm inhalation-rat LC50 (Phillips Chemical Co.); >2 gm/kg skin-rabbit LD50 (Phillips Chemical Co.); >5 gm/kg oral-rat LD50 (Phillips Chemical Co.); 190 ppm/8 week(s) inhalation-human TCLo; 28710 mg/kg oral-rat LD50; 48000 ppm/4 hour(s) inhalation-rat LC50; 9100 mg/kg intraperitoneal-rat LDLo; 120 gm/m3 inhalation-mouse LCLo; 831 mg/kg intravenous-mouse LDLo; 132 mg/kg intravenous-rabbit LDLo; 2000 ppm/12 hour(s)-24 week(s) intermittent inhalation-rat TCLo; 40 gm/kg/4 week(s) intermittent oral-rat TDLo; 1000 ppm/24 hour(s)-11 week(s) continuous inhalation-rat TCLo; 1 pph/6 hour(s)-13 week(s) intermittent inhalation-rat TCLo; 476 ppm/6 hour(s)-4 week(s) intermittent inhalation-rat TCLo; 3000 ppm/6 hour(s)-2 year(s) intermittent inhalation-rat TCLo; 500 ppm/24 hour(s)-9 week(s) continuous inhalation-rat

TCLo; 18900 mg/kg/35 day(s) intermittent intraperitoneal-rat TDLo; 4788 mg/kg/7 day(s) intermittent intraperitoneal-rat TDLo; 1200 ppm/12 hour(s)-16 week(s) intermittent inhalation-rat TCLo; 10000 ppm/6 hour(s)-13 week(s) intermittent inhalation-mouse TCLo; 18 gm/kg/90 day(s) intermittent intraperitoneal-chicken TDLo
LOCAL EFFECTS:
Irritant: inhalation, skin, eye
ACUTE TOXICITY LEVEL:
Slightly Toxic: inhalation
Relatively Non-toxic: ingestion
TARGET ORGANS: nervous system
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: kidney disorders, liver disorders, respiratory disorders, skin disorders and allergies
MUTAGENIC DATA:
sex chromosone loss and non disjunction - Saccharomyes cerevisae 132 mmol/L; cytogenetic analysis - hamster fibroblast 500 mg/L
REPRODUCTIVE EFFECTS DATA:
10000 ppm inhalation-rat TCLo/7 hour(s) 15 day(s) pre pregnancy/1-18 day(s)

pregnant female continuous; 1000 ppm inhalation-rat TCLo/6 hour(s) 8-16 day(s) pregnant female continuous; 5000 ppm inhalation-rat TCLo/20 hour(s) 6-19 day(s) pregnant female continuous; 238 gm/kg oral-mouse TDLo 6-15 day(s) pregnant female continuous

ADDITIONAL DATA: Alcohol may enhance the toxic effects.
A low order of myocardial sensitization to epinephrine may occur. Acetone and methyl ethyl ketone may enhance the toxic effects.

HEALTH EFFECTS:

INHALATION:

ACUTE EXPOSURE:

N-HEXANE: 880 ppm for 15 minutes has caused upper respiratory tract irritation. Exposure to 1000-5000 ppm may produce headache, nausea, and dizziness. Other effects may include giddiness, coughing, numbness in the extremities, difficulty walking, defects of memory, excitement followed by depression, and unconsciousness. Anesthesia of short duration without sequela is possible. Pulmonary edema, cardiac arrhythmias, brain damage, cardiac arrest and death may result. High concentrations may produce asphyxia. Convulsions have been produced in animals.

CHRONIC EXPOSURE:

N-HEXANE: Results in axonal neuropathy. Neuropathy is of an insidious bilateral, symmetrical, sensorimotor, peripheral nature. 100 ppm daily may produce changes in muscle strength. Prolonged exposure may cause effects as in acute exposure as well as memory loss, progressive weakness, aching muscles, sensory loss in feet and hands, calf cramps, facial numbness, impotence, blurred vision, color vision abnormalities, and paralysis of muscles usually of lower limbs. Examination reveals hypoactive deep knee reflexes, bilateral footdrop, reduction in nerve and sensitive conduction velocities, modification of distal latency, diminishing of sensory potential, and neurogenic atrophy of skeletal muscle. Reproductive effects have been reported in animals.

SKIN CONTACT:

ACUTE EXPOSURE:

N-HEXANE: Vapor may cause irritation with redness. 2 mL/kg/4 hours on rabbit skin resulted in ataxia and restlessness. At 5 mL/kg/4 hours some

deaths occurred.

CHRONIC EXPOSURE:

N-HEXANE: Repeated or prolonged contact may cause dermatitis due to defatting. Blister formation, itching, erythema, pigmentation and pain have been reported. Skin exposures may enhance neurotoxic effects from inhalation exposure.

EYE CONTACT:

ACUTE EXPOSURE:

N-HEXANE: Contact may cause irritation with redness and pain. Vapors at 880 ppm for 15 minutes caused irritation.

CHRONIC EXPOSURE:

N-HEXANE: Repeated or prolonged contact with irritants may cause conjunctivitis.

INGESTION:

ACUTE EXPOSURE:

N-HEXANE: May cause central nervous system effects, headache, nausea, vomiting, vertigo, bronchial and general intestinal irritation with abdominal swelling and pain. The fatal human dose may be about 50 grams. May vaporize when aspirated into the tracheobronchial tree with a resultant rapid dilution of alveolar air and marked fall in its oxygen content, with consequent brain damage or cardiac arrest.

CHRONIC EXPOSURE:

N-HEXANE: Reproductive effects have been reported in animals.

SECTION 12 ECOLOGICAL INFORMATION

ECOTOXICITY DATA:

FISH TOXICITY: 2500 ug/L 96 hour(s) LC50 (Mortality) Fathead minnow (Pimephales promelas)

ALGAL TOXICITY: 75 ug/L 28 hour(s) (Population Growth) Green algae (Chlamydomonas sp)
FATE AND TRANSPORT:
BIOCONCENTRATION: 3650 ug/L 11 hour(s) BCF (Residue) Mussel, eastern elliptio (Elliptio complanata) 0.43 ug/L

SECTION 13 DISPOSAL CONSIDERATIONS

Subject to disposal regulations: U.S. EPA 40 CFR 262. Hazardous Waste Number(s): D001. Dispose in accordance with all applicable regulations.

SECTION 14 TRANSPORT INFORMATION

U.S. DOT 49 CFR 172.101 SHIPPING NAME-UN NUMBER:

Flammable liquids, n.o.s. (n-Hexane)-UN1993
U.S. DOT 49 CFR 172.101 HAZARD CLASS OR DIVISION:
3
U.S. DOT 49 CFR 172.101 PACKING GROUP:
II
U.S. DOT 49 CFR 172.101 AND SUBPART E LABELING REQUIREMENTS:
Flammable liquid
U.S. DOT 49 CFR 172.101 PACKAGING AUTHORIZATIONS:
EXCEPTIONS: 49 CFR 173.150
NON-BULK PACKAGING: 49 CFR 173.202
BULK PACKAGING: 49 CFR 173.242
U.S. DOT 49 CFR 172.101 QUANTITY LIMITATIONS:
PASSENGER AIRCRAFT OR RAILCAR: 5 L
CARGO AIRCRAFT ONLY: 60 L
LAND TRANSPORT ADR/RID:
  SUBSTANCE NAME: Flammable liquid, n.o.s.
  UN NUMBER: UN1993
  ADR/RID CLASS: 3
  ITEM NUMBER: 3(b)
  WARNING SIGN/LABEL: 3
  HAZARD ID NUMBER: 33
AIR TRANSPORT IATA/ICAO:
  CORRECT TECHNICAL NAME: Flammable liquid, n.o.s.
  UN/ID NUMBER: UN1993
  IATA/ICAO CLASS: 3
  PACKAGING GROUP: II
  LABEL: Flammable liquid
MARITIME TRANSPORT IMDG:
  CORRECT TECHNICAL NAME: Flammable liquids, n.o.s.
  UN/ID NUMBER: UN1993
  IMDG CLASS: 3.1
  PACKAGING GROUP: II
  EmS No.: 3-07
  MARINE POLLUTANT: N

SECTION 15 REGULATORY INFORMATION

U.S. REGULATIONS:
  TSCA INVENTORY STATUS: Y
  TSCA 12(b) EXPORT NOTIFICATION: Y
    HEXANE
    CAS NUMBER: 110-54-3
    SECTION 4
  CERCLA SECTION 103 (40CFR302.4): Y

    N-HEXANE: 5000 LBS RQ
  SARA SECTION 302 (40CFR355.30): N
  SARA SECTION 304 (40CFR355.40): N
  SARA SECTION 313 (40CFR372.65): Y

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    N-HEXANE
  SARA HAZARD CATEGORIES, SARA SECTIONS 311/312 (40CFR370.21):
    ACUTE: Y
    CHRONIC: Y
    FIRE: Y
    REACTIVE: N
    SUDDEN RELEASE: N
  OSHA PROCESS SAFETY (29CFR1910.119): N
STATE REGULATIONS:
  California Proposition 65: N
EUROPEAN REGULATIONS:
  EC NUMBER (EINECS): 203-777-6
  EC RISK AND SAFETY PHRASES:
    R 11          Highly flammable.
    R 48/20       Harmful: danger of serious damage to health by prolonged
                  exposure through inhalation.
    S 2           Keep out of reach of children.
    S 9           Keep container in a well-ventilated place.
    S 16          Keep away from sources of ignition - No smoking.
    S 24/25       Avoid contact with skin and eyes.
    S 29          Do not empty into drains.
    S 51          Use only in well ventilated areas.
  CONCENTRATION LIMITS:
    C>=5%        Xn    R 48/20
GERMAN REGULATIONS:
  WATER HAZARD CLASS (WGK): 1 (Official German Classification)
-------------------------------------------------------------------------------
SECTION 16    OTHER INFORMATION
-------------------------------------------------------------------------------
MSDS SUMMARY OF CHANGES
  SECTION 14    TRANSPORT INFORMATION
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New Jersey Department of Health and Senior Services

HAZARDOUS SUBSTANCE FACT SHEET

Common Name: **n-HEXANE**

CAS Number: 110-54-3
DOT Number: UN 1208

RTK Substance number: 1340
Date: February 1989 Revision: April 1997

HAZARD SUMMARY

* **n-Hexane** can affect you when breathed in and by passing through your skin.
* Exposure can cause lightheadedness, giddiness, headaches and nausea. Higher exposures can lead to unconsciousness and death.
* High or repeated exposure can damage the nervous system, causing numbness, tingling, and/or muscle weakness.
* **n-Hexane** can irritate the eyes, nose, mouth and throat.
* Repeated skin contact can cause irritation and can lead to a rash.
* **n-Hexane** is a FLAMMABLE LIQUID and a FIRE HAZARD.

IDENTIFICATION

n-Hexane is a colorless liquid with a mild gasoline-like odor. It is used as a solvent and thinner for glue.

REASON FOR CITATION

* **n-Hexane** is on the Hazardous Substance List because it is regulated by OSHA and cited by ACGIH, NIOSH, DOT, HHAG and NFPA.
* This chemical is on the Special Health Hazard Substance List because it is **FLAMMABLE.**
* Definitions are provided on page 5.

HOW TO DETERMINE IF YOU ARE BEING EXPOSED

The New Jersey Right to Know Act requires most employers to label chemicals in the workplace and requires public employers to provide their employees with information and training concerning chemical hazards and controls. The federal OSHA Hazard Communication Standard, 1910.1200, requires private employers to provide similar training and information to their employees.

* Exposure to hazardous substances should be routinely evaluated. This may include collecting air samples. Under OSHA 1910.20, you have a legal right to obtain copies of sampling results from you employer.
* If you think you are experiencing any work-related health problems, see a doctor trained to recognize occupational diseases. Take this Fact Sheet with you.

* **ODOR THRESHOLD = 65 - 248 ppm.**
* The range of accepted odor threshold values is quite broad. Caution should be used in relying on odor alone as a warning of potentially hazardous exposures.

WORKPLACE EXPOSURE LIMITS

OSHA: The legal airborne permissible exposure limit (PEL) is **500 ppm** averaged over an 8-hour workshift.

NIOSH: The recommended airborne exposure limit is **50 ppm** averaged over a 10-hour workshift.

The recommended airborne exposure limit for other *Hexane* isomers is **100 ppm** averaged over a 10-hour workshift and **510 ppm** not to be exceeded during any 15 minute work period.

ACGIH: The recommended airborne exposure limit is **50 ppm** averaged over an 8-hour workshift.

The recommended airborne exposure limit for other *Hexane* isomers is **500 ppm** averaged over an 8-hour workshift and **1,000 ppm** as a STEL (short term exposure limit).

* The above exposure limits are for air levels only. When skin contact also occurs, you may be overexposed, even though air levels are less than the limits listed above.

WAYS OF REDUCING EXPOSURE

* Where possible, enclose operations and use local exhaust ventilation at the site of chemical release. If local exhaust ventilation or enclosure is not used, respirators should be worn.
* Wear protective work clothing.
* Wash thoroughly at the end of the workshift.
* Post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, communicate all information on the health and safety hazards of **n-Hexane** to potentially exposed workers.

This Fact Sheet is a summary source of information of all potential and most severe health hazards that may result from exposure. Duration of exposure, concentration of the substance and other factors will affect your susceptibility to any of the potential effects described below.

HEALTH HAZARD INFORMATION

Acute Health Effects

The following acute (short-term) health effects may occur immediately or shortly after exposure to **n-Hexane**:

* **n-Hexane** can irritate the eyes, nose, mouth and throat causing cough and/or difficulty in breathing.
* Exposure can cause lightheadedness, giddiness, headaches and nausea. Higher exposures can lead to unconsciousness and death.

Chronic Health Effects

The following chronic (long-term) health effects can occur at some time after exposure to **n-Hexane** and can last for months or years:

Cancer Hazard

* According to the information presently available to the New Jersey Department of Health and Senior Services, **n-Hexane** has not been tested for its ability to cause cancer in animals.

Reproductive Hazard

* The available data is inadequate to assess the reproductive risk of **n-Hexane**.

Other Long-Term Effects

* High or repeated exposure can damage the nervous system, causing numbness, tingling, and/or muscle weakness in the hands, feet, arms and legs.
* Repeated skin contact can cause irritation, dryness and cracking and can lead to a rash.

MEDICAL

Medical Testing

For those with frequent or potentially high exposure (half the TLV or greater, or significant skin contact), the following are recommended before beginning work and at regular times after that:

* Exam of the nervous system.
* Evaluate for brain effects such as changes in memory, concentration, sleeping patterns and mood (especially irritability and social withdrawal), as well as headache and fatigue. Consider evaluations of the cerebellar, autonomic and peripheral nervous systems. Positive and borderline individuals should be referred for neuropsychological testing.

Any evaluation should include a careful history of past and present symptoms with an exam. Medical tests that look for damage already done are not a substitute for controlling exposure.

Request copies of your medical testing. You have a legal right to this information under OSHA 1910.20.

WORKPLACE CONTROLS AND PRACTICES

Unless a less toxic chemical can be substituted for a hazardous substance, **ENGINEERING CONTROLS** are the most effective way of reducing exposure. The best protection is to enclose operations and/or provide local exhaust ventilation at the site of chemical release. Isolating operations can also reduce exposure. Using respirators or protective equipment is less effective than the controls mentioned above, but is sometimes necessary.

In evaluating the controls present in your workplace consider: (1) how hazardous the substance is, (2) how muc of the substance is released into the workplace and (3) whether harmful skin or eye contact could occur. Special controls should be in place for highly toxic chemicals or when significant skin, eye, or breathing exposures are possible.

In addition, the following control is recommended:

* Where possible, automatically pump liquid **n-Hexane** from drums or other storage containers to process containers.

Good **WORK PRACTICES** can help to reduce hazardous exposures. The following work practices are recommended:

* Workers whose clothing has been contaminated by **n-Hexane** should change into clean clothing promptly.
* Do not take contaminated work clothes home. Family members could be exposed.

* Contaminated work clothes should be laundered by individuals who have been informed of the hazards of exposure to **n-Hexane**.
  Do not eat, smoke, or drink where **n-Hexane** is handled, processed, or stored, since the chemical can be swallowed. Wash hands carefully before eating, drinking, smoking, or using the toilet.
* Wash any areas of the body that may have contacted **n-Hexane** at the end of each work day, whether or not known skin contact has occurred.
* Do not eat, smoke, or drink where **n-Hexane** is handled, processed, or stored, since the chemical can be swallowed. Wash hands carefully before eating or smoking.

PERSONAL PROTECTIVE EQUIPMENT

WORKPLACE CONTROLS ARE BETTER THAN PERSONAL PROTECTIVE EQUIPMENT. However, for some jobs (such as outside work, confined space entry, jobs done only once in a while, or jobs done while workplace controls are being installed), personal protective equipment may be appropriate.

The following recommendations are only guidelines and may not apply to every situation.

Clothing

Avoid skin contact with **n-Hexane**. Wear solvent-resistant gloves and clothing. Safety equipment suppliers/manufacturers can provide recommendations on the most protective glove/clothing material for your operation.

* All protective clothing (suits, gloves, footwear, headgear) should be clean, available each day, and put on before work.
* ACGIH recommends *Neoprene, Nitrile, Polyvinyl Alcohol* or *VITON* as suitable material.

Eye Protection

* Wear splash-proof chemical goggles and face shield when working with liquid unless full facepiece respiratory protection is worn.

Respiratory Protection

IMPROPER USE OF RESPIRATORS IS DANGEROUS. Such equipment should only be used if the employer has a written program that takes into account workplace conditions, requirements for worker training, respirator fit testing and medical exams, as described in OSHA 1910.134.

* Where the potential exists for exposures over **50 ppm**, use a MSHA/NIOSH approved full facepiece respirator with an organic vapor cartridge/canister. Even greater protection is provided by a powered-air purifying respirator.
* If while wearing a filter, cartridge or canister respirator, you can smell, taste, or otherwise detect **n-Hexane**, or in the case of a full facepiece respirator you experience eye irritation, leave the area immediately. Check to make sure the respirator-to-face seal is still good. If it is, replace the filter, cartridge, or canister. If the seal is no longer good, you may need a new respirator.
* Be sure to consider all potential exposures in your workplace. You may need a combination of filters, prefilters, cartridges, or canisters, to protect against different forms of a chemical (such as vapor and mist) or against a mixture of chemicals.
* Where the potential for high exposures exists, use a MSHA/NIOSH approved supplied-air respirator with a full facepiece operated in the positive pressure mode or with a full facepiece, hood, or helmet in the continuous flow mode.
* Exposure to **1,100 ppm** is immediately dangerous to life and health. If the possibility of exposure above **1,100 ppm** exist, use a MSHA/NIOSH approved self-contained breathing apparatus with a full facepiece operated in continuous flow or other positive pressure mode.

HANDLING AND STORAGE

* Prior to working with **n-Hexane** you should be trained on its proper handling and storage.
* **n-Hexane** must be stored to avoid contact with STRONG OXIDIZERS (such as CHLORINE, BROMINE and FLUORINE) because violent reactions occur.
* Store in tightly closed containers in a cool, well-ventilated area away from HEAT.
* Sources of ignition such as smoking and open flames are prohibited where **n-Hexane** is used, handled, or stored in a manner that could create a potential fire or explosion hazard.
* Metal containers involving the transfer of **n-Hexane** should be grounded and bonded.
* Use only non-sparking tools and equipment, especially when opening and closing containers of **n-Hexane**.

QUESTIONS AND ANSWERS

Q: If I have acute health effects, will I later get chronic health effects?

A: Not always. Most chronic (long-term) effects result from repeated exposures to a chemical.

Q: Can I get long-term effects without ever having short-term effects?

A: Yes, because long-term effects can occur from repeated exposures to a chemical at levels not high enough to make you immediately sick.

Q: What are my chances of getting sick when I have been exposed to chemicals?

A: The likelihood of becoming sick from chemicals is increased as the amount of exposure increases. This is determined by the length of time and the amount of material to which someone is exposed.

Q: When are higher exposures more likely?

A: Conditions which increase risk of exposure include physical and mechanical processes (heating, pouring, spraying, spills and evaporation from large surface areas such as open containers), and "confined space" exposures (working inside vats, reactors, boilers, small rooms, etc.).

Q: Is the risk of getting sick higher for workers than for community residents?

A: Yes. Exposures in the community, except possibly in cases of fires or spills, are usually much lower than those found in the workplace. However, people in the community may be exposed to contaminated water as well as to chemicals in the air over long periods. Because of this, and because of exposure of children or people who are already ill, community exposures may cause health problems.

Q: Aren't pregnant women at the greatest risk from reproductive hazards?

A: Not necessarily. Pregnant women are at greatest risk from chemicals which harm the developing fetus. However, chemicals may affect the ability to have children, so both men and women of childbearing age are at high risk.

Q: Can men as well as women be affected by chemicals that cause reproductive system damage?

A: Yes. Some chemicals reduce potency or fertility in both men and women. Some damage sperm and eggs, possibly leading to birth defects.

The following information is available from:

New Jersey Department of Health and
Senior Services
Occupational Disease and Injury Services
Trenton, NJ 08625-0360
(609) 984-1863

Industrial Hygiene Information

Industrial hygienists are available to answer your questions regarding the control of chemical exposures using exhaust ventilation, special work practices, good housekeeping, good hygiene practices, and personal protective equipment including respirators. In addition, they can help to interpret the results of industrial hygiene survey data.

Medical Evaluation

If you think you are becoming sick because of exposure to chemicals at your workplace, you may call a Department of Health and Senior Services physician who can help you find the services you need.

Public Presentations

Presentations and educational programs on occupational health or the Right to Know Act can be organized for labor unions, trade associations and other groups.

Right to Know Information Resources

The Right to Know Infoline (609) 984-2202 can answer questions about the identity and potential health effects of chemicals, list of educational materials in occupational health, references used to prepare the Fact Sheets, preparation of the Right to Know survey, education and training programs, labeling requirements, and general information regarding the Right to Know Act. Violations of the law should be reported to (609) 984-2202.

DEFINITIONS

ACGIH is the American Conference of Governmental Industrial Hygienists. It recommends upper limits (called TLVs) for exposure to workplace chemicals.

A **carcinogen** is a substance that causes cancer.

The **CAS number** is assigned by the Chemical Abstracts Service to identify a specific chemical.

A **combustible** substance is a solid, liquid or gas that will burn.

A **corrosive** substance is a gas, liquid or solid that causes irreversible damage to human tissue or containers.

DEP is the New Jersey Department of Environmental Protection.

DOT is the Department of Transportation, the federal agency that regulates the transportation of chemicals.

EPA is the Environmental Protection Agency, the federal agency responsible for regulating environmental hazards.

A **fetus** is an unborn human or animal.

A **flammable** substance is a solid, liquid, vapor or gas that will ignite easily and burn rapidly.

The **flash point** is the temperature at which a liquid or solid gives off vapor that can form a flammable mixture with air.

HHAG is the Human Health Assessment Group of the federal EPA.

IARC is the International Agency for Research on Cancer, a scientific group that classifies chemicals according to their cancer-causing potential.

A **miscible** substance is a liquid or gas that will evenly dissolve in another.

mg/m^3 means milligrams of a chemical in a cubic meter of air. It is a measure of concentration (weight/volume).

MSHA is the Mine Safety and Health Administration, the federal agency that regulates mining. It also evaluates and approves respirators.

A **mutagen** is a substance that causes mutations. A **mutation** is a change in the genetic material in a body cell. Mutations can lead to birth defects, miscarriages, or cancer.

NAERG is the North American Emergency Response Guidebook. It was jointly developed by Transport Canada, the United States Department of Transportation and the Secretariat of Communications and Transportation of Mexico. It is a guide for first responders to quickly identify the specific or generic hazards of material involved in a transportation incident, and to protect themselves and the general public during the initial response phase of the incident.

NCI is the National Cancer Institute, a federal agency that determines the cancer-causing potential of chemicals.

NFPA is the National Fire Protection Association. It classifies substances according to their fire and explosion hazard.

NIOSH is the National Institute for Occupational Safety and Health. It tests equipment, evaluates and approves respirators, conducts studies of workplace hazards, and proposes standards to OSHA.

NTP is the National Toxicology Program which tests chemicals and reviews evidence for cancer.

OSHA is the Occupational Safety and Health Administration, which adopts and enforces health and safety standards.

PEOSHA is the Public Employees Occupational Safety and Health Act, a state law which sets PELs for New Jersey public employees.

ppm means parts of a substance per million parts of air. It is a measure of concentration by volume in air.

A **reactive** substance is a solid, liquid or gas that releases energy under certain conditions.

A **teratogen** is a substance that causes birth defects by damaging the fetus.

TLV is the Threshold Limit Value, the workplace exposure limit recommended by ACGIH.

The **vapor pressure** is a measure of how readily a liquid or a solid mixes with air at its surface. A higher vapor pressure indicates a higher concentration of the substance in air and therefore increases the likelihood of breathing it in.

>>>>>>>>>>>>>>>>>> EMERGENCY INFORMATION <<<<<<<<<<<<<<<<<<

Common Name: **n-HEXANE**
DOT Number: **UN 1208**
NAERG Code: **128**
CAS Number: **110-54-3**

Hazard rating	NJ DOH	NFPA
FLAMMABILITY	-	3
REACTIVITY	-	0
POISONOUS GASES ARE PRODUCED IN FIRE CONTAINERS MAY EXPLODE IN FIRE		

Hazard Rating Key: 0=minimal; 1=slight; 2=moderate; 3=serious; 4=severe

FIRE HAZARDS

* **n-Hexane** is a FLAMMABLE LIQUID.
* Use dry chemical, CO_2, or foam extinguishers.
* Water may be used to keep fire exposed containers cool.
* POISONOUS GASES ARE PRODUCED IN FIRE.
* CONTAINERS MAY EXPLODE IN FIRE.
* Vapors may travel to a source of ignition and flash back.
* If employees are expected to fight fires, they must be trained and equipped as stated in OSHA 1910.156.

SPILLS AND EMERGENCIES

If **n-Hexane** is spilled or leaked, take the following steps:

* Vapor build-up may cause suffocation.
* Restrict persons not wearing protective equipment from area of spill or leak until cleanup is complete.
* Ventilate the area of spill or leak.
* Water spray may be used to disperse vapors.
* Absorb liquids in vermiculite, dry sand, earth, or a similar material and deposit in sealed containers.
* Keep **n-Hexane** out of a confined space, such as a sewer, because of the possibility of an explosion, unless the sewer is designed to prevent the build-up of explosive concentrations.
* It may be necessary to contain and dispose of **n-Hexane** as a HAZARDOUS WASTE. Contact your state Department of Environmental Protection (DEP) or your regional office of the federal Environmental Protection Agency (EPA) for specific recommendations.
* If employees are required to clean-up spills, they must be properly trained and equipped. OSHA 1910.120(q) may be applicable.

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FOR LARGE SPILLS AND FIRES immediately call your fire department. You can request emergency information from the following:

CHEMTREC: (800) 424-9300
NJDEP HOTLINE: (609) 292-7172

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HANDLING AND STORAGE (See page 3)

FIRST AID

In NJ, POISON INFORMATION 1-800-962-1253

Eye Contact

* Immediately flush with large amounts of water for at least 15 minutes, occasionally lifting upper and lower lids.

Skin Contact

* Remove contaminated clothing. Wash contaminated skin with soap and water.

Breathing

* Remove the person from exposure.
* Begin rescue breathing if breathing has stopped and CPR if heart action has stopped.
* Transfer promptly to a medical facility.

PHYSICAL DATA

Vapor Pressure: 124 mm Hg at 68°F (20°C)
Flash Point: -7°F (-21.7°C)
Water Solubility: Insoluble

OTHER COMMONLY USED NAMES

Chemical Name:
Hexane
Other Names:
Skellysolve-B

Not intended to be copied and sold for commercial purposes.

NEW JERSEY DEPARTMENT OF HEALTH AND SENIOR SERVICES
Right to Know Program
CN 368, Trenton, NJ 08625-0368
(609) 984-2202

ATTACHMENT 8

Project Forms and Permits

ATTACHMENT 9

CH2MHILL

Ordnance Explosives (OE)
Standard of Practice HSE-91

Note:

This Standard of Practice covers the entire spectrum of OE/UXO-related project activities, including investigation and removal.

CH2MHILL

Ordnance Explosives (OE)
Standard of Practice HSE-91

Applicability and Scope

Applicability

This Standard of Practice (SOP) applies to: 1) CH2M HILL employees who enter areas known or suspected of having Ordnance Explosives (OE) and 2) CH2M HILL Safety Coordinators (SCs) and CH2M HILL EE&SBG Unexploded Ordnance Safety Officers (UXOSO) who may be responsible for providing oversight of a subcontractors OE operations. OE operations may be conducted on active, inactive, closed, transferring, or transferred ranges; former battlefields; disposal sites; or munitions manufacturing and storage sites.

1.1 Scope

This SOP provides information regarding the spectrum of hazards and issues to be addressed during each phase of a project associated with OE operations. OE hazards addressed in this SOP include exposure to Unexploded Ordnance (UXO), Chemical Warfare Material (CWM), explosives contaminated soil and groundwater, and the hazards associated with operations to locate, identify, remove, and dispose of OE. CH2M HILL employees who enter OE areas must take precautions to avoid these hazards and be aware of associated safe work practices.

As described in the "Subcontractor, Contractor, and Owner" SOP HSE-55, responsibilities for health, safety and environment (HS&E) are expressly defined through the subcontract terms and conditions, and CH2M HILL's HS&E practices in the field are determined based on these defined responsibilities. Consistent with HSE-55, the subcontractor must determine how to operate safely and in compliance with applicable HS&E regulations and industry standards, and how to correct deficiencies. CH2M HILL employees shall not direct the means and methods of OE operations nor direct the details of corrective actions.

Regulatory Review

OE projects are often complex and have a myriad of regulatory requirements to ensure safety. Support for determining the governing laws and regulations for any specific OE project must be reviewed by the EE&SBG UXOSO to ensure compliance and safety.

Department of Defense (DOD) Ammunition and Explosives Safety Standards, DOD 6055.9-STD, establishes uniform safety standards applicable 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.

The U.S. Environmental Protection Agency (EPA) regulates the disposal of military munitions and waste containing military munitions through the Military Munitions Rule (RCRA; 40 CFR part 266, subpart M). The rule 1) identifies when conventional and chemical military munitions become a solid waste and 2) provides criteria for storage and transportation of such waste, including a conditional exemption if the munitions are managed under DOD rules.

Project Planning

Training Requirements

CH2M HILL employees and subcontractors who work on projects that involve OE must complete the following training:

- 40-hour hazardous waste comprehensive course with training in hazard recognition and basic health and safety issues, as required by the occupational safety and health regulations contained in 29 CFR 1910.120(e)
- Annual 8-hour hazardous waste refresher course
- Hazardous waste supervisory training as specified in 29 CFR 1910.120(e) [only required for management and supervisors]
- All UXO personnel will 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, FL; EOD Assistants Course, Redstone Arsenal AL; EOD Assistant Course at Eglin Air Force Base, FL; or a U.S. DOD-certified equivalent course

The EE&SBG UXOSO can provide assistance in reviewing subcontractor personnel qualifications.

Medical Surveillance Requirements

All CH2M HILL employees who work on OE sites must be on a medical surveillance program consisting of a baseline health assessment that includes a medical and occupational history review, blood and urine tests for contaminants of interest, electrocardiogram, slit-lamp corneal examination, pulmonary function tests, chest x-ray, respiratory fit test, and a general physical examination that includes hearing and vision.

Employees who terminate employment and who have worked at OE project sites may be required to undergo an exit examination equivalent to the baseline health assessment.

Subcontractors are responsible for ensuring that their employees receive medical surveillance as required.

Drug Abuse Surveillance Requirements

CH2M HILL employees who perform OE operations and oversight are subject to the provisions contained in HSE-76.

Competent Person Requirements

OE/UXO subcontractors are responsible for providing a competent person to oversee OE operations. A competent person may be a Senior UXO Supervisor, UXO Safety Officer, UXO Quality Control Specialist, or a UXO Technician III. The competent person must meet the following minimum qualification requirements:

- Be a graduate of either 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, FL; EOD Assistants Course, Redstone Arsenal Alabama; EOD Assistant Course at Eglin Air Force Base, FL; or a U.S. DOD-certified equivalent course
- Have at least 10 years of combined active duty military EOD and contractor UXO experience
- Have experience in OE clearance operations and supervising personnel

CH2M HILL competent person requirements are the same as for a subcontractor.

1.2 Safety Equipment

OE subcontractors are responsible for providing all personal protective equipment (PPE) necessary 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 referenced documents. The EE&SBG UXOSO must review subcontractor work plans and health and safety plans to ensure that appropriate safety equipment has been included to meet the scope of work requirements.

1.3 Subcontractor Selection

OE subcontractors are selected as described in the “Subcontractor, Contractor, and Owner” SOP HSE-55. The “Subcontractor Safety Procedure Criteria – OE Operations” found in Attachment 1 provides the minimum criteria for OE operations. Additional criteria may be developed dependent upon the specific OE scope of work requirements for the subcontractor. These criteria shall be used by the CH2M HILL EE&SBG UXOSO to review subcontractor OE procedures submitted when oversight is required by HSE-55.

1.4 Planning Activities

Assistance for planning OE operations is available from the CH2M HILL EE&SBG UXOSO for planning and executing OE support for Hazardous Toxic Radiological Waste (HTRW) support activities, construction support activities, OE response actions, CWM activities, explosive contaminated soils, and ordnance demilitarization. The following types of support may be needed for OE operations:

- On a HTRW site with known or suspected OE, UXO support refers to the anomaly avoidance techniques implemented to avoid any potential surface UXO and any subsurface anomalies.
- On a construction site with known or suspected OE, UXO support is provided by qualified UXO personnel during construction activities. The level of UXO support

required is dependent on the probability of encountering UXO, as determined on a project-by-project basis.

- OE response actions in which location, identification, excavation, removal, and disposal of UXO is accomplished require qualified UXO personnel, including a Senior UXO Supervisor, UXO Safety Officer, and UXO Quality Control Specialist to provide oversight for UXO Teams performing operations.
- On an OE site that has OE contamination of soils and/or groundwater, UXO support may include both anomaly avoidance techniques and OE construction support for excavation and/or treatment of OE contaminated soil and groundwater.
- On ordnance demilitarization and CWM projects, OE support may be needed for identification, handling, disassembly, processing, transportation, and treatment or disposal of munition components.
- On projects where OE waste (OEW) is transported or disposed off-range, the UXO and Environmental Compliance Coordinator (ECC) may assist in identifying the applicable regulations and permits required.
- On projects where Ordnance Related Scrap (ORS) or inert ordnance is recovered and processed for disposal as scrap, UXO and ECC support may determine if incineration and certification is required, along with any permitting requirements for portable incinerator operation.

The CH2M HILL EE&SBG UXOSO or EE&SBG UXO Quality Control Specialist shall verify subcontractor training and current medical examinations prior to the start of field operations.

Definitions

3.1 **Active Range.** A military range that is currently in use and being regularly used for range activities.

3.2 **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.

3.3 **Anomaly Avoidance.** Techniques employed by EOD or UXO personnel at sites with known or suspected OE to avoid any potential surface UXO or subsurface anomalies. This usually occurs at mixed hazard sites when HTRW investigations must occur prior to execution of an OE removal action. Intrusive anomaly investigations are not authorized during ordnance avoidance operations.

3.4 **Chemical Warfare Materials (CWM).** An item configured as a munition containing a chemical substance that is 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-munition 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.

3.5 **OE Construction Support.** Support provided by qualified UXO personnel during construction activities at potential OE sites to ensure the safety of construction personnel from the harmful effects of UXO. When a determination is made that the probability of encountering UXO is low (current or previous land use leads to a determination that OE may be present), a two person UXO team will stand by in case the construction contractor encounters a suspected UXO. When a determination is made that the probability of encountering a UXO is moderate to high (current or previous land use leads to a determination that OE 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 UXO clearance for the known construction footprint either in conjunction with the construction contractor or prior to construction.

3.6 **EOD Personnel.** EOD personnel are those active duty military individuals performing EOD operations.

3.7 **Explosive Ordnance Disposal (EOD).** EOD includes the detection, identification, field evaluation, rendering safe, and final disposal of OE.

3.8 **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, and potential hazards and the methods for their control.

3.9 **Explosive Soil.** Refers to mixtures of explosives in soil, sand, clay, or other solid media at concentrations such that the mixture itself is explosive.

(a) 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.”

(b) 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.

(c) 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.

(d) Soil containing 10 percent or more by weight of any secondary explosive mixture of secondary explosives is considered “explosive soil.”

(e) Soil containing propellants (as opposed to primary or secondary high explosives) may also present explosion hazards.

3.10 **Inactive Range.** A military range that is not currently being used, but that is still under military control and considered by the military to be a potential range area, and that has not been put to a new use that is incompatible with range activities.

3.11 **Intentional Detonation.** An intentional detonation is a planned, controlled detonation.

3.12 **Intrusive Activity.** An activity that involves or results in the penetration of the ground surface at an area known or suspected to contain OE. Intrusive activities can be of an investigative or removal action nature.

3.13 **Maximum Credible Event.** 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 unintended, unplanned, or accidental occurrence.

3.14 **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 OE activities. The event must be realistic with reasonable probability of occurrence.

3.15 **Most Probable Munition (MPM).** The OE item that has the greatest hazard distance based on calculations of the explosion effects of the OE items anticipated to be found at a site. Typically, the MPM is the OE item with the greatest fragmentation or overpressure distance based on the type of OE items that were historically used at the site.

3.16 **Military Munitions.** All ammunition products and components produced or used by or for the U.S. 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. Department of Energy (DOE), and the National Guard personnel. The term military munitions includes: confined gases, 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.

3.17 **Military Range.** Designated land and water areas set aside, managed, and used to conduct research on, develop, test, and evaluate military munitions and explosives, other ordnance or weapons systems, or to train military personnel in their use and handling. Ranges include firing lines and positions, maneuver areas, firing lanes, test pads, detonation pads, impact areas, and buffer zones with restricted access and exclusionary areas.

3.18 **Non-Stockpile Chemical Warfare Materials.** 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.

(5) Miscellaneous CWM (unfilled munitions and devices and equipment specially designed for use directly in connection with employment of chemical weapons).

3.19 **Ordnance and Explosives (OE)** consists of:

(1) Ammunition, ammunition components, chemical or biological warfare materials that have been abandoned, expelled from demolition pits or burning pads, lost, discarded, buried or fired. Such ammunition, ammunition components, and explosives are no longer under accountable record control of any DOD organization or activity.

(2) Explosive Soil. See definition under "explosive soils."

(3) OE market includes: Unexploded Ordnance (UXO), Chemical Weapons Materials (CWM), OE Contaminated Soils and Groundwater, Range Maintenance, Ordnance Demilitarization (Demil), and Demining (DM).

3.20 **Quantity-Distance (QD).** 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.

3.21 **Removal Action.** The cleanup of OE from the environment to include the disposal of removed material. The term includes, in addition, without being limited to, security fencing or other measures to prevent, minimize, or mitigate damage to the public health or welfare or the environment.

3.22 **Response Action.** Action taken instead of or in addition to a removal action to prevent or minimize the release of OE so that it does not cause substantial danger to present or future public health or welfare or the environment.

3.23 **Senior UXO Supervisor (SUXOS).** Supervises all contractor onsite 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. This individual 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.

3.24 **Unintentional Detonation.** A detonation not planned in advance.

3.25 **Unexploded Ordnance (UXO).** Military munitions that have been primed, fuzed, armed, or otherwise prepared for action, and have been fired dropped, launched, projected or placed in such a manner as to constitute a hazard to operations, installation, personnel, or material and remain unexploded either by malfunction, design, or any other cause.

3.26 **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.

3.27 **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. This individual must have the same minimum qualifications

as the UXO Technician III. In addition, this individual must have the specific training, knowledge, and experience necessary to implement the SSHP and verify compliance with applicable safety and health requirements.

3.28 **UXO Technician III.** Supervises a UXO team. This individual 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, or U.S. Naval EOD School, Elgin Air Force Base, FL, or a DOD-equivalent certified course. This individual must have a minimum of 10 years of military EOD or contractor UXO experience.

3.29 **UXO Technician II.** This individual 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, or U.S. Naval EOD School, Elgin Air Force Base, FL, or a DOD-equivalent certified course. This individual must have a minimum of 5 years of military EOD or contractor UXO experience.

Project Execution

Safe Work Practices

The requirements of this section are to be followed by CH2M HILL employees who enter OE exclusion zones, regardless of the company performing OE operations. These requirements also pertain to OE subcontractor personnel when CH2M HILL is providing oversight.

Regulations/Industry Standards

As described in the "Subcontractor, Contractor, and Owner" SOP HSE-55, CH2M HILL's project EE&SBG UXOSO may be required to provide oversight of an OE subcontractor. OE 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 standard requirements pertaining to OE operations.

General Safety Concerns and Procedures

(a) OE operations will not be conducted until a complete plan for the site is prepared and approved by the CH2M HILL EE&SBG UXOSO. These plans will be based upon limiting exposure to the minimum number of personnel, for the minimum amount of time, to the least amount of OE consistent with safe and efficient operations.

(b) Only UXO qualified personnel will perform OE procedures. Non-UXO personnel may be used to perform OE-related procedures when supervised by a UXO Technician III. All personnel engaged in field operations will 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 will be under the direct supervision of a UXO Technician III.

(c) Personnel who will be handling OE items will not wear outer or inner garments having static electricity-generating characteristics. Materials made of 100 percent polyester, nylon, silk, and wool are highly static producing.

(d) UXO Technicians are required to wear hard hats except when investigating suspect UXO. Hard hats may create an unsafe condition by falling off of the head of a UXO technician at a critical moment. In the event of the accidental detonation of a UXO (the worst case accident scenario), the hard hat will not protect the UXO 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 U.S. Army Corps of Engineers OE Center of Excellence. Also, protective shoes worn by personnel performing UXO operations should be constructed of nonferrous materials (e.g., fiberglass) to prevent interference with sensitive geophysical instruments.

(e) Prior to any action being performed on an ordnance item, all fuzing will be positively identified. This identification will consist of fuze type by function, condition (armed or unarmed), and the physical state/condition of the fuze, i.e., burned, broken, parts exposed/sheared, etc.

OE Safety Precautions

(a) Every effort will be made to identify a suspect OE item. Under no circumstances will any OE be moved in an attempt to make a positive identification. The OE item will be visually examined for markings and other external features such as shape, size, and external fittings. If an unknown OE item is encountered, the CH2M HILL EE&SBG UXOSO will be notified immediately. The following are additional considerations for the safe handling of OE items:

(1) Projectiles containing base detonating (BD) fuzes are to be considered armed if the round is fired.

(2) Arming wires and pop-out pins on unarmed fuzes should be secured prior to any movement.

(3) Do not depress plungers, turn vanes, rotate spindles, levers, setting rings, or other external fittings on OE items. Such actions may arm or activate the OE.

(4) Do not attempt to remove any fuzes from the OE. Do not dismantle or strip components from any OE items unless the item is included in the scope of work (SOW).

(5) UXO personnel are not authorized to inert any OE items found onsite unless it is a part of the SOW.

(6) OE/UXO items will not be taken from the site as souvenirs/training aids.

(7) Civil War ordnance will be treated as any other OE.

(b) Prior to entering U.S. Army-controlled areas/ranges contaminated with Improved Conventional Munitions (ICM), an approved Department of the Army (DA) wavier must be obtained.

(c) Any time suspect chemical warfare material (CWM) is encountered during conventional OE site activities, all work will immediately cease. Project personnel will withdraw along cleared paths upwind from the discovery. A team consisting of two personnel will secure the area to prevent unauthorized access. Personnel should position themselves as

far upwind as possible while still maintaining security of the area. The local point of contact designated in the Work Plan will be immediately notified.

(d) Avoid inhalation and skin contact with smoke, fumes, and vapors of explosives and other related materials.

(e) Consider OE items that have been exposed to fire and detonation as extremely hazardous. Chemical and physical changes may have occurred to the contents, which might render them more sensitive than their original state.

(f) Do not rely on the color coding of OE for positive identification. Munitions having incomplete or improper color codes have been encountered.

(g) Avoid approaching the forward area of an OE item until it can be determined whether or not the item contains a shaped charge. The explosive jet, which is formed during detonation, can be lethal at great distances. Assume that all shaped charge munitions contain piezoelectric (PZ) fuzing system until identified. PZ is extremely sensitive. It can function at the slightest physical change and can remain hazardous for an indefinite period of time.

(h) Approach an unfired rocket motor from the side at a 45-degree angle. Accidental ignition can cause a missile hazard and hot exhaust.

(i) Do not expose unfired rocket motors to any electromagnetic radiation (EMR) sources.

(j) Consider an emplaced landmine armed until proven otherwise. It may be intentionally booby-trapped to deceive.

(k) Assume that practice OE contains a live charge until it can be determined otherwise. Expended pyrotechnic and practice devices can contain red or white phosphorous residue. Due to incomplete combustion, the phosphorous may re-ignite if the crust is broken and exposed to air.

(l) Do not approach a smoking white phosphorous (WP) munition. Burning WP may detonate the explosive burster charge at anytime.

(m) Foreign ordnance was returned to the United States for exploitation and subsequent disposal. Every effort must be made to research the applicable documentation and publications prior to commencement of a project.

OE Storage

(a) During OE projects, explosive storage falls into two categories, on-DOD installations and off-DOD installations.

(b) For On-DOD installations the provisions of DOD 6055.9-STD will be followed.

(c) In the event the installation does not have an existing storage facility, the provisions of DOD 6055.9-STD will apply.

(d) For Off-DOD installations, establish a temporary explosive storage area that will meet all local, state, and 27 CFR, Bureau of Alcohol Tobacco, and Firearms (BATF) requirements and as much of DOD 6055.9-STD as is practical to implement. The

establishment of a temporary explosive storage area must meet the following requirements:

(1) The area will, if possible, meet the inhabited building and public traffic route distances specified in DOD 6055.9-STD. If the distances are less than required by the DOD guidance, a proposed barricading plan to protect the public from accidental detonation must be developed and reviewed by the CH2M HILL Corporate UXOSO.

(2) Magazines must meet the requirements of the BATF regulations, and each magazine must have a Net Explosive Weight (NEW) established for the explosives to be stored.

(3) Each magazine must be grounded as specified in NFPA 780 and must meet the intermagazine distances as defined in the DOD guidance.

(4) A physical security survey will be conducted to determine if fencing or guards are required. This survey will be coordinated through the CH2M HILL EE&SBG UXOSO and local law enforcement agencies.

(5) A fire plan for either on- or off-installation explosive storage areas will be prepared and coordinated through the CH2M HILL EE&SBG UXOSO and the local fire department. All magazines will have placards.

(e) OE Waste (OEW) may be stored: 1) in RCRA regulated units (i.e., tanks, containers, containment buildings, etc.) as described in HSE-80; 2) in military magazines conforming to DDESB standards (as described above); or 3) under the MMR conditional exemption (40 CFR 266.205). The MMR conditional exemption applies to military non-chemical munitions, and the following procedures must be met:

(1) Follow DDESB requirements for storage.

(2) Notify EPA of the location of the unit within 90 days of when storage unit first is used for waste munitions storage.

(3) Notify EPA within 24 hours of any loss or theft of munitions from the storage area.

(4) Inventory wastes annually, conduct inspections quarterly and keep records for at least three years.

(5) Limit access to the area to appropriately trained and authorized personnel.

OE Transportation

In the event that OE items must be transported offsite, the provisions of NAVSEA SW020-AC-SAF-010 state and local laws must be followed. These additional considerations are provided for the safe transport of OE items:

(a) Do not transport WP munitions unless they are immersed in water, mud, or wet sand.

(b) If loose pyrotechnic, tracer, flare, or similar mixtures are to be transported, they will be placed in #10 mineral oil or equivalent to minimize the fire and explosion hazards.

(c) Incendiary loaded munitions should be placed on a bed of sand and covered with sand to help control the burn if a fire should start.

(d) If a base-ejection projectile must be transported to a disposal area, the base will be oriented in the vehicle so that it is parallel to the rear axle. This will afford maximum protection for the personnel operating the vehicle.

(e) OE with exposed hazardous fillers such as high explosives (HE), will be placed in appropriate containers with packing materials to prevent migration of the hazardous fillers. Padding should be added to protect the exposed filler from heat, shock, and friction.

OE Exclusion Zone Operations

On OE project sites, it is the responsibility of the UXOSO to establish the exclusion zone for each UXO team. This exclusion zone should not be confused with the safe separation distance that is maintained between teams.

(a) The purpose of the exclusion zone is for the protection of nonessential project personnel and the public from blast overpressure and fragmentation hazards. There are two criteria for calculating exclusion zones:

(1) Intentional Detonations. When destroying ordnance, both the hazards from fragmentation and overpressure must be considered. The minimum separation distances in DOD 6055.9-STD will also be used unless otherwise stated.

(2) Unintentional Detonations. If the identification of OE on an OE site is unknown, the minimum separation specified in DOD 6055.9-STD, Chapter 5, Paragraph C5.5.4, will be used to establish the exclusion zones.

(b) When multiple teams are working onsite, a safe separation distance will be established. The minimum distance maintained between teams will never be less than 200 ft, the K50 overpressure distance, or the lethal fragrant distance. The one that is greater will be used.

(c) While OE operations are being conducted, only personnel essential for the operation will be allowed in the exclusion zone. When nonessential personnel enter the exclusion zone, all OE operations will cease. In addition to this work stoppage, the following actions will be accomplished:

(1) The individuals must receive a safety briefing and sign the visitors' log prior to entering the zone.

(2) The individuals will be escorted by a UXO qualified individual.

(3) All OE operations will cease within the radius of the exclusion zone for the areas to be visited.

(d) All personnel working within the exclusion zone must comply with the following:

(1) There will be no smoking within the exclusion zone, except in areas designated by the UXOSO.

(2) There will be no open fires for heating or cooking within the exclusion zone, except where authorized by the UXOSO.

(3) During magnetometer operations, workers will have no metal parts in or on their shoes that would cause the magnetometer to present false indications.

OE Excavation Operations

(a) Hand excavation is the most reliable method for uncovering OE, provided the item is near the surface. Hand excavation exposes personnel to the hazard of detonation for longer periods of time than any other method. Taking this into consideration, only UXO qualified personnel will be used to accomplish this task.

(b) Earth-Moving Machinery (EMM) may be used to excavate overburden from suspected OE. EMM will not be used to excavate within 12 inches of a suspected OE. Once the EMM is within 12 inches of the OE, the excavation will be completed by hand excavation methods. Personnel who are not UXO qualified may operate EMM only when supervised by a UXO Technician III.

(1) If more than one EMM is to be used onsite, the same minimum separation distances required for multiple work teams applies.

(2) EMM operations will be conducted within the guidelines of HSE-32 “Excavations.”

(c) Excavation operations, whether by hand or EMM, will employ a step-down or offset access method. Under no circumstances will any excavation be made directly over the suspected OE.

OE Disposal Operations

To avoid MMR regulation, all demolition operations will be conducted on-range in accordance with TM/EODB 60A 1-1-31. Any deviation from this policy must be approved by the UXOSO and the Environmental Compliance Coordinator (ECC). The following are on-range disposal procedures.

(a) As a general rule, all demolition operations will be accomplished by use of shock tubing or electrical means to assure maximum safety. There are exceptions to this requirement in situations where static electricity of EMR hazards are present.

(b) The only acceptable disposal method is the one stated in the appropriate TM/EODB 60-series manual for specific ordnance types. Any commercial explosives being used will be equivalent to the military explosive required for the disposal operation.

(c) If a situation dictates, protective measures to reduce shock, blast overpressure, and fragmentation will be taken. The CH2M HILL EE&SBG UXOSO will assist in any design work and must review and approve all proposed protective works. As a minimum requirement, all demolition shots will be tamped with clean earth or sand. In accordance with DOD 6055.9-STD the following separation distances will be observed unless otherwise directed:

(1) Minimum separation distance for nonfragmenting explosive materials will be no less than 1,250 ft.

(2) Minimum separation distance for fragmenting explosive ordnance will be no less than 2,500 feet. For bombs and projectiles with a diameter of 5 inches or greater, use a minimum distance of 4,000 ft.

(3) Ordnance items with lifting lugs, strong backs, base plates, etc., will be oriented away from personnel, as fragments from these items tends to travel farther than normal.

(d) Once demolition operations are completed, a thorough search of the demolition area will be conducted with a magnetometer to ensure a complete disposal was accomplished.

(e) Inert ordnance will not be disposed of for scrap until the internal fillers / voids have been exposed and unconfined. Heat generated during the reclamation process can cause the inert fillers, moisture, or air to expand and burst the sealed casings. In this situation, Oil Well Perforators can be used for venting these ordnance items that require demilitarization.

(f) Inert ordnance to be disposed of as scrap may require certification by the UXOSO and a government representative. This may require further treatment by operation of a portable incinerator, depending on local requirements and acceptance criteria. The UXOSO and ECC will determine if certification and incineration is necessary, along with any permitting requirements during project planning.

4.2.8 OEW Disposal

When the used or fired munition is 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 that 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 the EE&SBG UXOSO, who is trained in the proper identification of waste ordnance items and meet the requirements for an "emergency response expert" under RCRA. In the event the OEW is regulated as hazardous waste, refer to the Hazardous Waste SOP, HSE-80 for RCRA hazardous waste management requirements.

TABLE 4-1
Waste Characterization

Item	Characterization	Waste Code
Uncontaminated Metal Debris	If visual inspection determines if item does not contain waste residue, 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
Contaminated Metal Debris	If visual inspection determines item contains hazardous waste residue, manage as potential hazardous waste.	Potential D003 and/or D008
Ordnance Items Less than 0.5 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 0.5 Caliber	Untreated UXO presumed to be reactive hazardous waste using generator knowledge under 40 CFR 261.23.	D003
Ordnance Items Greater than 0.5 Caliber w/Lead Projectiles	Ordnance containing lead projectiles will be presumed to be toxic hazardous waste under 40 CFR 261.24.	D008

Forms/Permits

(a) **Type-33 User of High Explosives License/Permit** issued by the BATF? is required for the purchase, storage, and use of HE in support of OE operations, construction projects, and demolition and disposal (D&D) projects. Written authorization designating the individuals who can purchase, store, or use explosives must be included in the site-specific work plans.

(b) **State and Local Explosive Permits** may be required for the purchase, storage, and use of HE in support of OE operations, construction projects, and D&D projects.

4.4 Self-Assessment Checklists

The "HS&E Self-Assessment Checklist—OE Operations" found in Attachment 2 is provided as a method of verifying compliance with established safe work practices, regulations, and industry standards pertaining to OE operations. CH2M HILL's project UXOSO/EE&SBG UXOSO shall use this checklist when: 1) CH2M HILL employees are potentially exposed to hazards associated with OE operations, and/or 2) CH2M HILL oversight of an OE subcontractor is required. The EE&SBG UXOSO shall specify the frequency in which this checklist shall be completed and provide this information in the project's written safety plan. Completed checklists shall be sent to the EE&SBG UXOSO for review. The EE&SBG UXOSO shall assist the Site UXOSO in resolving any deficiencies identified during the self-assessment.

Attachments

Attachment 1: Subcontractor Safety Procedure Criteria for OE Operations

Attachment 2: H&S Self-Assessment Checklist for OE Operations

ATTACHMENT 1

Checklists for Site-Specific Plans

Site-Specific Investigation-Derived Waste Plan Checklist

This checklist supplements the Master IDW Plan with site-specific information. Once completed for a specific project, it provides necessary IDW information for each investigation. It is to be taken into the field with the Master IDW Plan.

Site: _____

1. IDW Media: _____Soil cuttings
   _____Well development or purge water
   _____Decontamination residual soil and wastewater
   _____PPE or disposable equipment
   _____Other _____

2. Expected Regulatory Status: _____Hazardous
   _____Solid Waste
   _____Unknown
   _____Other _____

3. Site Location: _____

4. Nature of Contaminants Expected: _____Petroleum contamination
   _____Polyaromatic hydrocarbon
   _____Pesticides
   _____Herbicides
   _____PCBs
   _____Metals
   _____Other _____

5. Volume of IDW Expected: _____Drums
   _____Cubic Yards
   _____Tons
   _____Gallons

6. Compositing Strategy for Sample Collection:_____

7. IDW Storage
   _____As per Master IDW Plan _____Other_____

8. Waste Disposal
   _____As per Master IDW Plan _____Other_____

Site-Specific Quality Assurance Project Plan Checklist

This checklist supplements the Master QAPP with site-specific information. Once completed for a specific project, it provides necessary quality assurance information for each investigation. It is to be taken into the field with the Master QAPP.

Site: _____

1. List sampling tasks:

2. List data quality objectives:

3. Organization:

   LANTDIV IR Section Head _____
   LANTDIV Navy Technical Representative _____
   USEPA Remedial Project Manager _____
   VDEQ Federal Facilities Project Manager _____
   CH2M HILL Activity Manager _____
   Quality Control Senior Review _____
   Technical Project Manager _____
   Field Team Leader _____

4. Table of samples with analyses to be performed and associated QC samples (attached):

5. Analytical Quantitation Limits:
   _____As per Table 8-2 of Master QAPP _____Other (attached)

6. QA/QC Acceptance Criteria (e.g., precision, accuracy)
   _____As per Table 4-1 of Master QAPP _____Other (attached)

7. Data reduction, validation, and reporting:
   _____As per Section 9 of Master QAPP _____Other (attached)

8. Internal QC Procedures (field and laboratory):
   _____As per Section 10 of Master QAPP _____Other (attached)

9. Corrective Action:
   _____As per Section 14 of Master QAPP _____Other (attached)

10. Other deviations from Master QAPP _____

Site-Specific Field Sampling Plan Checklist

This checklist supplements the Master Field Sampling Plan with site-specific information. Once completed for a specific project, it provides necessary field sampling information for each investigation. It is to be taken into the field with the Master FSP.

Site:_____

1. Tasks to be performed:

_____Geophysical surveys
_____Soil gas surveys
_____Surface water and sediment sampling
_____Surface soil sampling
_____Soil boring installation
_____Subsurface soil sampling
_____Monitoring well installation and development
_____Monitoring well abandonment
_____Groundwater sampling
_____In-situ groundwater sampling
_____Aquifer testing
_____Hydrogeologic measurements
_____Biota sampling
_____Trenching
_____Land surveying
_____Investigation derived waste sampling
_____Decontamination
_____Other_____

2. Field measurements to be taken:

_____temperature
_____pH
_____dissolved oxygen
_____turbidity
_____specific conductance
_____organic vapor monitoring
_____geophysical parameters (list):
_____electromagnetic induction
_____ground-penetrating radar
_____surveying
_____magnetometry
_____global positioning system
_____soil gas parameters (list):
_____combustible gases
_____water-level measurements
_____pumping rate
_____other_____

3. Sampling program (nomenclature, etc.):

_____As per Section 3.1 of Master FSP
_____Other _____

4. Map of boring and sampling locations (attach to checklist):

5. Table of field samples to be collected:

6. Applicable SOPs (attach to checklist) or references to specific pages in Master FSP:

7. Site-specific procedures or updates to protocols established in the Master FSP:

_____

Site-Specific Health and Safety Plan

This checklist must be used in conjunction with the Master HASP. This checklist is intended for use by CH2M HILL employees only. All CH2M HILL employees performing tasks under this checklist must read and sign both this checklist and the Master HASP and agree to abide by their provisions (see EMPLOYEE SIGNOFF attached to the checklist.

Site:_____

Location(s)_____(reference attached map)

This document shall be maintained on site with the Master Health and Safety Plan. It will include as attachments from the Work Plan a site map and the site characterization and objectives for this site.

The procedures described in the Master Health and Safety Plan will be followed unless otherwise specified in this Site-Specific Health and Safety Plan.

1. HAZWOPER-Regulated Tasks

_____Test pit and excavation
_____Soil boring installation
_____Geoprobe boring
_____Geophysical surveys
_____Hand augering
_____Subsurface soil sampling
_____Surface soil sampling
_____Soil gas surveys
_____Sediment sampling
_____Monitoring well/drive point installation
_____Monitoring well abandonment
_____Groundwater sampling
_____Aquifer testing
_____Hydrologic measurements
_____Surface water sampling
_____Biota sampling
_____Investigation-derived waste (drum) sampling and disposal
_____Observation of loading of material for offsite disposal
_____Oversight of remediation and construction
_____Other_____

2. Hazards of Concern: (Check as many as are applicable. Refer to Section 3 of Master H&S Plan for control measures):

_____Heat stress
_____Cold stress
_____Buried utilities, drums, tanks
_____Inadequate illumination
_____Drilling
_____Heavy equipment
_____Working near water
_____Flying debris
_____Gas cylinders
_____Noise
_____Slip, trip, or fall hazards
_____Back injury
_____Confined space entry
_____Trenches, excavations
_____Protruding objects
_____Vehicle traffic
_____Ladders, scaffolds
_____Fire
_____Working on water
_____Snakes or insects
_____Poison ivy, oak, sumac
_____Ticks
_____Radiological
_____Other_____

3. Contaminants of Concern (List if known. Reduce Table 3.8 of the Master HASP to site-specific contaminants, add additional chemicals if necessary, and attach to this checklist):

_____ _____ _____

_____ _____ _____

4. Personnel (List CH2M HILL field team members and telephone numbers):

Field team leader(s) _____ _____

Site safety coordinator(s) _____ _____

Field team members _____ _____

_____ _____

5. Contractors/Subcontractors

_____Procedures as per Master HASP

_____Other_____

Name: _____ _____ _____

Contact:_____ _____ _____

Telephone:_____ _____ _____

6. Level of personal protective equipment (PPE) required:_____
Refer to Table 5.1 of Master HASP, CH2M HILL SOPs HS-07 and HS-08, and Respiratory Protection, Section 2 of the Site Safety Notebook.

7. Air monitoring instruments to be used:

_____PID _____FID

_____CGI _____Dust monitor

_____O_2

8. Decontamination procedures:

_____As per Section 7 of Master HASP

_____Other _____

9. List any other deviations or variations from the Master HASP:

10. Emergency Response (Check that all names and numbers are correct on page 47 of Master HASP and attach corrected page to this checklist)

11. Map to hospital (Highlight route to hospital from site and attach to this checklist)

12. Emergency Contacts (Check that all names and numbers are correct on page 49 of Master HASP and attach corrected page to this checklist)

13. Approval. This prepared site-specific checklist must be approved by John Longo/NJO or Laura Johnson/NJO or their authorized representative

    Name_____Title_____Date_____

14. Employee Signoff. All CH2M HILL employees working at the site must sign the attached Employee Signoff for the checklist as well as for the Master HASP.

_____Site

HASP Checklist Employee Signoff

The employees listed below have been given a copy of this health and safety plan checklist, have read and understood it, and agree to abide by its provisions.

EMPLOYEE NAME	EMPLOYEE SIGNATURE AND DATE

EMPLOYEE NAME	EMPLOYEE SIGNATURE AND DATE

Site-Specific Work Plan Checklist

This checklist supplements the Master Work Plan (WP) with site-specific information. Once completed for a specific project, it provides necessary quality assurance information for each investigation. It is to be taken into the field with the Master WP.

Site(s): _____

1. Discussion of site background, previous investigations, and previous analytical results:

2. Description of site-specific geology, topography, water table elevation, and local direction of groundwater flow:

3. Map illustrating the area of investigation in relation to the entire Base:

4. Discussion of the field investigation and activities to be performed at the site, including methods, locations, and types of drilling, sampling, and analyses to be performed:

5. Map illustrating boring, well, and sample locations:

6. Description of the feasibility study tasks to be performed at the site:

7. Explanation of staff organization and task order management:

8. Task order schedule:

ATTACHMENT 2

Standard Operating Procedures

STANDARD OPERATING PROCEDURE

Field Measurement of pH

I. Purpose

To provide a general guideline for field measurement of pH of groundwater samples.

II. Scope

The following general discussion applies to most commonly used pH meters but may differ between specific brands. The operator's manual should be consulted for specific calibration and operating procedures.

III. Equipment and Materials

- pH buffer solution for pH 4, 7, and 10
- Deionized water in squirt bottle
- pH meter
- Combination electrodes
- Beakers
- Glassware that has been washed with soap and water, rinsed twice with hot water, and rinsed twice with deionized water

IV. Procedures and Guidelines

A. Calibration

Calibrate unit prior to initial daily use and at least once every 4 hours or every five samples, whichever is less. Calibrate with at least two solutions. Clean probe according to manufacturer's recommendations. Duplicate samples should be run once every 10 samples or every 4 hours which ever is more frequent.

1. Place electrode in pH 7 buffer solution.
2. Allow meter to stabilize and then turn calibration dial until a reading of 7.0 is obtained.
3. Rinse electrode with deionized water and place it in a pH 4 or pH 10 buffer solution.

4. Allow meter to stabilize again and then turn slope adjustment dial until a reading of 4.0 is obtained for the pH 4 buffer solution or 10.0 for the pH 10 buffer solution.

5. Rinse electrode with deionized water and place in pH 7 buffer. If meter reading is not 7.0, repeat sequence.

B. Procedure

1. Before going out into the field:

   a) Check batteries.
   b) Do a quick calibration at pH 7 and 4 to check electrode.
   c) Obtain fresh solutions.

2. Calibrate meter using calibration procedure in the operators manual.

3. Pour the sample into a clean beaker.

4. Rinse electrode with deionized water between samples.

5. Immerse electrode in solution. Make sure the white KCl junction on the side of the electrode is in the solution. The level of electrode solution should be one inch above sample to be measured.

6. Recheck calibration with pH 7 buffer solution after every five samples.

C. General

1. When calibrating the meter, use pH buffers 4 and 7 for samples with pH < 8, and buffers 7 and 10 for samples with pH > 8. If meter will not read pH 4 or 10, something may be wrong with the electrode.

2. Measurement of pH is temperature dependent. Therefore, buffers temperatures should be within about 2 degrees C of sample temperatures. For refrigerated or cool samples, use refrigerated buffers to calibrate the pH meter.

3. Weak organic and inorganic salts and oil and grease interfere with pH measurements. If oil and grease are visible, note it on the data sheet. Clean electrode with soap and water and rinse with distilled water. Then recalibrate meter.

4. Following field measurements:

   a) Report any problems.
   b) Compare with previous data.
   c) Clean all dirt off meter and inside case.
   d) Store electrode in pH 4 buffer.

5. Accuracy and precision are dependent on the instrument used; refer to manufacturer's manual. Expected accuracy and precision are +/- 0.1 pH unit.

V. Key Checks and Items

- Check batteries
- Calibrate

VI. Preventive Maintenance

- Refer to operation manual for recommended maintenance.
- Check batteries, have a replacement set on hand.

STANDARD OPERATING PROCEDURE

Field Measurement of pH and Eh

I. Purpose and Scope

The purpose of this procedure is to provide a guideline for field measurement of pH and Eh.

II. Equipment and Materials

- pH buffer solution for pH 4, 7, and 10
- Deionized water in squirt bottle
- pH/Eh meter, calibration sheet, and instructions
- pH and redox electrodes
- Beakers
- Glassware that has been washed with soap and water, rinsed twice with hot water, and rinsed twice with deionized water
- 4 M KCl saturated with Ag/AgC1 solution, electrode filling solution.

III. Procedures and Guidelines

A. Calibration

Calibrate unit prior to initial daily use. There are no calibration procedures for the redox electrode. Calibrate with at least two solutions. Clean the probe according to the manufacturer's recommendations. Duplicate samples should be run once every 10 samples. The order of calibration solutions will be based on the instrument manufacturer's recommendation.

1. Place electrode in pH 7 buffer solution.
2. Allow meter to stabilize, and then turn calibration dial until a reading of 7.0 is obtained.
3. Rinse electrode with deionized water and place it in a pH 4 or pH 10 buffer solution.
4. Allow meter to stabilize again and then turn slope adjustment dial until a reading of 4.0 is obtained for the pH 4 buffer solution or 10.0 for the pH 10 buffer solution.

5. Rinse electrode with deionized water and place in pH 7 buffer. If meter reading is not 7.0, repeat sequence.

B. Procedure

1. Before going out into the field:

   a. Check batteries.
   b. Do a quick calibration at pH 7 and 4 to check electrode.
   c. Obtain fresh calibration solutions.
   d. Fill electrodes.

2. Calibrate meter using calibration procedure.

3. Pour the sample into a clean beaker.

4. Rinse electrode with deionized water between samples.

5. Immerse electrode in solution. Make sure the white KCl junction on the side of the electrode is in the solution. The level of electrode solution should be one inch above sample to be measured.

6. Recheck calibration with pH 7 buffer solution after every five samples.

C. General

1. When calibrating the meter, use pH buffers 4 and 7 for samples with pH <8, and buffers 7 and 10 for samples with pH >8. If meter will not read pH 4 or 10, something may be wrong with the electrode.

2. Measurement of pH is temperature dependent. Therefore, buffers temperatures should be within about 2 degrees C of sample temperatures. For refrigerated or cool samples, use refrigerated buffers to calibrate the pH meter.

3. Weak organic and inorganic salts and oil and grease interfere with pH measurements. If oil and grease are visible, note it on the data sheet. Clean electrode with soap and water and rinse with distilled water. Then recalibrate meter.

4. Following field measurements, report problems and compare with previous data. Clean dirt off meter and inside case and store electrode in pH 4 buffer.

5. Accuracy and precision are dependent on the instrument used; refer to manufacturer's manual. Expected accuracy and precision are +/- 0.1 pH unit.

6. The redox electrode should be checked prior to beginning site work and when anomalous readings suggest that the probe is malfunctioning. The procedure for checking the redox electrode is as below:

   a. Prepare solution A (0.1 M potassium ferrocyanide and 0.005 M potassium ferricyanide): weigh out 4.22 g reagent-grade

$K_4Fe(CN)_6 \cdot 3H_2O$ and 1.65 g reagent-grade $K_3Fe(CN)_6$. Place in a 100 ml volumetric flask. Add about 50 ml distilled water and swirl to dissolve solids. Dilute to volume with distilled water.

b. Prepare solution B (0.01 M potassium ferrocyanide, 0.05 M potassium ferricyanide, and 0.36 M potassium fluoride): Weigh out 0.42 g reagent-grade $K_4Fe(CN)_6 \bullet 3H_2O$ 1.65 g reagent-grade $K_3Fe(CN)_6$, and 3.39 g reagent-grade $KF \bullet 2H_2O$. Place in a 100 ml volumetric flask. Add 50 ml distilled water, and swirl to dissolve solids. Dilute to volume with distilled water.

c. Transfer solution A to a 150 ml beaker. Place electrode in the solution and wait until the reading stabilizes. The potential should be about 234 mV.

d. Rinse electrode and repeat the measurement with solution B. The potential should be about 66 mV greater in solution B than in solution A.

IV. Key Checks and Preventive Maintenance

- Check batteries, have a replacement set on hand.
- Calibrate meter.
- Refer to operation manual for recommended maintenance.

STANDARD OPERATING PROCEDURE

Field Measurement of Specific Conductance and Temperature

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for field measurement of specific conductivity and temperature of groundwater samples. The following general discussion applies to most commonly used meters but may differ between specific brands. The operator's manual should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Conductivity meter and electrode
- Distilled water in squirt bottle
- Standard potassium chloride (KCl) solution (0.01 N)

III. Procedures and Guidelines

A. Technical:

Detection limit = 1 µmho/cm @ 25°C; range = 0.1 to 100,000µmho/cm

B. Calibration:

Calibrate prior to initial daily use with standard solution. Check calibration throughout and at the end of the day. The standards should have different orders of conductance. Clean probe according to manufacturer's recommendations. Duplicates should be run once every 10 samples. Calibration procedure:

1. With mode switch in OFF position, check meter zero. If not zeroed, set with zero adjust.

2. Plug probe into meter.

3. Turn mode switch to red line and turn red line knob until needle aligns with red line on dial. If they cannot be aligned, change the batteries.

4. Immerse probe in 0.01 N standard KCl solution. Do not allow the probe to touch the sample container.

5. Set the mode control to TEMPERATURE. Record the temperature on the bottom scale of the meter in degrees C.

6. Turn the mode switch to appropriate conductivity scale (i.e., x100, x10, or x1). Use a scale that will give a midrange output on the meter.

7. Wait for the needle to stabilize. Multiply reading by scale setting and record the conductivity.

8. If the conductivity meter does not perform an automatic temperature adjustment, the conductivity may be adjusted to 25°C using the formula:

$$G_{25} = G_T / [1 + 0.02 (T - 25)]$$

Where:

G_{25} = conductivity at 25°C, µmho/cm

T = temperature of sample, degrees C

G_T = conductivity of sample at temperature T, µmho/cm

The table below lists the values of conductivity that the calibration solution would have if the distilled water were totally nonconductive; however, even water of high purity will possess a small amount of conductivity.

Temperature °C	**Conductivity (mmho/cm)**
15	1,141.5
16	1,167.5
17	1,193.6
18	1,219.9
19	1,246.4
20	1,273.0
21	1,299.7
22	1,326.6
24	1,380.8
26	1,436.5
28	1,490.9
30	1,546.7

9. Rinse the probe with deionized water.

C. Sample Measurement:

Pour the sample into a small beaker and place the probe in the sample. Note and record the reading. Rinse the probe with deionized water when done.

IV. Attachments

- Conductivity meter calibration sheet

V. Key Checks and Preventive Maintenance

- Check battery.
- Calibrate meter.
- Clean probe with deionized water when done.
- When reading results, note sensitivity settings.
- Refer to operations manual for recommended maintenance.
- Check batteries, and have a replacement set on hand.

CONDUCTIVITY METER CALIBRATION SHEET

			Instrument Readings		
Date	**Time**	**Analyst Initials**	**Uncalibrated @ EC=225**	**Calibrated @ EC=225**	**Comments**

STANDARD OPERATING PROCEDURE

Field Measurement of Dissolved Oxygen

I. Purpose

To provide general guidelines for the calibration and use of the Dissolved Oxygen (DO) meter.

II. Scope

The following general discussion applies to more commonly used meters but may differ between specific brands. The operator's manual should be consulted for specific calibration and operation procedures.

III. Equipment and Materials

- Operations manual
- A DO probe and readout/control unit with batteries
- Electrolyte solution (KCl dissolved in deionized water) and probe membrane

IV. Procedures and Guidelines

A. Calibration

Calibrate prior to initial daily use before any readings are taken. Clean probe according to manufacturer's recommendations.

1. Prepare DO probe according to manufacturer's recommended procedures using electrolyte solution.
2. In the off position, set the pointer to zero using the screw in the center of the meter panel.
3. Turn function switch to red line and adjust using red line knob until the meter needle aligns with red mark at the 31 degrees C position.
4. Turn function switch to zero and adjust to zero using the zero control knob.
5. Attach prepared probe and adjust retaining ring finger tight.
6. Allow 15 minutes for optimum probe stabilization (when meter is off or during disconnection of the probe).
7. For YSI meters, place probe in hollow stopper that is supplied for use with the YSI Calibration Chamber.

8. Place approximately 1/2 inch of deionized water into a 4-ounce, wide mouth screw cap bottle. Keep this bottle capped and with the DO meter.

9. Just before use, shake the bottle to saturate the water with air.

10. Remove cap, place probe in bottle keeping an air-tight seal around the rubber stopper. Swirl water around in the bottle while waiting for conditions to reach equilibrium.

11. Shield chamber from sun and wind to avoid temperature fluctuations during calibration.

12. Turn function switch to temperature and record temperature reading. Determine calibration factor for that temperature and altitude correction factor from tables supplied by manufacturer.

13. Multiply the calibration factor by the correction factor to get a corrected calibration value.

14. Turn function switch to appropriate ppm range and adjust the calibrate knob until the meter reads the corrected calibration value. Wait two minutes to verify calibration value. Re-adjust as necessary.

B. Procedure

1. Before going out into the field:

   a) Check batteries
   b) Obtain fresh electrolyte solution
   c) Prepare DO probe

2. Calibrate meter using calibration procedure.

3. Place probe in water to be measured. The probe should be moved through the water at 1 ft/sec or use a probe with a built-in stirrer.

4. Allow sufficient time for probe to stabilize to water temperature and DO. Record DO meter reading.

V. Attachments

DO Meter Calibration Sheet.

VI. Key Checks and Items

- Battery check
- Calibration

VII. Preventive Maintenance

- Refer to operation manual for recommended maintenance.
- Check batteries, have replacement set on hand.

DO METER
CALIBRATION SHEET

Date	Time	Analyst's Signature	Temp (C)	Alt. (ft)	Predict (ppm 0_2)	Actual (ppm 0_2)	Comment

STANDARD OPERATING PROCEDURE

Field Measurement of Alkalinity

I. Purpose

To provide general guidance for field measurement of alkalinity.

II. Scope

Standard method for determining alkalinity of groundwater and surface water samples. Alkalinity can be used to estimate the concentrations of carbonate, bicarbonate, and hydroxide.

III. Equipment

See attachment.

IV. Procedures and Guidelines

Alkalinity will be measured in the field late the same day that the samples are collected. Analyses will be performed on filtered samples, following the method listed in the attachment.

V. Attachments

Standard Methods for the Examination of Water and Wastewater 14 ed.; Method 403 - Alkalinity; published by the American Public Health Association, American Water Works Association, and the Water Pollution Control Federation; 1976.

STANDARD OPERATING PROCEDURE

Field Measurement of pH, Specific Conductance, Turbidity, Dissolved Oxygen, and Temperature Using the Horiba® U-10

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for using the Horiba® U-10 for field measurements of pH, specific conductance, turbidity, dissolved oxygen, and temperature of groundwater samples. The operator's manual should be consulted for detailed operating procedures.

II. Equipment and Materials

- Horiba® U-10 Water Quality Checker
- Distilled water in squirt bottle
- Horiba® U-10 Auto-Calibration Standard Solution

III. Procedures and Guidelines

A. Technical:

Parameter	Range of measurement
pH	0 - 14 pH
Specific Conductivity	0 - 100 mS/cm
Turbidity	0 - 800 NTU
Dissolved Oxygen	0 - 19.9 mg/l
Temperature	0 - 50 °C
Salinity	0 - 4 %

B. Calibration:

Calibrate prior to initial daily use with Horiba® Standard Solution. Clean probe and calibration beaker with deionized water. Calibration procedure:

1. Fill the calibration beaker to about 2/3 with the standard solution.
2. Fit the probe over the beaker. All the parameter sensors will now be immersed in the standard solution except the D.O. sensor; the D.O. calibration is done using atmospheric air.
3. Turn power on.

4. Press MODE key to put the unit in the MAINT mode. The lower cursor should be on the AUTO Sub-Mode; if it is not, use the MODE key to move the lower cursor to AUTO.

5. With the lower cursor on AUTO, press the ENT Key. The readout will display CAL. Wait a moment, and the upper cursor will gradually move across the four auto-calibration parameters one by one: pH, COND, TURB, and DO. When the calibration is complete, the readout will briefly show END and then switch to the MEAS mode. The instrument is now calibrated.

6. If the unit does not switch to the MEAS mode, and the readout displays either Er3 or Er4, an auto-calibration error has occurred. Parameters will blink where an error occurred (i.e. the pH will blink if the error occurred with the pH calibration). If this occurs re-do the auto-calibration. First, press the CLR Key to cancel the error code. Next, press the ENT Key to restart the auto-calibration. If the error message continues consult the operator's manual.

C. Sample Measurement:

If dissolved oxygen is being measured and the sample water is being pumped, a flow-through cell will be used for parameter measurement. The probe will be tightly sealed in the flow-through cell and the parameter measurements taken. Otherwise, pour the sample into a small beaker and place the probe in the sample. Note and record the reading. Rinse the probe with deionized water when done.

IV. Key Checks and Preventive Maintenance

- Calibrate meter.
- Clean probe with deionized water when done.
- When reading results, note sensitivity settings.
- Refer to operations manual for recommended maintenance.
- Check batteries, and have a replacement set on hand.

STANDARD OPERATING PROCEDURE

Close Support Laboratory Method for Analysis of Chlorinated Volatiles in Soil

I. Scope and Application

This method is proposed for field screening of soil and solid samples for chlorinated volatile hydrocarbons. It is presented as a means to rapidly characterize contamination in soil samples.

Application of this method is limited to screening analysis of soil for the target constituents listed in the field sampling plan. The chromatographic record produced in the analyses allows the site investigation team to examine the relative degree of soil contamination associated with other nontargeted compounds in the sample extracts. Positive identification and quantification of specific constituents will be supported by analyses of duplicate and other composited samples at a remote CLP laboratory employing EPA approved testing protocols.

Preliminary method validation data indicates analysis recoveries of upwards of 80 percent.

The method detection limits (MDL) for the target constituents are estimated to be 10 ug/kg. These estimates are the result of previous method development work.

II. Summary of Method

The methods presented here are loosely based on EPA Method 3550, sonification extraction, found in the EPA SW846, *Test Methods for Evaluating Solid Waste*, 3rd ed., November 1986. In brief, pentane is used in conjunction with sonification to effect extraction of the target constituents from the sample matrix. The extract is subsequently analyzed on a capillary gas chromatograph using an electron capture detector (ECD).

III. Interferences

Samples containing compounds that co-elute with the target constituents may cause a positive bias in the results.

The presence of compounds that closely match the retention times of the target constituents may result in false identifications.

The MDLs for the target constituents may be suppressed by baseline noise associated with samples having high levels of background organics or other interferences.

The response factors for uncalibrated peaks that are significantly different than those

of the target constituents may produce errors in the estimation of the total target constituent contamination.

IV. Safety

The target constituents are either identified as or suspected of being carcinogens. All samples are assumed to be hazardous. All stock and working calibration standards, as well as all samples, shall be handled with the utmost care using good laboratory techniques in order to avoid harmful exposure.

Lab analysts shall wear lab coats, safety glasses, and surgical gloves at all times when preparing and handling standards and field and lab samples.

Standards and samples shall be prepared in a fume hood.

Pentane (C_5H_{12}) is regulated by NIOSH. The suggested permissible exposure level (PEL) is 120 ppm with a ceiling level of 610 ppm. Exposure pathways are oral, dermal, and airway. Effects of short term exposure are drowsiness and irritation of eyes and nose, large doses may cause unconsciousness. Prolonged overexposure may cause irritation of the skin. The odor threshold of n-pentane is reported as 2.2 ppm. Pentane is highly flammable and is incompatible with strong oxidizing agents.

Sample extracts and standards prepared in flammable solvents shall be stored in a cooler (outside the laboratory).

All of the target compounds are reported in the NIOSH manual as having "good warning properties." Any situation which leads to or causes noticeable odors or produces any physical symptoms in the workers shall be investigated immediately followed by appropriate corrective action.

The ultrasonic sonicator used for sample extraction emits a high frequency sound. When in use, the sonicator horn shall be inside the sound chamber with the door closed.

Safety equipment including a fire extinguisher, first aid kit, eye wash, and chemical spill cleanup kit shall be available for use at all times.

Lab wastes shall be separated and properly disposed. The wastes include: used sample aliquots initial wash water, chemical wastes generated in the analysis, and disposables used in the preparation of the samples. These wastes shall be collected and deposited in a drum clearly marked as "CSL Lab Wastes Only--Hazardous." Water used for final rinsing of glassware will be considered nonhazardous and will be released into a 50 gallon drum. These wastes will then be disposed of in accordance with the appropriate and relevant disposal method.

V. Apparatus and Materials

Soil sampling equipment as described in the Quality Assurance Project Plan.

Volatiles sample vials (i.e., 40 ml capacity with septum screw caps).

Balance--Sartorius top loading electronic with 1,500 gram capacity with 0.01 gram sensitivity.

Glassware--class A volumetric pipets and flasks, beakers, vials, pasteur pipets, and miscellaneous glassware as necessary for preparation and handling of samples and standards.

Labware--necessary for preparation and handling of samples and standards.

Syringes--Hamilton glass type as required for injection of sample extracts and standards, preparation of dilutions, and spiking of samples.

Sonifier--Heat Systems Ultrasonic Sonicator with variable control up to 375 watt output and watercooled cup horn.

Gas chromatograph (GC)--Hewlett-Packard Model 5890A; temperature programming, electronic integration, report annotation, automatic sampler, 30-meter megabore capillary column (DB-1, 1.50 micron film thickness), and ECD.

VI. Chemicals, Reagents, and Gases

Pentane–spectro grade, 99.9 percent.

Sodium sulfate–reagent grade, anhydrous powder form.

Stock standards–prepare or purchase stand materials at approximately 1,000 mg/L in methanol.

Working standards–prepared from stock standards by precise dilution in pentane.

Nitrogen–carrier gas, prepuried grade.

VII. Calibration

External calibration–four-level calibration at approximately 10.0, 1.0, 0.1, and 0.01 µg/ml for the target constituents in pentane.

Working calibration–working calibration shall be performed with the analysis of each working day's lot of samples or with each lot of 20 samples, whichever is more frequent. Working calibration shall be verified by use of a mid-range standard mix. If the response factors and retention times vary by more than ± 15 percent or ± 0.10 minutes from the initial calibration, then recalibration shall be performed on freshly prepared working standards.

VIII. Sample Preparation and Extraction

Place a labeled vial on the top loading balance and record its tare weight. Add an aliquot of soil, approximately 5 grams to the vial and accurately record the soil sample weight to the nearest 0.01 grams.

Sample treatment: If the sample is wet or a highly consolidated material (i.e, clay),

then add about 2 grams of sodium sulfate and mix using a glass rod.

In a labeled VOA vial, volumetrically pipet 5.0 ml of pentane (Section 6.8) and record the volume added.

With the VOA vial cap tightly in place, sonicate at an output setting of 30 percent for approximately 5 minutes. The resulting sonicated sample should be dispersed throughout the pentane solvent and have a grain-like appearance. If not, then add an additional 1 gram of sodium sulfate and resonify. Repetitions of this process may be needed to properly extract some samples.

After sonication, let the VOA vial stand until the solids have settled. Using a pasteur pipet, transfer a suitable aliquot of the pentane solvent (extract) from the vial into a labeled GC auto-sampler vial and cap immediately with septum crimp seals. Refrigerate the sample extracts until analyzed.

IX. Analysis

Perform GC analysis on the extract.

If the analysis indicates that the results are more than 50 percent above the calibration range, dilute the sample extract such that concentrations fall within the calibration range.

Check the retention values for each of the target constituents against the expected (calibration) value. Flag those results where the retention time does not fall within ± 0.05 minutes of the expected value. Reject those results where the retention time does not fall with ± 0.10 minutes of the expected value.

Use the retention time marker as an indicator of the reliability of each sample injection and GC run. The retention time marker should fall within the same windows as the target constituents and should be within ± 15 percent area counts of its initial calibration value. If these criteria are not met, re-evaluate the data using relative retention times. Reruns should occur to resolve data suspicions.

X. Calculations

Quantification of the target compounds is based on the integrated areas of samples in comparison to the integrated areas of the calibration standards for each analyst. The integrator reports the concentrations in ug/ml in the extracts. Calculation of the concentration for each target constituent in the original sample on an as received basis is as follows:

conc. in ug/kg = ((A x Vt x DF)/Ws) x 1000

where:

A	=	amount of target constituent found in the extract in ug/ml
Vt	=	volume of solvent added to the VOA vial, 5.0 ml (Section 8.1)
DF	=	dilution factor, if required (Section 10.2)

1,000 = dimensional correction factor

Ws = weight of the sample added to the VOA vial in grams (Section 8.1)

XI. Quality Assurance

Quality assurance measures shall include as a minimum:

- Daily mid-range calibration checks performed prior to the analysis of each day's lot of samples or with each lot of 20 samples, whichever is more frequent.
- Analysis of field blank samples at a frequency of 1 in 20 samples analyzed or 1/day, whichever is more frequent.
- Analysis of laboratory blank samples at the same frequency. Should the results of the laboratory blanks show contamination, the cause of the contamination should be investigated and corrective action taken.
- Analysis of field duplicate samples at a frequency of 1 in 20 samples or 1/day, whichever is more frequent.
- Analysis of a mid-range matrix spike samples and a matrix spike duplicate at a frequency of 1 in 20 samples analyzed or 1/day, whichever is more frequent.
- Use of the retention time marker during the analysis of all samples and standards.

STANDARD OPERATING PROCEDURE

Close Support Laboratory Method for Analysis of Semivolatile Organics in Soil

I. Scope and Application

This method is proposed for field screening of soil and solid samples for volatile hydrocarbon parameters that are indicative of contamination at the site. It is presented as a means to rapidly characterize contamination in soil samples.

Application of this method is limited to screening analysis of soil for the target constituents listed in the field sampling plan. The chromatographic record produced in the analyses allows the site investigation team to examine the relative degree of soil contamination associated with other nontargeted compounds in the sample extracts. Positive identification and quantification of specific constituents, such as these constituents and other priority pollutants, will be supported by analyses of duplicate and other composited samples at a remote CLP laboratory employing EPA approved testing protocols.

Preliminary method validation data indicates analysis recoveries of upwards of 80 percent.

The method detection limits (MDL) for the target constituents are estimated to be 1 ug/gm. These estimates are the result of previous method development work.

II. Summary of Method

The methods presented here are loosely based on EPA Method 3550, sonification extraction, found in the EPA SW846, *Test Methods for Evaluating Solid Waste*, 3rd ed., November 1986 and "Screening of Semivolatile Organic Extracts" found in the *CLP Statement of Work* (*2/88*). In brief, methylene chloride is used in conjunction with sonification to effect extraction of the target constituents from the sample matrix. The extract is subsequently analyzed on a capillary gas chromatograph using a flame ionization detector (FID).

III. Interferences

Samples containing compounds that co-elute with the target constituents may cause a positive bias in the results.

The presence of compounds that closely match the retention times of the target constituents may result in false identifications.

The MDLs for the target constituents may be suppressed by baseline noise associated with samples having high levels of background organics or other interferences.

The response factors for uncalibrated peaks that are significantly different than those of the target constituents may produce errors in the estimation of the total target constituent contamination.

IV. Safety

The target constituents are either identified as or suspected of being carcinogens. All samples are assumed to be hazardous. All stock and working calibration standards, as well as all samples, shall be handled with the utmost care using good laboratory techniques in order to avoid harmful exposure.

Lab analysts shall wear lab coats, safety glasses, and surgical gloves at all times when preparing and handling standards and field and lab samples.

Standards and samples shall be prepared in a fume hood.

Methylene chloride ($MeCl_2$), used in the preparation of sample extracts, is regulated by OSHA and described in NIOSH/OSHA manual, Occupational Health Guidelines for Chemical Hazards, 1981. The $MeCl_2$ permissible exposure level (PEL) is 500 ppm in air over an 8 hour period. Its odor threshold is between 25 and 50 ppm. Exposure pathways are oral, dermal, and airway. Effects of short term exposure are reported to be mental confusion, light headedness, nausea, vomiting, and headaches. High concentrations may cause irritation of the eyes and respiratory tract. Prolonged exposure may cause skin burns. $MeCl_2$ is nonflammable.

Sample extracts and standards prepared in flammable solvents shall be stored in a cooler (outside the laboratory).

The ultrasonic sonicator used for sample extraction emits a high frequency sound. When in use, the sonicator horn shall be inside the sound chamber with the door closed.

Safety equipment including a fire extinguisher, first aid kit, eye wash, and chemical spill cleanup kit shall be available for use at all times.

Lab wastes shall be separated and properly disposed. The wastes include: used sample aliquots initial wash water, chemical wastes generated in the analysis, and disposables used in the preparation of the samples. These wastes shall be collected and deposited in a drum clearly marked as "CSL Lab Wastes Only–Hazardous." Water used for final rinsing of glassware will be considered nonhazardous and will be released into a 50 gallon drum. These wastes will then be disposed of in accordance with the appropriate and relevant disposal method.

V. Apparatus and Materials

Soil sampling equipment as described in the Quality Assurance Project Plan.

Volatiles sample vials (i.e., 40 ml capacity with septum screw caps); precleaned as purchased from a vender.

Balance–Sartorius top loading electronic with 1,500 gram capacity with 0.01 gram sensitivity.

Glassware–class A volumetric pipets and flasks, beakers, vials, pasteur pipets, and miscellaneous glassware as necessary for preparation and handling of samples and standards.

Labware–necessary for preparation and handling of samples and standards.

Syringes–Hamilton glass type as required for injection of sample extracts and standards, preparation of dilutions, and spiking of samples.

Sonifier–Heat Systems Ultrasonic Sonicator with variable control up to 375 watt output and water cooled cup horn.

Gas chromatograph (GC)–temperature programming, electronic integration, report annotation, automatic sampler, 30-meter megabore capillary column (DB-1, 1.50 micron film thickness), and FID.

Refrigerator/freezer–complete with locks as needed for storage and controlled access to samples and sample extracts.

VI. Chemicals, Reagents, and Gases

Methylene chloride--spectro grade, 99.9 percent.

Sodium sulfate--reagent grade, anhydrous powder form.

Stock standards--prepare or purchase stand materials at approximately 1,000 mg/L in $MeCl_2$.

Working standards--prepared from stock standards by precise dilution in pentane.

Nitrogen--carrier gas, prepurified grade.

Hydrogen--FID gas, pre-purified grade.

Air--FID gas, zero grade.

VII. Calibration

External calibration–four-level calibration at approximately 100, 10, and 1 ug/gm for the target constituents.

Working calibration–working calibration shall be performed with the analysis of each working day's lot of samples or with each lot of 20 samples, whichever is more frequent. Working calibration shall be verified by use of a mid-range standard mix. If the response factors and retention times vary by more than 15 percent or 0.10 minutes from the initial calibration, then recalibration shall be performed on freshly prepared working standards.

VIII. Sample Preparation and Extraction

In a labeled VOA vial, accurately weigh out approximately 5 grams of soil recording the weight to the nearest 0.01 gram. This should be done immediately after weighing to avoid potential losses of analytes.

Sample treatment: If the sample is wet or a highly consolidated material (i.e, clay), then add about 2 grams of sodium sulfate and mix using a glass rod.

To the sample vial, volumetrically pipet 5.0 ml of methylene chloride (Section 6.8) and record the volume added.

With the VOA vial cap tightly in place, sonicate at an output setting of 30 percent for approximately 5 minutes. The resulting sonified sample should be dispersed throughout the pentane solvent and have a grain-like appearance. If not, then add an additional 1 gram of sodium sulfate and resonify. Repetitions of this process may be needed to properly extract some samples.

After sonification, let the VOA vial stand until the solids have settled. Using a pasteur pipet, transfer a suitable aliquot of the pentane solvent (extract) from the vial into a labeled GC auto-sampler vial and cap immediately with septum crimp seals. Refrigerate the sample extracts until use.

IX. Analysis

Perform GC analysis on the extract.

If the analysis indicates that the results are more than 50 percent above the calibration range, dilute the sample extract such that concentrations fall within the calibration range.

Check the retention values for each of the target constituents against the expected (calibration) value. Flag those results where the retention time does not fall within 0.05 minutes of the expected value. Reject those results where the retention time does not fall with 0.10 minutes of the expected value.

Use the retention time marker as an indicator of the reliability of each sample injection and GC run. The retention time marker should fall within the same windows as the target constituents and should be within 15 percent area counts of its initial calibration value. If these criteria are not met, re-evaluate the data using relative retention times. Reruns should occur to resolve data suspicions.

X. Calculations

Quantification of the target compounds is based on the integrated areas of samples in comparison to the integrated areas of the calibration standards for each analyst. The integrator reports the concentrations in

ug/ml in the extracts. Calculation of the concentration for each target constituent in the original sample on an as received basis is as follows:

conc. in ug/gm = (A x Vt x DF)/Ws)

where:

A	=	amount of target constituent found in the extract in ug/ml
Vt	=	volume of solvent added to the VOA vial, 5.0 ml (Section 8.1)
DF	=	dilution faction, if required (Section 9.2)
Ws	=	weight of the sample added to the VOA vial in grams (section 8.1)

XI. Quality Assurance

Quality assurance measures shall include as a minimum:

- Daily mid-range calibration checks performed prior to the analysis of each day's lot of samples or with each lot of 20 samples, whichever is more frequent.
- Analysis of field blank samples at a frequency of 1 in 20 samples analyzed or 1/day, whichever is more frequent.
- Analysis of laboratory blank samples at the same frequency. Should the results of the laboratory blanks show contamination, the cause of the contamination should be investigated and corrective action taken.
- Analysis of field duplicate samples at a frequency of 1 in 20 samples or 1/day, whichever is more frequent.
- Analysis of a mid-range matrix spike samples and a matrix spike duplicate at a frequency of 1 in 20 samples analyzed or 1/day, whichever is more frequent.
- Use of the retention time marker during the analysis of all samples and standards.

STANDARD OPERATING PROCEDURE

Close Support Laboratory Method for Analysis of PCBs in Soil Using a GC-ECD

Target Constituents

Polychlorinatedbiphenyls (PCBs)

Sample Matrix

Soil

Sample Preparation

Hexane Extraction/Perchlorination

Instrumental/Physical Method

Automated Sampler/Gas Chromatography

Method of Detection

Electron Capture Detector

Detection Level

The method detection limits (MDL) for PCBs are estimated to be 100 ug/kg. In general, the detection level is a function of sample matrix, sample preparation, and instrument performance.

I. Scope and Application

This procedure may be used for screening soil samples for polychlorinated biphenyls (PCBs). This procedure is applicable to samples containing PCBs as single congeners or as complex mixtures such as weathered, intact, or mixtures of commercial Aroclors. The procedure is incapable of identifying the parent PCBs because the original PCBs are chemically converted to a common product, decachlorobiphenyl (DCB).

This method is prone to false positive interferences. Positive identification and quantification of specific constituents, such as individual Arochlors, should be supported by analyses of duplicate and other composited samples at a laboratory employing agency-approved or published testing protocols.

Preliminary method validation data indicate analysis recoveries of 90 percent.

The method detection limit (MDL) is estimated to be 100 ug/kg for PCBs.

II. Summary of Method

The soil extraction and analysis is based on EPA Method 508A, Screening for Polychlorinated Biphenyls by Perchlorination and Gas Chromatography.

III. Interferences

In addition to PCBs, several compounds (biphenyl, polyhalogenated biphenyls, hydrogenated biphenyls) will form DCB with varying yields when extracted and perchlorinated according to this procedure. If such compounds are present in the extract, false positive or positively biased data could be generated.

Samples containing compounds that co-elute with the target constituent may cause a positive bias in the results.

The presence of compounds that closely match the retention times of the target constituent may result in false identifications.

The MDLs for the target constituent may be suppressed by baseline noise associated with samples having high levels of background organics or other interferences.

IV. Safety

All stock and working calibration standards, as well as all samples, shall be handled with the utmost care using good laboratory techniques in order to avoid harmful exposure.

$SbCl_5$ is a corrosive reagent that reacts violently with water. This compound must be used with extreme caution. All operations involving the pure reagent must be performed in a hood.

Lab analysts shall wear lab coats, safety glasses, and vinyl gloves at all times when preparing and handling standards, field samples, and lab samples.

Standards and samples shall be prepared in a fume hood.

n-Hexane (C_6H_{14}) is regulated by NIOSH. The suggested Threshold Limit Value (TLV) is 50 ppm, and the Permissible Exposure Level (8-hour PEL) is 50 ppm. Exposure pathways are oral, dermal, and airway. Exposure is harmful and may be fatal. Overexposure may be irritating to the respiratory tract and, in high concentrations, narcotic. Hexane has a faint, peculiar odor. Hexane is highly flammable and is incompatible with active metals and strong alkaline solutions.

Safety equipment including a fire extinguisher, first aid kit, and eye wash shall be available for use at all times.

Lab wastes shall be separated and properly disposed. The wastes include: unused soil samples, sample extracts, unused reagents, small quantities of alcohol waste generated by standard preparations and syringe rinsing, and water for cleaning glassware. Unused soil samples are placed in CSL waste drums labeled specifically

for soil jars. Unused samples are held by the CSL for seven days before disposal. Sample extracts will be combined in a carboy labeled waste solvents, the solvent volume will be reduced under nitrogen, and finally disposed with the other site-related organic solvents. Unused reagents will be properly labeled and landfilled. Water used for final rinsing of glassware will be considered nonhazardous and will be either be disposed at the facility, or drummed and disposed with the decon water.

V. Apparatus and Materials

Soil sampling equipment–described in "Field Sampling Plan."

Glassware–class A volumetric pipets and flasks; beakers, vials, pasteur pipets, and miscellaneous glassware as necessary for preparation and handling of samples and standards.

Labware–necessary for preparation and handling of samples and standards.

Syringes–Hamilton glass type as required for injection of sample extracts and standards, preparation of dilutions, and spiking of samples.

Gas chromatograph (GC)–a temperature programmable oven operated from 150°C to 280°C with a 530uM 30M SPB-5 1.5uM capillary column, split/splitless inlet, and ECD.

Autosampler

Computer System–at least 486 25 MHZ, with accompanying monitor and printer. The computer must contain the following software: HP Chemstation, Windows, and Excel.

Laboratory fume hood, absorbing type is acceptable.

Top-loading analytical balance with 10 mg resolution and 200 gram capacity.

VI. Chemicals, Reagents, and Gases

Stock standards–Purchase standard materials at a concentration of approximately 2 mg/ml in methanol.

Working standards–prepared from stock standards by precise dilution in water.

Ultra Pure Carrier Grade Nitrogen–for use as makeup gas.

Ultra Pure Carrier Grade Helium--for use as carrier gas.

Antimony pentachloride–perchlorination reagent (>98%), distilled under vacuum.

Hexane-pesticide grade

Iron Power-analytical grade, ≥99.1% pure.

Sodium sulfate–ACS granular, anhydrous.

Hydrochloric Acid–reagent grade.

VII. Calibration and Standard Verification

Initial calibration–Five-level calibration at approximately 2, 4, 10, 25 and 60 mg/L for decachlorobiphenyl. These concentrations define the linear calibration range of the instrument.

The calibration curve should be validated by the analysis of a laboratory control sample (LCS). The LCS must be obtained from an independent, EPA authorized, second source. The LCS will verify the concentration of the standards used to obtain the initial calibration.

Continuing calibration–The continuing calibration standard (CCV) should be selected from the initial calibration standards, and it should be the standard that is closest to the mid point of the calibration range. The working calibration curve for each analyte must be verified daily by the analysis of a continuing calibration standard. The ongoing daily continuing calibration must be compared to the initial calibration curve to verify that the operation of the measurement system is in control. A day is defined as 24 hours from the start run time of the last valid continuing calibration.

For each analyte, calculate the percent difference of the continuing calibration from the initial curve using the following equation:

$$\% \ D = \frac{[\ RRF_m - RRF\ ] \ \_ \ 100}{RRF_m}$$

Where:

RRF_m = the mean response from the initial calibration curve

RRF = the daily response from the continuing calibration standard

The acceptance criterion for this screening method's continuing calibration is 40 percent D. If one of the target analytes that exceeded the 40 percent D criteria is detected in a sample, then a new calibration of the instrument must be performed for that target analyte, and the sample must be reanalyzed after a valid initial calibration is achieved. If the acceptance criteria are achieved, the calibration curve can be used to calculate the results of sample analyses.

Sample results for any target analyte can **only** be reported if the initial and continuing calibrations are valid.

Surrogate Recovery–Hexabromobiphenyl (HCB) shall be used as a surrogate. The surrogate compound shall be used as a retention marker. Retention time shifts greater than 0.2 minutes shall require corrective action.

Prepare secondary dilutions of the surrogate compound. This spiking solution must be added to all standards, blanks (except the instrument blanks), and samples. The surrogates must be at a concentration which provides a response similar to the response of the target analytes in the mid point standard used for continuing calibration.

Laboratory check standard (LCS)–The LCSs are to be obtained from the EPA or an EPA approved vendor. The LCSs must be prepared independently from the standards used for initial and continuing calibration standards.

Prepare and analyze a LCS at the beginning of each work day. For each parameter, calculate the percent recovery. All parameters in the LCS should be recovered within the precision requirements of the project (50 to 150 percent). If any parameter exceeds this criterion, then a new calibration curve should be established. Sample results for a target analyte can only be reported if the initial calibration of the instrument is valid.

VIII. Sample Preparation and Extraction

A. General

1. Log balance calibration with 0.10 gram, 1 gram and 10 gram standards.
2. Enter the samples to be prepared into the sample prep logbook.
3. Prelabel all sample vials using a permanent marker.
4. Record preparation for all BLKs, LCSs, CCVs, and samples in sample prep log book. Each page of the log book should contain the following columns; Lab #, sample wt. (gram), final volume (mL), dilution, Prep by, and Prep date.

B. Instrument blank preparation procedure

1. Prelabel an autosampler vial "IBLK-dateseq" (i.e., IBLK-082801). Assure from sample preparation log and standards log that the seq # is unique (i.e., If IBLK 0828-01 is already used name it IBLK 0828-02). Fill the autosampler vial three-quarters full with hexane, do not add the surrogate, cap, and inject onto the GC system as would occur with a field sample. **NOTE**: This sample is not passed through the extraction procedure.

C. Reagent blank preparation procedure

1. Prelabel centrifuge vial "RBLK-dateseq." Add 10 mL of hexane to the vial, add 10 µL of the surrogate solution (200 ug/mL HCB in hexane) with a syringe under the hexane surface and quickly cap the vial.

   Pass this sample through the entire procedure as if it was a field sample.

D. Laboratory control sample (LCS) preparation procedure

1. Prelabel a centrifuge vial "LCS-dateseq." Weigh approximately 1 gram of control sample matrix into the vial, add 5 uL of LCS solution by placing syringe needle under soil and dispensing solution. Quickly add 10 mL hexane and 10 uL of surrogate. Quickly cap vial.

   Pass this sample the entire procedure as if it was a field sample.

E. Continuing calibration verification standard preparation procedure

1. Prelabel a centrifuge vial "CCV-dateseq." Add 10 mL hexane, 10 uL surrogate, and quickly add 20 uL of the spiking standard (a 50 ug/mL mixture of PCB 1254 and 1260 in hexane). Quickly cap vial.

   Pass this sample through the entire procedure as if it was a field sample.

F. Method blank preparation procedure

1. Prelabel HS vial "MBLK-dateseq." Weigh 1 gram of control soil sample into a centrifuge vial. Add 10 mL of hexane to vial, add 1 gram of sodium sulfate, add 10 uL of surrogate solution (200 ug/mL HCB in hexane) with syringe under the hexane surface. Quickly cap.

   Pass this sample the entire procedure as if it was a field sample.

G. Matrix spike/matrix spike duplicate preparation procedure

1. Weigh approximately 1 gram of sample into a prelabeled centrifuge vial. Attempt to use the same weight of sample as used for the non-spiked sample.

2. Add 20 ul of the spiking standard solution by placing syringe needle under the soil surface and dispensing solution. Quickly add 10 mL of hexane and 10 uL surrogate. Quickly cap vial.

   Pass this sample through the entire procedure as if it was a field sample.

H. Field Sample

1. Accurately weigh approximately 1 g of soil into a centrifuge tube containing 1 g of sodium sulfate, conditioned at 400°C for 4 hours.

2. Add 10 ml of pesticide grade hexane 10 ul of surrogate solution, and shake/vortex for 1 minute. Allow the sodium sulfate and soil to settle to the bottom.

3. Transfer a 300 ul aliquot to a 13 mm x 100 mm tube and reduce under dry nitrogen to approximately 10-25 ul.

4. Immediately, and rapidly add 0.2 ml of distilled animony pentachloride and cap the tube. The sample should remain light yellow after this addition, but if the sample turms dark brown or black, it must be discarded and another aliquot of that sample used.

5. Place the samples in a 160°C sand bath for three hours. Remove from the bath and cool to room temperature.

6. To each sample add dropwise 0.5 ml of 20% hydrochloric acid. This mixture is then extracted 3 times with 3 ml of n-hexane. Each extract

is passed through a funnel containing approximately 0.5 g of anhydrous sodium sulfate into a 10 ml volumetric flask.

7. If the sample is obviously contaminated and experience has shown similar extracts to contain high levels of contamination, it is recommended that a preliminary dilution be prepared to avoid grossly contaminating the gas chromatograph.

IX. Analysis

Perform GC analysis on the extract using the instrument conditions similar to those listed in Attachment 1.

If the analysis indicates that the results are more than 50 percent above the calibration range, prepare a dilution of the sample to yield concentrations that fall within the calibration range.

Check the retention times for decachlorobiphenyl against the expected (calibration) value. Reject those results where the retention time does not fall with 0.2 minutes of the expected value.

X. Calculations

Quantification of the target compounds is based on the integrated areas of the samples in comparison to the integrated areas of the calibration standards for each analysis. The integrator reports the concentrations in points per billion (ppb) in the extracts. Calculation of the concentration for total PBCs in the original sample is as follows:

$$\text{Conc. in ug/kg} = \frac{A \times Vt \times 33.33 \times DF}{Ws}$$

Where:

A	=	Amount of target constituent found in ug/l.
Vt	=	Volume of the hexane in liters.
Ws	=	Weight of the sample added in kilograms.
33.33	=	Dilution factor of 0.3 ml aliquot brought to 10 ml.
DF	=	Dilution Factor if required.

XI. Quality Assurance

Quality assurance measures shall include as a minimum:

- Daily continuing calibration performed before the analysis of each day's samples. The linear calibration range of the instrument must be determined before the analysis of any samples. The instrument must be calibrated using the same instrument conditions that are used to analyze the samples. Prepare groundwater calibration standards at a minimum of five concentration levels for each parameter analyzed. The concentrations of the

standards should bracket the linear range of the instrument. The CCV recovery shall recover within 50% and 150% of known concentration. If these limits are exceeded the instrument shall be reinitial calibrated.

- Daily LCS performed before the analysis of each day's samples. The instrument calibration must be confirmed with a LCS before the analysis of any samples. This sample must be analyzed using the same instrument conditions that are used to analyze the samples. If the LCS recoveries are less than 50% or greater than 150%. If these limits are exceeded the instrument shall be reinitial calibrated.

- Daily analysis of an instrument blank, performed before the analysis of each day's samples. If the results of the instrument blank show contamination, the cause of the contamination should be investigated and corrective action taken.

- Daily analysis of a reagent blank, performed before the analysis of each day's samples. If the results of the reagent blank show contamination, the cause of the contamination should be investigated and corrective action taken.

- Analysis of a method blank. A method blank is to be performed at a frequency of one in 20 samples of the same matrix. A method blank must contain no greater than five times the stated MDL of blank contaminants. For all other volatile compounds, the method blank must contain less than the stated detection limit. If the method blank exceeds these criteria, the laboratory must consider the analytical system out-of-control. Appropriate corrective actions must be taken and documented before further sample analysis.

Contamination by carryover can also occur when high-level and low-level samples are analyzed in sequence. To reduce the possibility of carryover, disposable headspace vials are used only once and only after being baked at 70-85°C and samples are weighed directly into the headspace vials. Also, frequent baking and purging of the entire system may be required. For samples thought to contain high concentrations of any volatile analyte, an organic free water blank should be analyzed immediately afterwards to verify that the analytical system is clean before the analysis of other samples. All sample analytical results following a high level sample must be examined for the possibility of carryover. If target analytes are found in the samples that are common to a previously analyzed high sample, the samples may be re-analyzed after it is demonstrated that the analytical system is clear by analysis of blanks. Method blanks are tested immediately after matrix spikes to demonstrate that the system is not prone to carryover.

The results of blank analyses must be reviewed before results for samples are reported. The blank results should not be subtracted from the sample analytical results.

- Surrogate recoveries from every sample will be calculation, if surrogate recoveries are less than 50% or greater than 150% the sample will be reanalyzed.
- Analyses of mid-range matrix spike and matrix spike duplicate samples at a frequency of one in 20 samples of the same matrix. If MS/MSD recoveries are less than 50% or greater than 150% the samples associated with this data set will be qualified as estimated and flagged with a "J" on the results spreadsheet.

STANDARD OPERATING PROCEDURE

Field Measurement of Mercury Vapor Using the Jerome 411® Mercury Vapor Analyzer

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for using the Jerome 411® Mercury Vapor Analyzer for field measurements of mercury vapor. The operator's manual should be consulted for detailed operating procedures.

II. Equipment and Materials

- Jerome 411® Mercury Vapor Analyzer
- Probe and Tubing Adapter
- Trimmer Tool
- Zero Air Filters
- Battery Charger
- Battery Pack

III. Procedures and Guidelines

A. Technical:

Detection Range: 0.000 to 1.999 mg/m^3
Sensitivity : 0.003 mg/m^3
Accuracy : +/- 5% @ 0.107 mg/m^3

B. Calibration:

The Jerome 411 is factory calibrated and guaranteed for one year.

C. Operational Test procedure:

Before each day's use the following steps must be taken to verify that the unit is operational.

1. Press power ON. The digital meter will display .000. If LO BAT indicator remains on press OFF and replace with a fully charged battery.
2. Perform a FILM HEAT
   a) Insert a zero air filter in the instrument's intake and tighten the intake tube nut to ensure an airtight seal.
   b) Attach the line cord to the 411 and plug into a 115-120 VAC outlet.
   c) Connect the battery charger to the 411 and plug into a VAC outlet.
   d) Press power ON.

e) Press FILM HEAT. The digital meter flashes .H.H.H for the duration of the 15-minute cycle. *Once this procedure is initiated do not interrupt*

f) Press SENSOR STATUS and hold down. Adjust the BRIDGE BALANCE using the trimmer tool until the digital meter reads greater than 02, or less than 06.

g) Press power OFF.

h) Disconnect the battery charger.

i) Disconnect the line cord.

j) Remove the zero air filter.

k) The Jerome 411 is now ready for sampling

D. Sample Measurement:

1. Press SENSOR STATUS. The digital meter displays the percent of mercury saturation of the sensor. The SENSOR STATUS must be between 01 and 99 for the instrument to operate. Consult the operating manual for the adjustment procedure.

2. Press SAMPLE. The digital meter counts up 9 seconds , as indicated by E01 through E09. At the end of the cycle, the digital meter displays the level of mercury present in the air.

3. Repeat these two steps when sampling new locations.

IV. Key Checks and Preventive Maintenance

- Insure battery is fully charged.
- Perform FILM HEAT before each day's use.
- Refer to operations manual for recommended maintenance.

STANDARD OPERATING PROCEDURE

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.

OVA, Organic Vapor Analyzer

1. Introduction

   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.

2. Operational Checks

   - See OVA Operators Manual included with instrument.

3. Calibration

   - See OVM Operators Manual included with instrument.

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

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.

OVM, Organic Vapor Monitor

1. Introduction

   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.

2. Operational Checks

   - See basic operating instructions in operations manual.

3. Calibration

   - See basic operating instructions in operations manual.

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.

STANDARD OPERATING PROCEDURE

Field Measurement of Organic Vapors Using an HNU

I. Purpose

To provide general guidelines for the calibration and use of the HNU photoionization detector.

II. Scope

This is a broad guideline for the field use of an HNU. For specific instructions, refer to the operations manual.

III. Equipment and Materials

- Operations manual
- An HNU readout/control unit and photoionization probe (either 10.2 or 11.7 eV depending on requirements) with fully charged battery pack
- Charging unit
- A cylinder of calibration gas, typically 100 ppm isobutylene in air
- A regulator for the calibration gas cylinder
- A short length of 1/8th-inch tube to transfer calibration gas from the cylinder to the HNU probe (as short as possible)

IV. Procedures and Guidelines

ONLY PROPERLY TRAINED PERSONNEL SHOULD USE THIS INSTRUMENT. FOR SPECIFIC INSTRUCTIONS, SEE OPERATIONS MANUAL.

A. CALIBRATE THE HNU

1. Identify the probe by lamp model.
2. Connect the sensor/probe to the readout/control unit.
3. Perform a battery check by turning the function switch to "Batt."
4. Turn function switch to "Standby" and set the readout to zero by turning the zero knob.
5. Hold the sensor/probe to your ear to verify that it is powered. A faint humming sound will be heard.
6. Set the range to the appropriate setting.

7. Connect the tube from the calibration gas cylinder to the end of the probe and open the valve on the calibration gas cylinder.

8. Sample the calibration gas and adjust to the proper reading with the span control knob.

9. If calibration cannot be achieved, disassemble the sensor/probe assembly and clean lamp. If the span knob setting is at the end of the span range, unit must be serviced by qualified personnel.

B. SAMPLING WITH THE HNU

1. Once calibration is complete, unit is ready for sampling. When not in use, set function knob to ``Standby.”

2. When done for the day, turn unit off and disconnect the sensor/probe.

3. Charge the battery overnight (complete recharge takes 14 hours).

4. For preventive maintenance, refer to instruction manual.

V. Attachments

HNU calibration sheet

VI. Key Checks and Items

- Check battery.
- Zero and calibrate.
- Verify sensor probe is working.
- Recharge unit after use
- Select the probe suitable for the monitoring required.

VII. Preventive Maintenance

A complete preventive maintenance program is beyond the scope of this document. For specific instructions, refer to the operations manual. Some key items are discussed below:

- A complete spare HNU should be available on site whenever field operations require this instrument.
- A spare lamp should be on hand so a defective unit can be changed without returning the unit.
- Occasional cleaning of the lamp should be performed as needed.
- Charge batteries daily.
- Occasionally allow the batteries to totally discharge before recharging to prevent battery memory from occurring.

HNU Calibration Sheet

Date	Time	Analyst Initials	Uncalibrated @ 10 ppm	Calibrated @ 10 ppm	Comments

STANDARD OPERATING PROCEDURE

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 ersonnel. 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

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.

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.

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

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

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

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

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 manometers (=); 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 minutes 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/M3, 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

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). 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.

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.

STANDARD OPERATING PROCEDURE

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
- Vermiculite
- 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 rooves, 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 an OVM 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 Decon.

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

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

V. Attachments

None.

VI. Key Checks and Items

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

STANDARD OPERATING PROCEDURE

Soil Boring Drilling and Abandonment

I. Purpose and Scope

The purpose of this guideline is to describe methods to obtain samples of subsurface 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 barge-mounted 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 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.

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.

If the split-spoon sampling is to be advanced with a 3.25-inch ID, 8.25-inch outside diameter (O.D.) HSA, the surface casing will require a minimum 10.25-inch surface casing. The casing would be installed using a 14.25-inch I.D. HSA. Alternatively, the split-spoon sampling may be advanced with mud-rotary drilling, which would require a only a 6.25-inch I.D. surface casing and a 10.25-inch I.D. HSA.

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.

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 and Thin-Walled Tube.*

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 are 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

ASTM D 1587

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.

STANDARD OPERATING PROCEDURE

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

Logging of Soil Borings

I. Purpose and Scope

This SOP provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

II. Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCl, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart (e.g., Munsell)
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification

III. Procedures and Guidelines

This section covers several aspects of the soil characterization: instructions for completing the CH2M HILL soil boring log Form D1586 (attached), field classification of soil, and standard penetration test procedures.

A. Instructions for Completing Soil Boring Logs

Soil boring logs will be completed in the field log books. Information collected will be consistent with that required for Form D1586 (attached), a standard CH2M HILL form or an equivalent form that supplies the same information.

The information collected in the field to perform the soil characterization is described below.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both jar lids and labels and on the log sheets.

B. Heading Information

Boring/Well Number. Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.

Location. If stationing, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.

Logger. Enter the first initial and full last name.

C. Technical Data

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1 foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record recovery in feet.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A

partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons.

Sample also may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. However, use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection of samples using either a 3-inch split-spoon, or a 300-pound hammer. An "N" value need not be calculated.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection below. `

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

D. Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils (attached).

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests (ASTM D 2487). It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488). In addition, some elements of a complete soil description, such as the presence of cobbles or boulders, changes in

strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example "POORLY-GRADED SAND."
2. Group symbol, in parentheses, for example, "(SP)."
3. Color, using Munsell color designation
4. Moisture content
5. Relative density or consistency
6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488.

E. Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488.

F. Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

G. Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

H. Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 2.

I. Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in tables 3 and 4.

J. Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

K. Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586. The split-barrel sampler should measure 2-inch or 3-inch O.D., and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is "A" rod (1-5/8-inch O.D.). A stiffer rod, such as an "N" rod (2-5/8-inch O.D.), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

IV. Attachments

Soil Boring Log, CH2M HILL Form D1586, and a completed example

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

Tables 1 through 5

V. Key Checks and Preventive Maintenance

Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later. Check that sample numbers and intervals are properly specified. Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP *Decontamination of Drilling Rigs and Equipment*.

STANDARD OPERATING PROCEDURE

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.

STANDARD OPERATING PROCEDURE

Soil Gas Sampling Surveys

I. Purpose

The purpose of this SOP is to describe the methods and procedures involved in conducting a soil gas survey.

II. Scope

The methods described in this SOP are applicable to the detection of groundwater and soil contamination, determining the extent of the contamination, and identifying the source(s) of contamination. Soil gas monitoring provides a quick means of waste site evaluation. Using this method, underground contamination can be identified, and the source, extent, and movement of the pollutants can be traced.

III. Definitions

Dynamic Device - A method whereby soil gas samples are extracted through a hollow steel tube using a vacuum extraction pump.

Passive Device - A method where adsorption devices are implanted in the shallow surface soils. These are left in place for days or weeks. After a set time, the devices are dug out and sent out for analysis.

Direct Connection - The direct transfer of soil gas into the on-site gas chromatograph (GC) via a vacuum pump.

Syringe - Device used to transfer the soil gas sample into the GC.

Gas Bulbs/Bags - Devices to hold soil gas samples prior to analysis.

IV. Responsibilities

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or other approval methods are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the specific sampling techniques and equipment to be used, and documenting these in the Sampling and Analysis Plan. 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.

Sampling Personnel - It is the responsibility of the field 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 acquisition of soil gas samples.

V. Procedures

Prior to selecting sample locations, an underground utility search is recommended. The local utility companies or Base utility personnel can be contacted and requested to mark the locations of their underground lines. Sampling plans/designs can then be drawn up accordingly.

Typical methodology involves the insertion of (3/8-inch diameter) probes into the ground to a desired depth via a hydraulic pusher/puller mechanism. A 1/4-inch O.D. stainless steel probe is inserted into the hole and sealed at the top around the probe. The gas contained in the interstitial spaces of the soil is sampled by pulling the sample through the probe using an air sampling pump.

Attachment A is a generalized SOP including quality control procedures performed by soil gas survey firms. The methods and procedures described herein are typical for this type of subsurface investigation.

Some soil gas firms have the ability to collect and analyze groundwater samples using the probe apparatus in a manner similar to collecting soil gas samples. Specific project requirements are documented in the site-specific work plan.

VI. Quality Assurance Records

Quality assurance records will vary between soil gas survey firms. Ordinarily QA/QC records accompany soil gas survey firm reports in the form of spike or blank results from analysis of "Field QA Samples" prepared and analysis, as required under each individual project. Project plans should include QA/QC specific requirements for the soil gas or in situ groundwater sampling program.

VII. Attachment

Generalized Soil Gas Sampling Standard Operating Procedure – Soil Gas Sampling Procedure

VIII. References

1. Schuring, D. C. "Soil Gas Testing," *Hazmat World*. Tower-Borner Publishing, Inc, Glen Ellyn, Illinois. August 1989.

2. La Fond, J. W. "EmFlux Soil Gas Survey." Quadrel Services, Inc., Jamsville, Maryland. July 30,1991.

3. Tillman, J. E., Ranlet, K. B., and Meyer, T. J. "Soil Gas Sample Collection Procedures." Target Environmental, Columbia, Maryland. June 20,1991.

4. Marrin, D. L. and Kerfoot, H. B. "Soil Gas Surveying Techniques for Subsurface Volatile Organic Contaminants." *Environmental Science and Technology*, Volume 22,1988.

5. Tillman, J. E., Ranlet, K. B., and Meyer, T. J. "Advanced Soil Gas Surveys and Their Application to Hazardous Waste Management." Haztech Conference, Cleveland, Ohio. 1988.

6. Roy, K. A. "Understanding Soil Gas Velocity Leads to New Sampling Technique." *Hazmat World*, Tower-Bomer Publishing, Inc, Glen Ellyn, Illinois. December 1989.

7. Tracer Research Corporation. *Sampling Procedures and QA/QC Procedures*. 1991.

STANDARD OPERATING PROCEDURE

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 (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 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.

ATTACHMENT A

Generalized
Soil Gas Survey Standard Operating Procedure
Soil Gas Sampling Procedure

I. Probe Placement

A. A clean probe (pipe) is removed from the "clean" storage tube.

B. The soil gas probe is placed in the jaws of hydraulic pusher/puller mechanism.

C. A sampling point is put on the bottom of the probe.

D. The hydraulic pushing mechanism is used to push the probe into the ground.

E. If the pusher mechanism will not push the probe into the ground a sufficient depth for sampling, the hydraulic hammer is used to pound the probe into the ground. Please note that concrete cutting may be required prior to probe placement pending sampling point location.

II. Sample Extraction

A. An adaptor is put onto the top of the soil gas probe.

B. The vacuum pump is hooked onto the adaptor.

C. The vacuum pump is turned on and used to evacuate soil gas.

D. Evacuation will be at least 30 seconds but never more than 5 minutes for samples having evacuation pressures less than 15 inches of mercury. Evacuation times will be at least 1 minute, but no more than 5 minutes for probes reading greater than 15 inches of mercury.

E. Gauges on the vacuum pump are checked for inches of mercury.

1. Gauge must read at least 2 inches of mercury less than maximum vacuum to be extracting sufficient soil gas to collect a valid sample.

III. Sample Collection

A. With vacuum pump running, a hypodermic syringe needle is inserted through the silicone rubber and down into the metal tubing or adaptor.

B. Gas samples should only contact metal surfaces and never contact potentially sorbing materials (i.e., tubing, hose, pump diaphragm).

C. The syringe is purged with soil gas then, without removing syringe needle from adaptor, a 10 mL soil gas sample is collected.

D. The syringe and needle are removed from the adaptor and the end of the needle is capped.

E. If necessary, a second 10 mL sample is collected using the same procedure.

IV. Deactivation of Sampling Apparatus

A. The vacuum pump is turned off and unhooked from the adaptor.

B. The adaptor is removed and stored with equipment to be cleaned.

C. Using the hydraulic puller mechanism, the probe is removed from the ground.

D. The probe is stored in the "dirty" probe tube.

E. The probe hole is backfilled, if required.

V. Log Book Notations for Sampling

A. Time (military notation)

B. Sample number

C. Location (approximate description - i.e., street names)

D. Sampling depth

E. Evacuation time before sampling

F. Inches of mercury on vacuum pump gauge

G. Probe and adaptor numbers

H. Number of sampling points used

I. Observations (i.e., ground conditions, concrete, asphalt, soil appearance, surface water, odors, vegetation, etc.)

J. Backfill procedure and materials, if used

VI. Other Recordkeeping

A. Data sheets are filled out, if required

B. Sample location is marked on the site map

Note:

Typical soil gas/in situ groundwater sampling investigations include a report of results from the soil gas survey. Report format and content may vary; however, project specific requirements (i.e., recordkeeping/documentation) should be identified and confirmed prior to onsite operations.

V. Key Checks and Items

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

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

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

STANDARD OPERATING PROCEDURE

Surface Water Sampling

I. Purpose and Scope

This procedure presents the techniques used in collecting surface water samples. Materials, equipment, and procedures may vary; refer to the Field Sampling Plan and operators manuals for specific details.

II. Materials and Equipment

Materials and equipment vary depending on type of sampling; the Field Sampling Plan should be consulted for project-specific details.

- Open tube sampler
- Dip sampler
- Weighted bottle sampler
- Hand pump
- Kemmerer or Van Dorn sampler
- Depth-integrating sampler
- Sample containers
- Meters for specific conductance, temperature, pH, and dissolved oxygen

III. Procedures and Guidelines

Before surface water samples are taken, all sampler assemblies and sample containers are cleaned and decontaminated as described in SOP Decontamination of Personnel and Equipment. Methods for surface water sample collection are described below.

A. Manual Sampling

Surface water samples are collected manually by submerging a clean glass, stainless steel, or Teflon container into the water body. Samples may be collected at depth with a covered bottle that can be removed with a tripline. The most common sampler types are beakers, sealable bottles and jars, pond samplers, and weighted bottle samplers. Pond samplers have a fixed or telescoping pole attached to the sample container. Weighted bottle samplers are lowered below water surface, where the attached bottle is opened, allowed to fill, and pulled out of the water. When retrieved, the bottle is tightly capped and removed from the sampler assembly. Specific types of weighted bottle samplers include dissolved oxygen, Kemmerer, or Van Dorn, and are acceptable in most instances.

A sample is taken with the following specific steps:

1. The location and desired depth for water sampling are selected.
2. The sample site is approached from downstream in a manner that avoids disturbance of bottom sediments as much as possible. The sample bottle is gently submerged with the mouth pointed upstream and the bottle tilted slightly downstream. Bubbles and floating materials should be prevented from entering the bottle.
3. For weighted bottle samplers, the assembly is slowly lowered to the desired depth. The bottle stopper is unseated with a sharp tug and the bottle is allowed to fill until bubbles stop rising to the surface.
4. When the bottle is full, it is gently removed from the water. If sample transfer is required, it should be performed at this time.
5. Measure dissolved oxygen, specific conductance, temperature, and pH at the sampling location.

IV. Attachments

None.

V. Key Checks and Items

- Start downstream, work upstream
- Log exact locations using permanent features
- Beware of hidden hazards

STANDARD OPERATING PROCEDURE

Sediment Sampling

I. Purpose

These general outlines describe the collection and handling of sediment samples during field operations.

II. Scope

The sediment sampling procedures generally describe the equipment and techniques needed to collect representative sediment samples. Operators manual , if available, should be consulted for specific details

III. Equipment and Materials

- Sample collection device (hand corer, scoop, dredge, grab sampler, or other suitable device)
- Stainless steel spoon or spatula for media transfer
- Measuring tape
- Log book
- Personal protection equipment (rubber or latex gloves, boots, hip waders, etc.)
- Materials for classifying soils, particularly the percentage of fines
- Sample jars, including jars for Total Organic Carbon and pH, as appropriate

IV. Procedures and Guidelines

1. Field personnel will start downstream and work upstream to prevent contamination of unsampled areas.
2. Make a sketch of the sample area showing 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 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 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

None.

VI. Key Checks and Items

- Start downstream, work upstream.
- Log exact locations using permanent features.
- Beware of hidden hazards.

STANDARD OPERATING PROCEDURE

Flat Bottom Boat 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 water craft shall operate on a "line of sight" rule. No water craft will go out of sight of each other.
5. All personnel shall wear their Personnel Floatation Devices at all times while they are on the water.
6. 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).
7. All personnel shall wear bright colors (for example: hunter orange, yellow, etc.) to enhance their visibility to one another.
8. All personnel shall collect one sample at a time, and return that sample to the "mother ship," the dock, or other location as determined by site conditions and situation.
9. Team Leader has final authority on operations with regards to weather and water conditions.

STANDARD OPERATING PROCEDURE

Groundwater Sampling from Monitoring Wells

I. Purpose and Scope

This procedure presents general guidelines for the collection of groundwater samples from monitoring wells. The procedure does not address purging and sampling using "low-flow" techniques (see SOP *Low-Flow Groundwater Sampling from Monitoring Wells)*. Operations manuals should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Probe box with inlet/outlet ports for purged groundwater and watertight ports for each probe
- pH meter: Orion® Model SA250 or equivalent
- Temperature/conductivity meter: YSI® Model 33 or equivalent
- Dissolved oxygen meter: YSI® Model 57 or equivalent
- In-line disposable 0.45µ filters: QED® FF8100 or equivalent
- Bailer, teflon or stainless steel
- Peristaltic pump, bladder pump, or submersible sampling pump with tubing, support cables, and power supply (may not be required if well yield is low)

III. Procedures and Guidelines

A. Setup and Purging

1. For the well to be sampled, information is obtained on well location, diameter(s), depth, and screened interval(s), and the method for disposal of purged water.
2. A pump will be used for well purging if the well yield is adequate; otherwise, a bailer may be used.
3. Instruments are calibrated according to manufacturer's instructions.
4. The well number, site, date, and condition are recorded in the field logbook.
5. Plastic sheeting is placed on the ground, and the well is unlocked and opened. All decontaminated equipment to be used in sampling will be

placed only on the plastic sheeting until after the sampling has been completed.

6. Water level measurements are collected in accordance with SOP *Water Level Measurements*, and the total depth of the well is measured.

7. The volume in gallons of water in the well casing or sections of telescoping well casing is calculated as follows:

   $0.052\ (\pi\ r^2 h) = 0.163\ (r^2 h) = \text{gallons}$

   where: $\pi = 3.14$

   r = Radius of the well pipe in inches
   h = height of water in well in feet

   The volume of water in typical well casings may be calculated as follows:

   2-inch diameter well:
   0.163 gal/ft x ___ (linear feet of water) = gallons

   4-inch diameter well:
   0.653 gal/ft x ___ (linear feet of water) = gallons

   6-inch diameter well:
   1.469 gal/ft x ___ (linear feet of water) = gallons

   The initial field parameters of pH, specific conductance, and temperature of water are measured and recorded in the field logbook. The measurement probes are inserted into the probe box. The purged groundwater is directed through the box, allowing measurements to be collected before the water contacts the atmosphere.

8. Sampling equipment is cleaned and decontaminated prior to sampling in accordance with SOP *Decontamination of Personnel and Equipment*.

9. If a bailer is being used, it is removed from either its protective covering or the well casing and attached to a cord compatible with constituents and long enough to reach the bottom of the well. If a sampling pump is being used, the airline, discharge line, and support cable or rope is attached to the pump. The support line should bear the weight of the pump. If the well is purged using dedicated tubing, it is lowered into the well to the top of the screened zone.

10. The sampling device is lowered to the well interval from which the sample is to be collected. The pump intake will be placed above the top of the screen, where possible. If a bailer is being used, it is allowed to fill with a minimum of surface disturbance to prevent sample water aeration. When the bailer is raised, the bailer cord must not touch the ground.

During purging, the field parameters are measured at least once for each well volume. In productive wells, the well purging end point is determined using the field measurements. In nonproductive wells, the well is repeatedly bailed dry to obtain a minimum of three well volumes, then allowed to recover before sampling.

12. Three to five well volumes are purged (more may be purged if parameters do not stabilize). Purging is stopped when field parameters have stabilized over three consecutive well volumes. Field parameters are considered stabilized when pH measurements agree within 0.5 units, temperature measurements agree within 1°C, and specific conductance and dissolved oxygen measurements agree within 10 percent.

B. Sample Collection

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

Samples will be placed in bottles that are appropriate to the respective analysis and that have been cleaned to laboratory standards. Each bottle typically will have been previously prepared with the appropriate preservative, if any.

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

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; time and date; sampler's identity)
2. Sample source and source description
3. Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, number of well volumes purged, and field parameter measurements
4. Sample disposition (preservatives added; laboratory sent to, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)
5. Additional remarks

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

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.
2. The sample is slowly poured from the bailer or discharged from the pump so that it runs down the inside of the sample bottle with a minimum of splashing. The pumping rate should be reduced to approximately 100 ml per minute when sampling VOCs. Samples may be field filtered before transfer to the sample bottle. Filtration must

occur in the field immediately upon collection. Inorganics, including metals, are to be collected and preserved in the filtered form as well as the unfiltered form. The recommended method is through the use of a disposable in-line filtration module (0.45 micron filter) using the pressure provided by the pumping device for its operation. When a bailer is used, filtration may be driven by a peristaltic pump.

3. VOC samples from wells purged using dedicated tubing and a sampling pump will be collected using a bailer

4. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to overflowing and capped.

5. The bottle is capped, then labeled clearly and carefully.

6. Samples are placed in appropriate containers and, if necessary, packed with ice in coolers as soon as practical.

7. If the sampler is dedicated, it is returned to the well and the well is capped and locked. Nondedicated samplers are cleaned and decontaminated in accordance with SOP *Decontamination of Personnel and Equipment.*

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

Maintain field equipment in accordance with the manufacturer's recommendations. This will include, but is not limited to:

- Inspect sampling pump regularly and replace as warranted
- Bring supplies for replacing the bladder if using a positive-displacement bladder pump
- Inspect tubing regularly and replace as warranted
- Inspect air/sample line quick-connects regularly and replace as warranted
- Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

STANDARD OPERATING PROCEDURE

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 non-dedicated downhole equipment in accordance to 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. Decontaminate all non-dedicated downhole equipment (lead rod, foot valve, etc.) in accordance to SOP Decontamination of Personnel and Equipment.

7. Backfill bore hole at each sampling location with grout or bentonite and repair the surface with like material (bentonite, asphalt patch, concrete, etc.), as required.

V. Key Checks and Items

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

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

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

STANDARD OPERATING PROCEDURE

Low-Flow Groundwater Sampling from Monitoring Wells

I. Purpose and Scope

This procedure presents general guidelines for the collection of groundwater samples from monitoring wells. Low-flow purging and sampling procedures are specifically addressed. Operations manuals should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Flow-through cell with inlet/outlet ports for purged groundwater and watertight ports for each probe
- pH/Eh meter: Orion® Model SA250 or equivalent
- Temperature/conductivity meter: YSI® Model 33 or equivalent
- Dissolved oxygen meter: YSI® Model 57 or equivalent
- Water-level indicator
- In-line disposable 0.45µ filters: QED® FF8100 or equivalent
- Bailer, teflon or stainless steel
- Adjustable-rate, positive-displacement pump
- Generator
- Disposable polyethylene tubing
- Plastic sheeting

III. Procedures and Guidelines

A. Setup and Purging

1. For the well to be sampled, information is obtained on well location, diameter(s), depth, and screened interval(s), and the method for disposal of purged water.

2. Instruments are calibrated according to manufacturer's instructions.

3. The well number, site, date, and condition are recorded in the field logbook.

4. Plastic sheeting is placed on the ground, and the well is unlocked and opened. All decontaminated equipment to be used in sampling will be placed only on the plastic sheeting until after the sampling has been completed.

5. Water level measurements are collected in accordance with SOP Water Level Measurements. **Do not measure the depth to the bottom of the well at this time** (in order to avoid disturbing any accumulated sediment). Obtain depth to bottom information from well installation log.

6. The volume in gallons of water in the well casing or sections of telescoping well casing is calculated as follows:

   $0.052\ (\pi\ r^2 h) = 0.163\ (r^2 h) =$ gallons

   where: $\pi = 3.14$

   r = Radius of the well pipe in inches
   h = height of water in well in feet

   The volume of water in typical well casings may be calculated as follows:

   2-inch diameter well:
   0.163 gal/ft x ___ (linear feet of water) = gallons

   4-inch diameter well:
   0.653 gal/ft x ___ (linear feet of water) = gallons

   6-inch diameter well:
   1.469 gal/ft x ___ (linear feet of water) = gallons

   The initial field parameters of pH, specific conductance, and temperature of water are measured and recorded in the field logbook. The measurement probes are inserted into the probe box. The purged groundwater is directed through the box, allowing measurements to be collected before the water contacts the atmosphere.

7. Sampling equipment is cleaned and decontaminated prior to sampling in accordance with SOP *Decontamination of Personnel and Equipment*.

8. Lay out polyethylene sheeting and place all equipment on the sheeting. To avoid cross-contamination, do not let any downhole equipment touch the ground surface.

9. Attach and secure the polyethylene tubing to the low-flow pump. Lower the pump slowly into the well and set it at approximately the middle of the screen. Place the pump intake at least two feet above the bottom of the well to avoid mobilization of any sediment present in the bottom. Start purging the well at 0.2 to 0.5 liters per minute. Avoid surging. Purging rates for more transmissive formations could be started at 0.5 to 1 liter per minute.

10. The water level should be monitored during purging, and ideally, the purge rate should equal the well recharge rate so that there is little or no drawdown in the well. (The water level should stabilize for the specific purge rate.) There should be at least one foot of water over the pump

intake so there is no risk of the pump suction being broken, or entrainment of air in the sample. Record adjustments in the purge rate and changes in depth to water in the logbook. Purge rates should, if needed, be decreased to the minimum capabilities of the pump (0.1 to 0.2 liters per minute) to avoid affecting well drawdown. The well should not be purged dry. If the recharge rate of the well is so low that the well is purged dry, then the contractor may wait until the well has recharged to a sufficient level and collect the appropriate volume of water for the sample with the pump.

11. During purging, the field parameters are measured frequently (every three to five minutes) until the parameters have stabilized. Field parameters are considered stabilized when pH measurements agree within 0.5 units, temperature measurements agree within 1°C, and specific conductance, Eh, and dissolved oxygen measurements agree within 10 percent.

B. Sample Collection

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

Samples will be placed in bottles that are appropriate to the respective analysis and that have been cleaned to laboratory standards. Each bottle typically will have been previously prepared with the appropriate preservative, if any.

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

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; time and date; sampler's identity)
2. Sample source and source description
3. Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, number of well volumes purged, and field parameter measurements
4. Sample disposition (preservatives added; laboratory sent to, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)

Additional remarks

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

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.

2. The sample is slowly discharged from the pump so that it runs down the inside of the sample bottle with a minimum of splashing. The pumping rate should be reduced to approximately 100 ml per minute when sampling VOCs. Samples may be field filtered before transfer to the sample bottle. Filtration must occur in the field immediately upon collection. Inorganics, including metals, are to be collected and preserved in the filtered form as well as the unfiltered form. The recommended method is through the use of a disposable in-line filtration module (0.45 micron filter) using the pressure provided by the pumping device for its operation.

3. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to overflowing and capped.

4. The bottle is capped, then labeled clearly and carefully following the procedures in SOP *Packaging and Shipping Procedures*.

5. Samples are placed in appropriate containers and, if necessary, packed with ice in coolers as soon as practical.

6. If the sampler is dedicated, it is returned to the well and the well is capped and locked. Nondedicated samplers are cleaned and decontaminated in accordance with SOP *Decontamination of Personnel and Equipment*. Disposable polyethylene tubing is disposed of with PPE and other site trash.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

Maintain field equipment in accordance with the manufacturer's recommendations. This will include, but is not limited to:

- Inspect sampling pump regularly and replace as warranted
- Inspect air/sample line quick-connects regularly and replace as warranted
- Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

STANDARD OPERATING PROCEDURE

Groundwater Sampling from Shallow Multi-Level Samplers

I. Purpose and Scope

This procedure presents guidelines for the collection of groundwater samples from multi-level groundwater sampling devices (MLS).

II. Equipment and Materials

- Multiple-head peristaltic pump with tubing
- Probe box; box with inlet/outlet ports for purged groundwater and watertight ports for each probe
- pH meter; Orion Model SA250 or equivalent
- Temperature/conductivity meter; YSI Model 33 or equivalent
- In-line disposable 0.45µ filters; QED FF8100 or equivalent

III. Procedures and Guidelines

A. Setup and Purging

1. For the MLS to be sampled, information is obtained on port locations, tubing inner diameter (ID), and the method for disposal of purged water.
2. Peristaltic pumps will be used for purging sampling tubes.
3. Instruments are calibrated according to manufacturer's instructions.
4. The MLS number, site, date, and condition are recorded in the field logbook.
5. Plastic sheeting is placed on the ground, and the locking cover or manhole cover is opened.
6. If piezometers are incorporated in the MLS design, water-level measurements are collected in accordance with SOP Water Level Measurements, and the total depth of the piezometer is measured.
7. The volume in gallons of water in a given sampling tube is calculated as follows:

   $0.052\ (\pi\ r^2 h) = 0.163\ (r^2 h) = \text{gallons}$

where: $\pi = 3.14$

r = radius of the sampling tubing in inches (typically, $r = 0.094$ in)

h = height of water table above port in feet

The initial field parameters of pH, specific conductance, and temperature of water are measured and recorded in the field logbook. The measurement probes are inserted into the probe box. The purged groundwater is directed throughout the box, allowing measurements to be collected before the water contacts the atmosphere.

8. Sampling equipment is cleaned and decontaminated prior to sampling in accordance with SOP Decontamination of Personnel and Equipment.

9. During purging, the field parameters are measured at least twice.

10. Three to five tube volumes are purged.

B. Sample Collection

Once purging of a single sampling tube has been completed, the sampling tube is ready to be sampled. The elapsed time between completion of purging and collection of the groundwater sample from the MLS port should be minimized. Typically, the sample is collected immediately after the MLS tube has been purged.

Purging and sampling shall begin at the upper most port and proceed down. Where hydrogen gas samples are to be collected, all ports on an MLS shall first be purged and sampled for all other parameters before initiating the hydrogen gas sampling. Hydrogen gas samples require a constant stream of water for 35 minutes, which may impact the representativeness of samples from closely spaced ports. (Representativeness is not a significant concern for the hydrogen samples themselves)

Samples will be placed in bottles that are appropriate to the respective analysis and that have been cleaned to laboratory standards. Each bottle typically will have been previously prepared with the appropriate preservative, if any.

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

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; time and date; sampler's identity)

2. Sample source and source description

3. Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, number of purge volumes collected, and field parameter measurements

4. Sample disposition (preservatives added; laboratory sent to, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)

5. Additional remarks

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

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.

2. The sample is slowly discharged from the pump so that it runs down the inside of the sample bottle with a minimum of splashing. Samples may be field filtered before transfer to the sample bottle. Filtration must occur in the field immediately upon collection. Inorganics, including metals, are to be collected and preserved in the filtered form as well as the unfiltered form. The recommended method is through the use of a disposable in-line filtration module (0.45 micron filter) using the pressure provided by the pumping device for its operation.

3. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to overflowing and capped.

4. The bottle is capped, then labeled clearly and carefully.

5. Samples are placed in appropriate containers and, if necessary, packed with ice in coolers as soon as practical.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

Maintain field equipment in accordance with the manufacturer's recommendations; this will include, but is not limited to:

- Inspect sampling pump regularly and replace as warranted
- Inspect tubing regularly and replace as warranted
- Inspect air/sample line quick-connects regularly and replace as warranted
- Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

STANDARD OPERATING PROCEDURE

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

Drilling

- Drilling rig (hollow stem auger or mud rotary) and associated tools and equipment

Well Riser/Screen

- 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.

Bottom Cap

- PVC, threaded to match the well screen; alternatively, stainless steel
- Centering Guides (if used)

Well Cap

- Above-grade well completion: PVC, threaded or push-on type, vented
- Flush-mount well completion: PVC, locking, leak-proof seal
- Stainless steel to be used as appropriate

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.

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

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

Well Development

- Double surge block with solid bottom, top open, separated by 2 feet of slotted pipe
- Well-development pump, and associated equipment
- 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 6-inch inside diameter (ID) will be used to drill shallow monitoring well boreholes. Alternatively, mud rotary may be used. Split-spoon samples will be collected at selected intervals for chemical analysis and/or lithologic classification. Soil sampling procedures are detailed in SOP *Soil Boring Sampling – Split Spoons*.

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 Field Sampling Plan.

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. Based on lithologic samples previously obtained at the site, and comparison with samples to be obtained in the well borings, standard well screen slot of 0.010-inch and silica sand gradations conforming to Morie #2 are anticipated.

A primary sand pack (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 pellet seal at least 2 feet thick will be placed above the sand pack. The pellets 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.

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 or round, with a minimum radius of approximately 3.5 feet. 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, within the edges of the concrete pad. 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.

C. 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 two surge blocks separated by approximately 2 feet of coarsely slotted pipe. The lower surge block will be solid; the upper surge block will be open and attached to riser pipe leading to the ground surface. Water will be pumped continuously from the surge block screened interval throughout the surging process. The pumping will be accomplished by airlift induction methods or using a centrifugal pump or equivalent.

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.

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 Investigation Derived Waste Management Plan.

IV. Attachments

Schematic diagram of shallow monitoring well construction

STANDARD OPERATING PROCEDURE

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.

II. Equipment and Materials

Drilling

- Drilling Rig (hollow-stem auger and air-rotary)

  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.

Well Installation

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded well casing
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted well screen
- PVC, 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.

Development

- Double surge block with bottom solid, top open, separated by 2 feet of slotted pipe for well development
- 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, surface casing installation, and air rotary 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. Lithologic samples also may be collected; sampling procedures and frequency are outlined in the Sampling and Analysis Plan.

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 soil coring 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.

The borehole will extend a minimum of 5 feet into competent bedrock for seating of the surface casing.

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. Rotary Drilling

Air rotary drilling techniques will be used to install wells in each of the bedrock monitoring wells. 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 continuation of rotary 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 IDW-MP.

B. Surface Casing Installation

Surface casing will be constructed of 6-inch ID steel or 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 and the surface casing will be set into 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.

C. Monitoring 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 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 pellet seal at least 2 feet thick will be placed above the sand pack. The pellets 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 pellet seal.

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, 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, within the edges of the concrete pad. 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 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.

STANDARD OPERATING PROCEDURE

General Guidance for Monitoring Well Installation

I. Purpose

To provide site personnel with a review of the well installation procedures that will be performed. These procedures are to be considered general guidelines only and are in no way intended to supplement or replace the contractual specifications in the driller's subcontract.

II. Scope

Monitoring well installations are planned for shallow and/or deep unconsolidated aquifers and/or for bedrock aquifers. The SOPs *Installation of Shallow Monitoring Wells, Installation of Surface-Cased Monitoring Wells, Installation of Bedrock Monitoring Wells,* and *Installation of Monitoring Wells Using Sonic Drilling* provide more specifics.

III. Equipment and Materials

1. Drilling rig (hollow stem auger, sonic, or mud rotary)
2. Well-construction materials (i.e., surface casing, screens, riser, casing, caps, bottom plugs, 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.
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.

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 proper 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 #1 or #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 pellets have been allowed to hydrate and before the grout is applied. The grout will be allowed to hydrate for at least 8 hours before work in the well continues.
- The annular space above the bentonite seal will be filled to grade with a bentonite-cement slurry grout mixture.

- The grout mixture consists of 94 pounds (lbs) of cement (1 bag) per 6 gallons of water and 2 to 3 lbs of powdered bentonite per bag of cement to reduce shrinkage.
- The grout mix will be carefully applied to avoid disturbing the bentonite seal; the method of grout placement must force grout from the bottom of the space to be grouted to the surface.
- After allowing the grout to settle and set up overnight, additional grout will be added to maintain grade.
- A protective steel casing equipped with keyed alike locking caps will be grouted in place for each new well; the casing will extend at least 2 feet above grade and 3 feet below grade, and will be painted a bright color.

Well Development

- New monitoring wells will be developed after the well has been completely installed and the grout has hardened (at least 24 hours)
- The well will be developed by surging and pumping.
- Equipment placed in the well will be decontaminated before use.
- If information is available, begin developing in the least-contaminated well first.
- Development will include surging the well by abruptly stopping flow and allowing water in the well column to fall back into the well.
- Pipes and pumps must not be fitted with foot valves or other devices that might inhibit the return flow of water to the well.
- Surging should continue throughout the development process.
- The air lift method will be used to pump materials out of the well. The air compressor will be fitted with filters to remove all oil and the air lift hose used will be made of inert materials.
- Well development will continue until the water produced is free of turbidity, sand, and silt.
- Development water will be considered hazardous and placed in sealed 55-gallon U.S. DOT approved steel drums. CH2M HILL will label and date the drums, and transport the drums to a designated site for storage.

V. Attachments

None.

VI. Key Check and Items

Ensure that all equipment is properly decontaminated as needed. Only new, sealed materials (e.g., screens, risers, and sand) will be used in constructing the well. Care shall be taken when making downhole measurements to ensure that proper heights of sand, seal, and grout are achieved.

STANDARD OPERATING PROCEDURE

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 , not in bedrock (see 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

Drilling

- Drilling rig (hollow stem auger or mud rotary)

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.

Well Installation

- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted well screen
- PVC, 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.
- Above-grade well completion: PVC well cap, threaded or push-on type, vented.
- Flush-mount well completion: PVC well cap, locking, leak-proof seal.
- 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.

Well Development

- Double surge block with bottom solid, top open, separated by 2 feet of slotted pipe for well development
- 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.

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.

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 casings. The borehole will extend a minimum of 5 feet into the clay layer for seating of the 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. The split spoon is advanced through repeated blows from a 140-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.

Drill cuttings and fluids generated during rotary drilling activities will be contained until completion of activities at the drilling location.

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.

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. Well Completion

Typically, the well is completed within the surface casing using mud rotary.

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 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 pellet seal at least 2 feet thick will be placed above the sand pack. The pellets 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 pellet seal.

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, 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, within the edges of the concrete pad. 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 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.

IV. Attachments

Schematic diagram of double-cased monitoring-well construction.

STANDARD OPERATING PROCEDURE

Installation of Shallow Multi-Level Samplers

I. Purpose and Scope

The purpose of this guideline is to describe methods for drilling and installation of multi-level groundwater sampling devices (MLS) in unconsolidated or poorly consolidated materials. The MLS described below is designed for monitoring groundwater at discrete vertical intervals at shallow depths.

II. Equipment and Materials

Drilling

- Drilling rig
- Hollow-stem augers

MLS

- Polyvinyl chloride (PVC), Schedule 40, minimum 1.5-inch (nominal diameter) pipe
- Polypropylene, 3/16-inch inside diameter (ID), 1/4-inch outside diameter (OD), color-coded tubing (yellow, orange, red, green, blue, black)
- Stainless steel safety lock wire, 0.020-inch diameter
- Nylon filter fabric or synthetic (non-metal) screen

Bottom Cap

- PVC, threaded or female to match the center-structure
- Centering Guides (if used)

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.

Bentonite

- Pure, additive-free bentonite pellets
- 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

Protective Casing

- Above-grade MLS completion: 6-inch minimum ID steel pipe with locking cover, diameter at least 2 inches greater than the MLS casing, painted with epoxy paint for rust protection; heavy duty lock; protective posts if appropriate

Figure 1. Above-grade MLS prior to installation of locking cover and pad.

- Flush-mount MLS completion: Morrison 9-inch or 12-inch 519 manhole cover,

or equivalent; rubber seal to prevent leakage; locking cover inside of road box

Figure 2. Flush-mount MLS with cover removed.

MLS Development

- Peristaltic pump, and associated equipment
- Containers (e.g., 55 gallon drums) for water produced from MLS

III. Procedures and Guidelines

A. Drilling Method

Continuous-flight hollow-stem augers with a minimum 3.5-inch and maximum 5-inch ID will be used to drill shallow MLS boreholes. Split-spoon samples will be collected at selected intervals for chemical analysis and/or lithologic classification. Soil sampling procedures are detailed in SOP Soil Sampling.

The use of water to assist in hollow-stem auger drilling for MLS installation will be avoided, unless required for such conditions as running sands.

Hollow-stem augers, 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 Drilling Rigs and Personnel details proper decontamination procedures.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in the Field Sampling Plan.

B. MLS Construction and Installation

MLS will be constructed above-ground, once the borehole has been advanced to the desired depth. If the borehole has been drilled to a depth greater than that at which the MLS is to be set, the borehole will be backfilled with bentonite pellets or a bentonite-cement slurry to a depth approximately 1 foot below the intended MLS depth. Approximately 1 foot of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for MLS installation.

Selection of sampling port intervals and corresponding sampling tubing lengths for each shallow MLS shall be made in the field. Sampling ports are typically spaced from 2.0 to 2.5 ft apart. Spacing intervals are estimated prior to drilling based on lithologic samples previously obtained at the site. Actual spacing will be based on a identification and vertical thickness of permeable layers of samples obtained in the MLS borings. Centering guides, if used, will be placed below the bottom MLS sampling port screen and above the interval in which the bentonite seal is placed.

Port locations are marked on the PVC core. Each core is no more than 10 feet in length. Holes for the tubing to enter the PVC core are drilled about 3 inches up the PVC core from the port location using a ¼-inch drill bit. After drilling through the PVC, electric drill handle is rotated approximately 90° down towards the actual port location, leaving a trough in the PVC core. Tubing is pushed through the holes and fed up through PVC core.

Ports are constructed by cutting the end of each sampling tube on a slant and then cover it with nylon material. The stainless steel wire is wrapped 3 or 4 times around just the tubing and the nylon screen to secure the screen to the tube. Excess nylon is folded back behind the port and then secure with the stainless-steel wire. The wire is fastened around the PVC core to secure the port to its proper location against the outside wall of the PVC core.

If the MLS exceeds 10 feet in length, additional sections of PVC core (either blank sections or sections with MLS ports) are assembled and added to the bottom section of PVC core. Sections of the PVC core are joined using a female-female coupling during installation.

If site conditions permit, a primary sand pack (usually a Morie No. 1) consisting of clean silica sand will be placed around the well screen. Selection of the filter pack shall be made in the field. Based on lithologic samples previously obtained at the site, and comparison with samples to be obtained in the MLS borings, silica sand gradations conforming to Morie No.1 are anticipated.

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. If site conditions permit, a 12-inch layer of bentonite pellets will be placed between the MLS sampling ports. As a result, the primary sand pack will consist of intermittent layers of sand and bentonite and sand layers centered about each sampling port. The primary sand pack will be extended from the bottom of the borehole to a minimum height of 2 feet above uppermost MLS port. A secondary, finer-grained, 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 the shallow water table and small saturated thickness of the surficial aquifer.

A bentonite pellet seal at least 2-feet thick will be placed above the fine sand pack. The pellets 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.

For MLS 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 or round, with a minimum radius of approximately 3.5 feet. 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, within the edges of the concrete pad. Guard posts will be concrete-filled, at least 2 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 MLS 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 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 MLS locations 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 MLS will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the permanent MLS number.

C. MLS Development

MLS development will be accomplished by 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.

MLS development equipment will be decontaminated prior to initial use and after the development of each MLS. Decontamination procedures are detailed in SOP Decontamination of Personnel and Equipment. Water generated during MLS development will be contained and managed as detailed in the Field Sampling Plan Investigation Derived Waste Management Plan.

IV. Attachments

Schematic diagram of shallow monitoring MLS construction

STANDARD OPERATING PROCEDURE

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 ir 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

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 = Average 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 will 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.

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

Seepage Meter

I. Purpose

The purpose of this procedure is to provide general guidance and reference material regarding the installation and use of seepage meters at various sites.

II. Scope

This SOP describes the methods of installing a seepage meter and calculating seepage flux.

III. Definitions

Seepage Meter - An instrument that measures the flow rate between the ground-water and the overlying surface water with plastic bag containing a known volume of water attached to an open bottom container covering an area of sediment and submerged in a water body.

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.

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 Investigation Personnel performing the testing activities have been briefed and trained to execute these procedures before the start of site operations.

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. The field team is responsible for installing the seepage meter and recording the results in the field logbook during each test.

V. Procedures

The seepage meter test will determine the type of hydraulic interaction between a shallow groundwater table and the surface water body. The test will also determine the groundwater velocity or seepage flux.

A. Seepage Meter Construction

The seepage meter instrument can be made by cutting the end section (approximately 5 to 10 inches long) from a 55-gallon drum. A valve is attached to the side near the closed top of the inverted drum. Tygon tubing with an in-line needle valve is attached to the valve. A thinwalled plastic bag containing a known volume of water is attached to the tubing.

B. Seepage Meter Testing

Installation of the seepage meter consists of slowly pushing the open end into the sediments until the top rests on the surface water body sediments, with a slight tilt so that the valve represents the highest point of the system. The plastic bag must be submerged to maintain the same piezometric head in the seepage meter as the surface water. The needle valve is opened to bleed any air in the system connecting the system to the surface water. After the sediments return to an undisturbed state, the test is started by opening the valve attached to the drum and monitoring time for the appropriate period. When the appropriate amount of time has passes, the valve attached to the drum is closed and the volume of water within the bag is measured. The type of hydraulic interaction between the groundwater and surface water body is determined. If the measured water volume is greater than the original volume, groundwater is discharging to the surface water, and if the measured amount of water is less than the original volume, the surface water is discharging to groundwater.

C. Calculations

The procedure for calculating the groundwater velocity or seepage flux is determined by the following equation:

$$Q\ (\mu m/s) = (\text{Volume change } [cm^3])\ (0.0643)\ /\ (\text{Elapsed time } [min])$$

where Q is seepage flux and the factor 0.0643 converts units of time, volume and area covered by the seepage meter (0.255 m^2) to equivalent units of velocity (µm/s) or seepage flux ($cm^3/m^2/s$).

VI. Quality Assurance Records

The field logbook will serve as quality assurance record for water volume measurements and elapsed time monitoring.

VII. References

Lee, D. R. and J. A. Cherry. 1978. A field exercise on groundwater flow using seepage meters and mini piezometers. *Journal of Geological Education*. Volume 27.

STANDARD OPERATING PROCEDURE

Installation of Monitoring Wells by Sonic Drilling

I. Purpose and Scope

The purpose of this guideline is to describe methods for drilling and installation of groundwater monitoring wells and piezometers in unconsolidated or poorly consolidated materials using sonic drilling techniques. Sonic drilling technology eliminates telescoping monitoring wells, allowing the installation of aquifer penetrating, single-cased wells.

II. Equipment and Materials

Drilling

- Sonic drilling rig
- Temporary outer steel casing
- Drill rods and core barrel

Well Riser/Screen

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded riser; alternatively, stainlesss steel riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted screen; alternatively, stainless steel screen.

Bottom Cap

- PVC, threaded to match the well screen; alternatively, stainless steel
- Centering Guides (if used)

Well Cap

- Above-grade well completion: PVC, threaded or push-on type, vented
- Flush-mount well completion: PVC, locking, leak-proof seal
- Stainless steel to be used as appropriate

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.

Bentonite

- Pure, additive-free bentonite pellets
- 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

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

Well Development

- Double surge block with solid bottom, top open, separated by 2 feet of slotted pipe
- Well-development pump, and associated equipment
- Containers (e.g., 55 gallon drums) for water produced from well.

III. Procedures and Guidelines

A. Drilling Method

Drill rods and core barrel with a minimum 8-inch inside diameter (ID) will be used to drill monitoring well boreholes. Continuous core soil samples (6-inches outside diameter) will be collected for lithologic classification and intervals selected for chemical analysis. Soil sampling procedures are detailed in SOP *Shallow Soil Sampling.*

The use of water and drilling fluid to assist in sonic drilling for monitoring well installation will be avoided, unless required for such conditions as running sands or drilling bedrock formations.

Temporary outer casing, drill rods, core barrels, and other downhole drilling tools will be properly decontaminated prior to the initiation of drilling activities and between each borehole location. Core barrels and other downhole soil sampling equipment will also be properly decontaminated before and after each use. SOP *Decontamination of Drilling 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 Field Sampling Plan.

B. Monitoring Well Installation

Sonic drilling technology eliminates the necessity to install double or triple cased wells since the borehole will be fully cased during drilling activities. Monitoring wells will be constructed inside the temporary outer casing, once the borehole has been advanced to the desired depth. Following setting the well screen, riser, filter pack, and bentonite seal, the well will be grouted as the temporary casing is withdrawn, preventing cross contamination. 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 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 temporary casing 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. Based on lithologic samples previously obtained at the site, and comparison with samples to be obtained in the well borings, standard well screen slot of 0.010-inch and silica sand gradations conforming to Morie No. 1 are anticipated.

A primary sand pack (Morie No. 1) 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 temporary casing will be raised gradually during sand pack installation to avoid caving of the borehole wall; at no time will the temporary casing 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, 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 the shallow water table and small saturated thickness of the surficial aquifer.

A bentonite pellet seal at least 2 feet thick will be placed above the sand pack. The pellets 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.

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 or round, with a minimum radius of approximately 3.5 feet. 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, within the edges of the concrete pad. Guard posts will be concrete-filled, at least 2 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 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.

C. 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 two surge blocks separated by approximately 2 feet of coarsely slotted pipe. The lower surge block will be solid; the upper surge block will be open and attached to riser pipe leading to the ground surface. Water will be pumped continuously from the surge block screened interval throughout the surging process. The pumping will be accomplished by airlift induction methods or using a centrifugal pump or equivalent.

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.

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 Field Sampling Plan Investigation Denied Waste Management Plan.

IV. Attachments

Schematic diagram of shallow monitoring well construction

STANDARD OPERATING PROCEDURE

Magnetometry

I. Purpose

This SOP provides general reference information and standard techniques for using magnetometry.

II. Scope

This SOP provides a description of the field procedures, equipment, and interpretation methods necessary to fully utilize this procedure.

III. Definitions

Diurnal variations - daily changes in the total magnetic field strength due to solar activity and which (may be as large as 100 gammas or more)

Gradient - change in magnetic field strength in a given vertical or horizontal distance

Magnetic storm - sudden and simultaneous variations of up to several hundred gammas throughout the world. Magnetic storms can occur as often as several times a month and can last one to several days.

Total magnetic field intensity - a scaler measurement of the magnitude of the earth's magnetic field vector independent of its direction.

IV. Responsibilities

Project Manager - The Project Manager is responsible for ensuring that the project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed. The Project Manager is responsible for ensuring that the personnel operating and interpreting the geophysical data are trained, skilled in that endeavor, so far as to receiving documentation on the training and experience of the operating personnel.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the geophysical technique and equipment to be used. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that the field investigation personnel performing the activities have been briefed and trained to execute these procedures.

V. Procedures

A. Overview

Magnetic surveying is a passive geophysical technique which measures the strength of the earth's magnetic field. The earth's field is a vector quantity having a unique magnitude and direction at every point on the earth's surface. A magnetometer is the instrument which measures the magnetic field strength in units of gammas or nanoteslas. In order to recognize a magnetic anomaly, it must be several times larger than the background noise level along that profile. Buried ferrous metal objects such as steel drums or tanks cause local variations or anomalies in the earth's magnetic field that can be detected by a magnetometer. Geologic features such as igneous intrusion or iron rich sands can also be mapped using magnetic surveying.

The earth's magnetic field is not completely stable. It undergoes long-term (secular) variations over centuries; small, daily (diurnal) variations (less than 1% of the total field magnitude); and transient fluctuations called magnetic storms resulting from solar flare phenomena. Both naturally-occurring and manmade magnetic materials can modify the earth's magnetic field locally.

Analysis of magnetic data by an experienced geophysicist can provide an estimate of the areal extent and quantity of buried ferrous objects. Depth of burial approximations can be made using graphical methods of interpretation such as slope techniques and half-width rules as described in Nettleton (1 976).

B. Application and Uses

Buried ferrous metal objects such as pipelines, barrels, tanks, etc., generally produce a perturbation in the earth's naturally occurring magnetic field. The size (amplitude) of this perturbation is related to the size of, distance to, susceptibility and remnant magnetization of the buried object. The magnetic survey method, therefore, is a useful tool for site studies to locate and identify buried ferrous metal. Non-anomalous magnetic data acquired over EM conductivity anomalies is an indication of the existence of buried conductive, non-ferrous metal (copper, aluminum, brass) objects.

Magnetic data also can be helpful in determining the size and geometry of geologic features such as fault zones, mineralized zones, and bedrock valleys and depressions. These features are characterized generally by longer wavelength anomalies and are readily distinguishable from anomalies associated with buried metal. In many areas, such geologic features may control or affect the direction and magnitude of groundwater flow.

The total field proton precession magnetometer, the fluxgate magnetometer, and the magnetic gradiometer are commonly used magnetometers in environmental site investigations. The total field proton precession magnetometer is the most commonly used magnetometer because they are easy to operate, have no instrumental drift, and can acquire data rapidly. The fluxgate magnetometer can better define the boundaries of buried ferrous objects than the proton precession magnetometer but is subject to instrument drift, and needs to be exactly oriented.

Magnetic gradiometer measurements enhance anomalies resulting from shallow magnetic sources.

C. Equipment

Magnetometers commonly used in hazardous waste site investigations include the total field proton procession magnetometer, the flux gate magnetometer, and the magnetic gradiometer. Text books such as Telford (1976) and Nettleton (1976) discuss in detail the operation and construction of these and other magnetometers.

The total field proton procession magnetometer is the most commonly used magnetometer in hazardous waste investigations. This instrument utilizes the precession of spinning protons of hydrogen atoms in a sample fluid (kerosene, alcohol or water) to measure the total magnetic field intensity. Total field proton precession magnetometers are portable and do not require precise orientation and leveling; the sensor must be oriented with one side facing approximately north and the sensor held stationary during the cycling period. Proton precession magnetometers have no instrument drift, do not require calibrations, are easy to operate, and have an accuracy of 0.1 gamma. Most modern proton precession magnetometers have digital readouts and electronic storage of data.

Vertical magnetic gradiometers are magnetometers that measure vertical differences of the earth's total magnetic field. Gradient measurements enhance magnetic anomalies resulting from near surface magnetic source and discrimination between neighboring magnetic anomalies is also enhanced. These measurements are generally made using an instrument similar to a total field magnetometer that has two or more sensors mounted on a staff. The sensors are vertically separated by a constant distance, usually one to three feet. Gradient readings are adversely affected by ferrous metal surface debris since signals from this surface debris are also amplified. Consequently, removal of surface metal should be considered before conducting a gradiometer survey.

The flux gate magnetometer was developed during World War II as a submarine detector. Text books such as Telford (1976), RAO and Murthy (1978) explain in detail the principals of operation of the flux gate magnetometer. A fluxgate magnetometer can define the boundaries of regions of buried ferrous metal objects more precisely than the proton precession magnetometer. There are several sources of errors in flux gate magnetometers including unbalance in the two coils, thermal and shock noise, circuit drift and temperature sensitivity. The advantages are direct readout, no azimuth orientation, coarse leveling required, light weight and portability (Telford, 1976).

D. Field Procedures

Magnetic data are generally acquired at relatively close station spacings (5 to 50 foot intervals) along closely spaced (10 to 50 feet) parallel survey lines.

Magnetic data can be acquired in a rectangular grid pattern or along traverses. Grid data are readings acquired at the nodes of a rectangular grid; traverse data is acquired at fixed intervals along a line. Traverse data is often preferable to grid data because it generally is less expensive to acquire (heavily vegetated sites require time

consuming brush cutting to establish a complete grid) and more useful for interpretation than an equal number of grid readings. Traverse lines generally ought to be oriented in a north-south direction so that the maximum amplitude of an anomaly can be detected. However, line orientations are often more dependent on site obstacles and sources of magnetic noise.

Station and line spacing intervals are determined on the basis of the desired resolution of the survey. If individual drums or clusters of deeply (greater than 25 feet) buried drums are the objective of the survey, then a detailed magnetic survey with relatively close station spacings (approximately 5 to 10 feet) and line spacings (approximately 10 to 25 feet) should be used. If large metal objects such as 10,000 gallon tanks or trenches filled with barrels are the objective of the magnetic survey, then a reconnaissance or screening survey with longer station spacings (25, 50, or 100 feet) and line spacings of (25, 50, or 100 feet) may be appropriate.

In conducting a survey, the field operator must avoid or note any sources of high magnetic gradients and alternating currents, such as power lines, buildings, and any large iron or steel objects. It is also important that the operator be relatively free of magnetic materials on his/her person and the magnetometer sensor be kept clean to avoid possible magnetic-bearing soil. Periodically during a survey, and particularly when an anomaly is detected, it is important to establish that the magnetometer is providing valid readings and not random, meaningless instrument noise. The simplest means of verifying magnetometer field readings is to take several successive readings at one location. These readings should repeat to within ± 1 gamma. Readings are taken at predetermined intervals which depend on the nature of the survey and which may have to be modified depending on the gradients encountered. For detailed surveys, a base station or the reoccupation of a set of stations several times a day or a continuous monitoring station (within 100 miles) is established to check for diurnal variations and magnetic storms. At the height of a magnetic storm, magnetic surveying may be impractical due to the large instantaneous changes in the total magnetic field.

E. Interpretation

1. Data Analysis

Magnetic data can be corrected for diurnal variations; however, diurnal changes are generally very gradual and linear and should not have the extreme fluctuations associated with buried ferrous metal objects. Magnetic data can be plotted in profile form or contoured depending upon the survey coverage. Noise sources (surface ferrous metal objects, fences, power lines, etc.) should be noted on the profiles or contour map so that anomalies due to these known sources can be accounted for. The amplitudes of similar sized surface metal objects should be compared. If similar sized ferrous metal surface objects have extremely different anomaly amplitudes, it may be an indication that buried ferrous metal objects exist in the vicinity of the higher amplitude anomalies.

2. Presentation of Results

The results of a magnetic survey should be presented in profile and/or contour map form. The orientation of the traverses should be indicated on profiles and lines of coverage on contour maps. Locations of observed ferrous metal and other cultural features (hills, valleys, streams, etc.) should be noted on both the profile and the contour maps.

3. Interpretation

Magnetic anomalies can be analyzed both qualitatively and quantitatively. The shape and gradient of an anomaly (slope, wave-length, amplitude, etc.) contains enough information to draw qualitative conclusions regarding the location and depth of the causative source.

Quantitative computer modeling interpretations of magnetic data are complicated both by the inherent complexity of dipole magnetic behavior and by the fact that a number of different types and configurations of sources can cause the same anomaly. Where the properties of the earth's field and the local geologic materials (inclination, declination, susceptibility, and remanent magnetization) are well known, reasonable assumptions regarding the nature of the source- can be made, and a fairly accurate model of the source generally can be derived.

F. Advantages and Limitations

Advantages of the magnetic survey method include:

- Rapid operation
- Low expense
- Identification of buried metal (ferrous)
- Sensitivity to small ferrous objects

Limitations of the magnetic survey method include:

- Susceptible to effects of manmade structures, utilities, buildings, fences, etc.
- Detection is limited to the distance to and quantity of ferrous metal present

VI. Quality Assurance Records

All data will be recorded in log books and/or data logging sheets designed for this procedure. All data will be entered with the following basic information: date, start and end times (military time), location, personnel on site, Contract Task Order number, and weather.

VII. References

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STANDARD OPERATING PROCEDURE

Ground-Penetrating Radar (GPR)

I. Purpose

The purpose of this SOP is to provide general reference information and technical guidance on the methods and techniques of ground-penetrating radar (GPR).

II. Scope

These procedures provide overall technical guidance.

III. Definitions

Bistatic Antenna - An antenna system in which transmitting and receiver coils are housed in separate antenna units.

Deconvolution - A computer processing method. The process of undoing the effect of another filter (in this instance the "earth"). A process that removes ringing, multiples, ghosts, and some background noise (Sheriff, 1973).

Dielectric Permittivity - (Also known as the relative dielectric permittivity): 1. A complex number consisting of a real and imaginary part, which uniquely describes the propagation and attenuation of electromagnetic energy in every material. The real dielectric permittivity (dielectric constant) characterizes the propagation and reflection of electromagnetic (EM) waves, while the imaginary part (dielectric loss) characterizes the attenuation of EM signal (Kutrubes and Olhoeft, 1987). 2. A measure of the capacity of a material to store charge when an electric field is applied (Sheriff, 1973).

Electromagnetic Waves - One of the waves that are propagated by simultaneous periodic variations of electric and magnetic field intensity and that include radio waves, infrared, visible light, ultraviolet, X-rays and gamma rays (Webster's New Collegiate Dictionary. 1979).

Migration - here velocity varies laterally, data will migrate (relative to the time versus antenna distance plot), and ray tracing is used to determine migrated positions (Sheriff, 1973).

IV. Responsibilities

Project Manager - The Project Manager is responsible for ensuring that the project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed. The Project Manager is responsible for ensuring that the personnel operating and interpreting the geophysical data are

trained, skilled in that endeavor, so far as to receiving documentation on the training and experience of the operating personnel.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the geophysical technique and equipment to be used. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that the field investigation personnel performing the activities have been briefed and trained to execute these procedures.

V. Procedures

A. Overview

Ground penetrating radar (GPR) is an active geophysical system which transmits high frequency electromagnetic (EM) waves into the ground and detects the energy reflected back to the -surface. GPR operates on a similar principle as seismic reflection, except, instead of acoustic waves, electromagnetic waves of radio and microwave frequencies (80 MHz to 1,000 MHz) are utilized. Electromagnetic signals are reflected back to the surface from interfaces with differing electrical properties, such as dielectric permittivity and conductivity. The greater the contrast in the real dielectric permittivity (dielectric constant) between two materials, the more energy is reflected to the surface. Reflections typically occur at lithologic changes, subsurface discontinuities, and internal soil structures such as:

- Top of bedrock surfaces
- Soil and rock stratification
- Water table
- Seepage and leachate zones
- Buried metal objects such as drums and utilities
- Open and water filled voids
- Bedrock fractures
- Archaeological structures

The depth of penetration of GPR is site specific, being limited by the attenuation of the electromagnetic energy. Signal attenuation is controlled by four different mechanisms listed below, any or all of which may be present at a site.

- Scattering losses
- Conduction losses
- Water losses
- Clay losses

Energy losses due to scattering occur when signals are dispersed in random directions, away from the receiving antenna, by large irregularly shaped objects, such as boulders and tree stumps.

Signal attenuation due to conduction is a function of the conductivity of a material, which varies with mineral composition, the amount of water, and the total dissolved solids (salt, heavy metals) within the water. The greater the electrical conductivity

values of materials at a site, the more signal attenuation (hence less penetration) there will be.

Energy losses attributed to water occur when water molecules polarize in the presence of the applied electromagnetic field. Electromagnetic energy is lost to the radar system when it is converted to kinetic and thermal energy as a result of the rotation of water molecules.

Signal attenuation due to clay losses occurs when electrochemically charged ions polarize along clay surfaces in the presence of the electromagnetic field induced by the radar system. The migration and subsequent collision of these charged particles causes electromagnetic energy to be converted to kinetic and thermal energy, which is lost to the radar system.

Signal penetration is also dependent on the frequency of the transmitting antenna used in the radar system. Higher frequency antennas produce waves with shorter wave lengths, which are attenuated more rapidly with depth, but give better resolution. Specially designed 2 MHz antennas have been used to detect the ice-rock boundary of a 2 km thick glacier. Penetration of up to 75 feet has been reported for water saturated, clean sands in a Massachusetts glacial delta using a commercial antenna. Signal penetration in saturated clays, on the other hand, is on the order of magnitude of a few inches. Olhoeft (1986a) determined that even 5% clay added to a clean sand and gravel will cause a decrease in penetration by a factor of 20. Salt water is also a high loss substance, as signal penetration in sea water is less than a foot. It is important to note that in a layered medium a single, highly reflective layer alone can limit signal penetration by preventing the propagation of energy through it. In this instance the apparent loss of energy is caused by reflection rather than by signal attenuation.

B. Applications and Uses

Ground penetrating radar (GPR) is a shallow penetrating geophysical profiling system used where rapid and accurate surveys are desired. GPR can be used for both area and source detection studies. GPR has been used to locate underground pipes, buried drums, foundations, voids in rock and concrete, lithologic contacts, determine stratigraphy, depth to the water table, and depth to bedrock, locate buried archaeological artifacts, excavations, filled pits and lagoons, and numerous other site specific applications. GPR has been used successfully to delineate the lateral extent of plumes. Haeni et al. (1985) used GPR to investigate the thickness, type, and extent of sediments beneath a frozen lake with a 80 MHz antenna. The information acquired with GPR was used to help map the lateral extent of an aquiclude, and better estimate inputs to the mass balance equation for water budget calculations.

A GPR system can be used to determine depths to reflecting discontinuities by conducting a depth calibration. Typically, calibration is performed by moving the radar antenna over a metal target of known depth, such as a buried metal plate. Also, if transmitting and receiving antennas are housed in different units, designated as a bistatic antenna system, a common depth- point (CDP) survey, identical to surveys conducted with seismic reflection, can be used to calculate the velocity of the medium, and hence depth to the reflector. Sakayama and others (1988) describe

another method to calculate velocity from bistatic antennas where the receiving antenna is continually moved away from the stationary transmitting antenna. The velocities of the direct arrival and the first strong reflector are recalculated from the inverse slope of the time-distance display (antenna separation) on the GPR record in a similar manner as seismic refraction.

To verify GPR results, other geophysical or ground truth methods can be utilized. Haeni et al. (1985) utilized seismic refraction to correlate calculated depths of stratigraphic horizons and water tables with radar reflections. Magnetometry and electromagnetic induction methods have been utilized to verify the presence of buried drums and fuel tanks. Electromagnetic induction and electrical resistivity have been utilized to verify the lateral extent of conductive plumes. The depth to a particular reflector or target can also be verified by boreholes and/or test pit excavation.

C. Equipment

A ground penetrating radar system, shown on Figure 1, consists of.

- AC/DC power supply
- Control unit (pulse transmitter)
- Antenna(s)
- Graphic recorder
- Digital recorder (optional)
- Magnetic tape recorder (optional)
- Coaxial cable which connects the control unit to the antenna

Typically, radar antennas contain both the transmitter and receiver within one fiberglass unit. Once a radar impulse is transmitted, the antenna switches to the receiver mode and records reflected radar impulses. The pulse receiver contains an amplifier which increase the amplitude of reflected signals. Bistatic antennas (transmitter-receiver are separate) allow the coverage of larger areas with one pass, and multi-receiver combinations allow the "stacking" of radar data which increases the signal to noise ratio.

Field data are generally printed by a graphic recorder and simultaneously can be stored on magnetic tape or diskette. The graphic recorder produces a continuous time (vertical) versus distance (horizontal) profile of the subsurface for field quality control and qualitative interpretations. Radar impulses are synchronized with the swept-stylus type graphic recorder, producing a dark band proportional to the amplitude of reflected radar signal. Because the antenna is moving, each pass of the stylus represents a slightly different antenna position. Gradually, as the recorder paper advances under the moving stylus, a pattern of reflective interfaces emerges.

Storage of data on diskette or magnetic tape allows opportunity of additional printing and/or computer processing for the refinement of data. Deconvolution of stored data enhances stratigraphic reflections from the water table and soil structures (Olhoeft, 1988). Migration of data allows easier resolution of metallic targets, such as buried drums, and delineation of excavations and sinkholes (Hogan, 1988).

Radar systems are designed to use antennas of various electrical characteristics. Selection of the antenna is dictated by the requirements of the survey. If high resolution, near-surface data are desired, a small, high frequency antenna is used; if the survey requires deeper probing, a larger, lower frequency antenna is used (80, 120, 250, 300, 400, 500, 900, and 1,000 MHz antennas are commercially available). The drawback of using the lower frequency antennas is that resolution of data is sacrificed for penetration. Also, the low frequency antennas (less than 250 MHz) are generally not shielded, making them susceptible to overhead power line noise and spurious reflections from passing cars. The 900 and 1,000 MHz antennas are used almost exclusively for short penetration projects such as the detection of rebar in concrete, as their penetration is generally limited to 2 to 3 feet.

D. Field Procedures

The majority of time involved with any GPR survey is spent establishing survey lines in the area of investigation so that detected anomalies can be easily located and excavated. Survey lines should be set to maximize coverage, while maintaining a grid spacing proportional to the presumed target dimensions. A minimum survey line spacing of 10 feet is desired when looking for a 1,000 gallon fuel tank, while a larger spacing of 50 feet or more may be used to define the lateral extent of a conductive plume.

At the onset of any GPR survey the radar control unit should be adjusted for the anticipated depth of penetration. Adjustments of the time window of exploration should be made by estimating the velocity of the medium and desired depth of penetration. Most surveys can be effectively conducted with a minimum time window of 50 nanoseconds.

Accurate determination of the depth to any layer requires calibration of the radar system. The easiest way of calibrating the GPR system to specific settings is by burying a plate at a measured depth, and moving the antenna slowly along the survey line. The plate will produce on the GPR record a thick, dark band, parabolic or flat in shape, with many multiple reflections beneath it. Once a certain confidence level is attained from depth calibration, the survey is conducted by slowly pulling the antenna along survey lines. A slow walking pace increases the horizontal resolution as radar signals are propagated in a 15 to 45 degree cone from the bottom of the antenna. A slow walking pace is recommended for hazardous waste investigations as targets are better defined and easier to resolve. On the other hand, the radar antenna can be towed from the back of a car or truck at speeds up to 10 miles an hour if the "target" is a continuous reflector, such as the water table.

E. Interpretation

A typical GPR record is shown on Figure 1. A representation of a single GPR signal pulse is shown along the side of the record. The horizontal scale of the record is maintained by marking on the record the locations of survey stations as they are reached by the antenna. Accurate determination of the vertical scale (i.e., conversion of a time into a depth) requires calibration of the radar system. If the depth to a known reflector can not be determined through calibration or verification using boreholes and test pits, the velocity of the medium can be approximated from

relationships involving the velocity of the medium, and the dielectric constant (real dielectric permittivity) of the medium. Values of the dielectric constant can be found in GSSI (1974), and Kutrubes (1986). It is important to note that the relationship is no longer valid when signal losses are great. The depth to the reflector can be calculated from time and velocity values.

Interpretation of GPR data is subjective, even among experienced interpreters. The strength of a reflected signal and/or the continuity of that reflector across the record may be indicative of a stratigraphic contact. The water table in an unconfined sand and gravel aquifer may also produce a similar signature on the GPR record. The strong continuous reflector shown in Figure 2 delineates the contact between bedrock and unconsolidated materials. Point targets, such as buried drums, pipes, boulders, tree stumps, etc., create a distinctive parabolic feature on GPR-records. Positive identification of point targets are subjective, as the GPR signature of a pipe is similar to that of a large boulder.

Figure 3 shows the characteristic parabolic signal created by a point target, underground storage tanks in this instance, which are situated in a clean sand and gravel deposit. Metallic objects, such as buried drums and pipes, also produce a characteristic parabolic signal on the record, and sometimes produces a "ringing" noise, denoted by the heavy, dark banding, as shown in Figure 3.

Recorded data from diskettes or magnetic tapes can be enhanced using numerous computer processing methods to remove constant noise problems, such as ringing, or to sharpen up geologic contact features and point target boundaries. Such methods are described in detail by Hogan (1988) and Olhoeft (1988). Computer processing is costly and generally not necessary in most instances.

F. Advantages/Disadvantages

Advantages of ground penetrating radar systems include:

- Rapid coverage of an area
- GPR is a non-destructive technique
- Portable equipment
- Provides high vertical resolution **profiles** in the field for immediate interpretation

Ground penetrating radar provides a cost effective way of evaluating a large site in a short amount of time. One day of work coverage completed by GPR may be equivalent to four or five days of work with seismic refraction or electrical resistivity. The GPR method is "nondestructive" in that it does not require any excavation or probing of the overburden materials, although verification of anomalies should be conducted.

Equipment can be easily loaded in the back of a truck as most pieces comprising the radar system weigh under 40 pounds. The 80 MHz antenna weighs about 100 pounds and is less portable as it is approximately 4 feet wide.

Limitations of radar systems include:

- Survey lines must be cleared to ground level
- Multiple receiver antennas are generally required to stack and process radar data
- Penetration is site specific, requiring data corroboration using alternative geophysical methods and/or verification
- Interpretations are subjective

To maximize resolution and minimize scattering losses, survey lines must be as level as possible to prevent the bouncing and jarring of the radar antenna. Survey lines cleared of debris also allow the antenna to be pulled at an even, continuous pace, permitting the easy determination of horizontal scale.

Application of GPR to a site is limited by soil type and presence of high loss materials. In New England, the presence of glacial tills, and lacustrine and marine clays limit the depth of penetration. Delineation of buried drums beneath a conductive plume also may not be possible. The unpredictability of radar effectiveness requires that site investigations be conducted with alternative geophysical methods, such as electromagnetic induction, seismic refraction, magnetometry, and/or electrical resistivity.

VI. Quality Assurance Records

All data will be recorded in field log books with the following information: date, location, personnel on site, start and finish times (in military time), instrument gain and time settings, and Contract Task Order number.

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STANDARD OPERATING PROCEDURE

Electromagnetic Induction

I. Purpose

The purpose of this SOP is to provide general reference information for using electromagnetic induction (EM) methods.

II. Scope

This SOP provides a description of field procedures, equipment, and interpretation methods necessary to fully utilize this procedure.

III. Definitions

Conductivity - Ability of a material to transmit an electrical current. Inverse of resistivity.

Horizontal dipole mode - Transmitter and receiver coils oriented vertically.

Vertical dipole mode - Transmitter and receiver coils oriented horizontally.

Vertical sounding - Multiple EM measurements centered at a point with varying coil spacings.

Vertical profiling - EM measurements along a traverse with a fixed coil spacing and coil orientation.

IV. Responsibilities

Project Manager - The Project Manager is responsible for ensuring that the project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed. The Project Manager is responsible for ensuring that the personnel operating and interpreting the geophysical data are trained, skilled in that endeavor, so far as to receiving documentation on the training and experience of the operating personnel.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the geophysical technique and equipment to be used. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that the field investigation personnel performing the activities have been briefed and trained to execute these procedures.

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

and the Project Manager. Field personnel are responsible for the proper acquisition of geophysical data.

V. Procedures

A. Overview

Electromagnetic Induction (EM) methods are non-intrusive geophysical techniques of measuring the apparent conductivity of the subsurface materials. Electrical conductivity values of subsurface materials are determined by transmitting a high frequency electromagnetic (primary) field into the earth and measuring the secondary electromagnetic field produced by the eddy current as illustrated in Figure 1. The transmitter and receiver coils do not require direct ground contact thus permitting continuous profiling and rapid data acquisition.

The strength of the secondary field is a function of the inter coil spacing, operating frequency and ground conductivity. The ratio of the secondary to the primary magnetic field is directly proportional to the terrain conductivity which enables direct instrument readout of apparent conductivity values (measured conductivity values are the bulk average conductivity for the area or volume of earth sampled). Conductivity ranges typical of various earth materials are shown on Figure 2. EM conductivity values are usually expressed in units of milliohms per meter. Conductivity values are converted to resistivity values in ohm-meters by use of the following relationship:

$$\text{resistivity (ohm - meters)} \quad \frac{1{,}000}{\text{EM instrument readout (milliohms per meter)}}$$

The apparent conductivity of the subsurface materials is dependent upon subsurface conditions such as:

- Lithology
- Porosity
- Permeability
- Conductivity of subsurface pore fluids

Changes in these parameters causing measurable variations in electromagnetic conductivity can result from:

- Conductive contaminant plumes
- Abandoned trenches and lagoons
- Lateral changes such as backfill or landfill materials
- Bedrock fracture zones
- Lithological variations
- Buried metallic objects

The sampling depth or depth of investigation is related to the coil spacing and coil mode. The two coil modes used are the vertical dipole mode (coils horizontal) and the horizontal dipole mode (coils vertical). Figure 3 shows the relationship of the coil spacings, mode and relative responses.

Two common terrain conductivity meter are EM-31 and the EM-34-3. The EM-31 has a fixed intercoil spacing of 3.7 meters and an effective depth of penetration of approximately 6 meters. The EM-34-3 has two coils which can be separated by 10, 20, or 40 meters and can be oriented in either the horizontal or vertical dipole modes, Intercoil separations increase the effective depth-of investigation as shown below.

Intercoil Spacing (meters)	Depth of Investigation (meters) Horizontal Dipoles	Vertical Dipoles
10	7.5	15
20	15	30
40	30	60

The coil orientation (horizontal or vertical) allows the EM-34-3 to respond to materials of different depths.

Vertical sounding and horizontal profiling are the two EM survey techniques. Vertical profiling is accomplished by multiple measurements about a point with varying coil spacing. Horizontal profiling is performed by making measurements along traverses with a fixed coil spacing. General discussions of electromagnetic induction methods are presented in texts by Grant and West (1965), Telford and others (1976), and Griffiths and King (1981).

B. Applications and Uses

The measurement of subsurface conductivity at a hazardous waste site provides a valuable contribution to site characterization. The conductivity (resistivity) of the hydrogeologic section is predominantly influenced by the pore fluids. Consequently, conductivity measurements provide indirect information on the porosity and permeability of subsurface materials, the degree of saturation, and the conductivity of the pore fluids. The conductivity of the pore fluid is influenced by the presence of dissolved electrolytes. Contaminant plumes in the unsaturated and saturated zones can be mapped provided there is a sufficient change in the conductivity to be detected by the EM instrument. Generally, contaminant plumes of inorganic waste are easily detected because the pore fluids often have conductivity values as much as three orders of magnitude above background values. Figure 4 illustrates an EM anomaly associated contamination plume. EM conductivity measurements can also be used to detect the presence of buried waste; filled disposal trenches, and buried metal objects such as drums, tanks or metal debris. Figure 5 illustrates an EM anomaly over a buried metal object. Electromagnetic surveys can be used to locate conductive as well as and non-conductive bodies. The many applications include:

- Contaminant plume mapping
- Locating abandoned trenches and lagoons
- Delineating bedrock fracture zones
- Determining thickness of weathered layers
- Lithology mapping

- Locating buried metallic objects
- Lateral anomalies such as pockets or pits of different materials

Examples of EM applications at sites where groundwater is contaminated are presented by Duran (1982), Greenhouse (1983), and Greenhouse and Slaine (1983).

C. Equipment

The two-coil EM instrument and the VLF (very low frequency) instrument are basically the two different types of electromagnetic surveying instruments in use; each is capable of sensing to different depths. There are several models and manufacturers of this equipment.

The two-coil system consists of a transmitter coil and a receiver coil. Refer to Figure 1 which illustrates the basics of a two-coil electromagnetic induction apparatus. The transmitter coil induces an electromagnetic field of known strength and the receiver coil measures the resulting quadrature, or ratio of primary to secondary fields resulting from subsurface features. Each instrument is read directly in units of milliohms per meter (conductivity). EM readings represent the average bulk conductivity at a point halfway between the two coils.

The VLF instrument is a receiver which relies on specialized, very low frequency communication antennas for induction of an electromagnetic field. Surveying with the VLF or equivalent instrumentation is commonly referred to as VLF surveying.

The VLF Instrumentation is a small, lightweight hand-held instrument which can be operated by one person. Principal components of the instrument are a pair of mutually perpendicular coils and a receiving crystal with a frequency specific to a transmitting antenna. The two receiving coils are used to measure local characteristics of the primary induced field and any secondary fields emanating from bodies of variable conductivity. Typical sources of induced electromagnetic fields for VLF surveying are the very low frequency antennas used for submarine communications.

D. Data Acquisition

The advantage of the EM survey method is the speed and accuracy with which lateral changes of terrain conductivity can be measured. The EM conductivity data can be acquired using sounding and profiling techniques similar to those used in electrical resistivity. EM profiling is accomplished by traversing an area with a fixed coil spacing and orientation; EM sounding is accomplished by expanding the inter-coil spacings in a manner similar to that used by electrical resistivity soundings. Some commonly used EM equipment is limited in the number of available inter-coil spacings that can be used; however, there are other EM instruments available that can operate at many coil spacings and frequency ranges to provide numerous sounding data points necessary for accurate computer modeling and profiling.

The factors determining which instrument is used and what the grid spacing should be at particular sites are:

- Depth to target and size of target
- Accessibility of the site

- Effects of manmade structures and utilities, such as electric power lines
- Conductivity of the earth materials

EM induction instruments may have a depth of investigation of up to 200 feet depending upon coil spacing and orientations used (see Figure 3). The very low frequency VLF device has the greatest depth of investigation and is generally used to evaluate large geologic structures.

In conducting a VLF survey, VLF readings should be acquired with the instrument oriented perpendicular to a straight line from the site to the transmitter antennas. This orientation is necessary to ensure optimum data quality. All readings from a particular VLF station must be obtained with the instrument oriented in the same direction.

For an EM induction survey, a regular pattern of survey stations will provide coverage of the area in question. Typically, use of a grid spacing which is approximately equal to the size of the target sought by the survey, and a coil spacing with a maximum response for the depth of interest will produce satisfactory results. Specific needs for local detail, however, may require a refined coverage. The chosen spacing should always be site and target specific.

In conducting an EM survey, the field operator must avoid or note any potential sources of anomalous (noise) conductivity values such as power lines, buildings, fences, buried pipelines or any other large metal objects. Noise sources should be noted on the profiles or contour maps accounting for anomalies due to these known sources.

Important information that should be known for planning and before conducting an EM conductivity survey are: assumed hydrogeologic characteristics of the site, potential source locations and migration paths, characteristics of the hazardous substance of interest, and depths of interest. The level of detail necessary (size of object of interest and detail of resolution) determines the number of lines and station spacings of readings required.

EM data, if not recorded on a strip chart or digital recording instrument, should be recorded on standardized data sheets. At a minimum all data (strip chart, digital disks, or standard forms) should have the following information listed:

- Project/site location identification
- Company
- Date and time
- Operators name
- Instrument make, model
- Coil spacings and configuration
- Line and station numbers
- Instrument reading scales
- Weather conditions/temperature

E. Interpretation

1. Data Analysis

In general, electromagnetic survey data require relatively little processing before they can be interpreted. This is especially true for fixed coil spacing surveys because the data are recorded in units of conductivity; preliminary interpretations are made by comparison of conductivity values. A contour map can be prepared from the data and compared with results of other surveys. EM instruments also can be used for vertical soundings similar to resistivity sounding. Vertical sounding with EM equipment, however, has lower resolution than that performed with the resistivity technique. As a result, EM data are generally more useful for continuous profiling surveys.

VLF instruments do not read directly in units of conductivity. The in-phase measurement (the tilt of primary induced field) is read in terms of the tangent to the angle of tilt and is given as a percentage. Quadrature measurements, which are the ratios of voltage required to equalize the primary to secondary signal strengths, are also given as percentages. For field interpretation these two sets of data can be plotted in profile form, percentage versus distance. Greenhouse and Slaine (1983) describe a simple mathematical conversion so that VLF data can be presented in contour format and compared to other available data such as resistivity and magnetics. Digital data acquisition systems are now available that allow calculation of conductivity.

2. Presentation of Results

Results of an EM conductivity survey can be presented in profile and/or contour map form. The orientation of the traverses should be indicated on profiles in lines of coverage on contour maps. Locations of observed surface metal and other cultural features such as topography, buildings, fences, power lines etc. should be noted on both the profiles and the contour maps.

3. Interpretation

EM conductivity data can be analyzed qualitatively and quantitatively. Generally, profiling data are presented as a contour map or profiles. Profile lines should be stacked and aligned. A qualitative analysis of the contour map or aligned profiles usually can allow an interpreter to identify any conductivity trends that may be indicative of buried metal, groundwater flow and contaminant transport. A comparison of available geologic data, cultural ferrous metal and debris maps prepared during data acquisitions should be made to evaluate the causes of any conductivity trends observed.

Computer or chart comparisons of EM sounding data with available theoretical models can be made. This type of interpretation is similar to that used in electrical resistivity, but in EM sounding it is limited to relatively simple hydrogeologic conditions.

F. Advantages and Limitations

Advantages of the electromagnetic induction method include:

- No ground contact required
- Rapid data acquisition (faster than resistivity)
- Lightweight, one or two man operation
- Wide range of applications
- High lateral resolution
- Field interpretation possible

Limitations of the electromagnetic induction method include:

- Limited dynamic range l-1,000 milliohm/meter
- Susceptible to effects of man-made structures, utilities, etc.
- Less vertical resolution than resistivity
- Limited penetration
- Does not distinguish even simple layering without more complex application and interpretation
- Setting and maintaining instrument at zero

VI. Quality Assurance Records

Field data will be recorded in log books and/or data recording sheets accompanying the monitoring equipment. Data recorded in a field log book will be entered with the following data: date, site location, Contract Task Order number, personnel conducting the investigation, time (military time), start time and end time, weather.

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STANDARD OPERATING PROCEDURE

Gravimetry

I. Purpose

The purpose of this SOP is to provide general reference information for using gravimetric methods.

II. Scope

This SOP indicates a description of field procedures, equipment, and interpretation methods necessary to fully utilize this procedure.

III. Definitions

Bouguer slab - A slab of infinite horizontal extent, constant density and thickness

Bouguer anomaly - Gravity value after the observed (measured) gravity has been corrected for latitude, free-air, Bouguer slab and terrain.

Complete Bouguer anomaly - Gravity value after the observed (measured) gravity has been corrected for latitude, free-air, Bouguer slab and terrain.

Simple Bouguer anomaly - Gravity value after the observed (measured) gravity has been corrected for latitude, free-air, and Bouguer slab.

Earth tides - Variations in the gravitational attraction of the sun and the moon as their positions change with respect to the earth, (maximum amplitude 0.3 gal occurring in a period as short as an hour).

Residual gravity map - resulting gravity map after regional gravity affects are removed from Bouguer anomaly values.

The international gravity value - Equation that accounts for the fact that the earth is not a perfect sphere, but is more like a perfect fluid for which balance is maintained between the gravitational forces tending to make it spherical and the centrifugal forces of rotation tending to flatten it. As a result, the equatorial radius is approximately 21 km greater than the polar radius.

IV. Responsibilities

Project Manager - The Project Manager is responsible for ensuring that the project-specific plans are in accordance with these procedures, where applicable, or other approval procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that the field investigation personnel performing the activities have been briefed and trained to execute these procedures.

V. Procedures

A. Overview

The gravity survey method is a passive - geophysical technique which measures extremely small variations in the earth's gravitational field, using a highly sensitive instrument. Observed gravity measurements are variations of the earth's true gravitational attraction from one location on the earth's surface to another (Dobrin, 1960). Spatial variations in the value of observed gravity depend upon a number of factors including:

- Lateral density variations of earth materials in the vicinity of an observation point
- Elevation
- Latitude
- Surrounding terrain variations (topography)
- Tidal fluctuations

In gravity exploration the variation in density is the only significant factor (Telford, 1978). Lateral variations in the distribution of mass in the earth's crust produce distortions or differences in the gravitational field. Tectonics, faulting, erosion, deposition and other geologic movement involving rock often result in lateral density variations in the subsurface rocks. Measured gravitational differences are interpreted in terms of probable subsurface mass distributions, which are inferred from surface and near surface geologic conditions (Nettleton, 1975).

The acceleration of gravity at the earth's surface is approximately 980 centimeters per second squared or 980 gals. In gravity exploration work, anomalies as small as one ten - millionth of the earth's field are detected with gravimeters. The unit used in exploration gravity surveying is the milligal (10-3 gals). Microgravimeters are more sensitive instruments which can detect smaller magnitude anomalies, measured in the unit of microgals (10-6 gals).

B. Applications and Uses

After the appropriate corrections have been made, gravity values can be presented as Bouguer anomalies. A Bouguer anomaly map (Figure 1) looks very much like a topographic contour map. Bouguer anomalies are interpreted in terms of the size, shape and position of the subsurface structures. Microgravity measurements can be used to detect the following conditions:

- Joints
- Dissolutions
- Collapses

- Cavities
- Buried river channels
- Fault scarps

C. Equipment

The Lacoste - Romberg and Worden gravimeters are two commercially available gravimeters. The Lacoste - Romberg Model D is the only commercially available microgravimeter. These instruments measure the elongation of a spring which supports a weighted beam. An increment of elongation of the spring is proportional to an increment of gravity. The principal of operation of a Lacoste -Romberg microgravimeter is illustrated in Figure 2.

The Lacoste-Romberg gravimeter is heated to maintain a constant instrument temperature and, consequently, a more sensitive and stable reading. Some instruments are not temperature controlled and, consequently, instrument temperatures must be noted and corrected for. Gravimeters with heaters require a portable energy source (batteries) and must have an appropriate warm up time (approximately one day) to acquire stable, accurate readings.

D. Field Procedures

The gravimeter itself can be operated by a single operator. The topographic survey can be performed before, during, or after the gravity measurements.

The operation of the instrument is rather straightforward, but acceptable levels of accuracy require meticulous attention to details, such as:

- Instrument leveling
- Surveyed location
- Surveyed elevation
- Instrument drift
- Time of measurement

Survey accuracies of at least one-tenth of a foot of elevation, and horizontal accuracy of approximately 2 feet are required for microgravity surveys. The high level of accuracy required in gravity surveys dictates repeated readings at a base station throughout the period of the survey to compensate for time variations (drift) inherent in all instruments. Typically, base station readings are taken at least three times a day and often are repeated in one-hour intervals. Loop times for microgravity instruments that have been recently reheated to operating temperatures initially should be at about 30 minutes intervals. Loop times can then progress up to a maximum of 1 hour. Initial short loop times are to minimize errors due to mechanical adjustments caused by internal thermal stress. Microgravity instruments with fluid levels should have 30 second levels rather than 60 second levels. The 30 second levels provide a more precise leveling accuracy.

At each station the gravimeter is set on a metal tripod which provides a stable base. The instrument is leveled by two horizontal and mutually-perpendicular levels in the instrument. Three readings are commonly taken at each station. Levels checked between readings to ensure data quality and minimize operator error.

Important information that should be recorded in field note books are:

- Instrument identification number
- Date and time of reading
- Operator
- Station identification number
- Base station location
- Instrument readings

To assure correlation between data sets, the relative gravity for each base station can be established by looping with absolute base stations which are part of an international gravity network adjusted to the 1979 Potsdam value. A listing of absolute base station locations can be obtained from NOAA in Washington, D.C.

Gravity stations are arranged either in gridded survey patterns or in linear traverses. Gridded survey patterns provide more detailed information, but at a higher cost due to the higher number of stations.

Precautions should be taken in locating gravity stations to avoid whenever possible areas with nearby (50 + feet) severe topographic changes. These topographic changes affect gravity measurements. Hills rising above the gravity station and valleys (lack of material) affect the gravity measurements by reducing the recordings due to upward attraction of hills or lack of downward attractions by a valley (Telford). Earthquakes and other vibratory phenomena also can adversely affect gravity readings. Generally, when an earthquake has occurred the instrument reading beam may drift and cannot be stabilized. Depending on the distance to and magnitude of the earthquake, gravity measurements should be suspended for a few hours or Fail -the next day. Another potential problem in conducting a gravity investigation is unstable ground materials such as loose sand, nearby sources of vibration (heavy truck traffic, construction equipment, etc.) or stone ballast. Generally, these situations can be overcome with patience, slight changes in station locations or altering the time of day in which the investigation is conducted.

E. Interpretation

1. Data Analysis

Gravity data obtained in the field must be corrected for:

- Instrument drift
- Earth-tide variations
- Elevation
- Bouguer slab
- Latitude
- Influence of surrounding topographic (terrain) variations

All gravity stations within a common data set must be reduced to a common elevation datum plane. Sea level is the most often used datum plane.

Instrument Drift and Earth-Tide Variations

The observed gravity for each station is determined by looping with a base station with a known gravity value and correcting readings for instrument drift and earth tide variations. Instrument drift and earth tide variations are calculated by dividing the difference in the base station readings (end of loop minus beginning of loop) by the time required to complete the loop. Each station reading is then corrected by adding the drift factor by the time between stations. Observed gravity values are then calculated by multiplying the corrected meter reading difference between the base and the gravity station by factors unique to the particular gravity meter.

Elevation Correction

Since gravity varies inversely with the square of distance, it is necessary to correct for changes in elevation. Correction for elevation or the free-air correction compensates for elevation variations between stations so that all the field readings are reduced to common datum surface. Sea level is the common datum surface used for the free-air corrections. When the gravity stations are above the datum plane, the free-air corrections are added to the observed gravity values (Telford, 1978).

Latitude Corrections

Latitude corrections compensate for the centrifugal acceleration due to the rotation of the earth and radius variation between the poles and equator. Maximum latitude corrections occur at latitude 450 where the variation is approximately 0.01 milligals per 40 feet of north-south displacement.

The International Gravity Formula of 1967 incorporates the latitude correction in the calculation of theoretical gravity. When gravity stations are north of the reference latitude, all corrections are subtracted from the observed gravity values (Telford, 1978).

Bouguer Slab-Correction

The free-air correction accounts for elevation differences, but not for attraction of the material between the station and the common datum surface. The Bouguer correction accounts for the attraction of this material. Bouguer corrections assume a slab of infinite horizontal extent.

A commonly used slab density in New England is 2.67 g/cm , which is the approximate density of the granitic crust. Bouguer corrections are applied in the opposite sense of the free-air corrections; that is, they are subtracted when the station is above the common datum plane (Telford, 1978).

Terrain Correction

Terrain corrections are applied to the gravity data when the topography of the surveyed area is not relatively flat. Nearby hills result in an upward component of gravity and nearby valleys result in an apparent loss of mass between the station and datum elevation. Both effects diminish the measured gravitational field, therefore, the terrain correction is always added to the data. Terrain corrections are calculated using the slab density used in the Bouguer slab correction. There are

several graphical methods for calculating terrain corrections. All require a good topographic map of the area at a minimal 10 foot contour interval. The most commonly used graphical method uses templates that divide the area into zones for which the average elevation can be estimated and the terrain correction calculated. Tables of terrain corrections, for zone charts of particular dimensions developed by Hammer (1939) facilitate this operation considerably (Telford 1976).

Theoretical Gravity

The difference between the corrected station gravity and the calculated theoretical gravity for each station is the Bouguer gravity. Theoretical gravity values are calculated using station latitudes and a relationship adopted by the International Association of Goedesy.

2. Presentation of Results

The results of a gravity survey can be presented as contour maps or as profiles depending upon the data processing and/or interpretation techniques. A raw-data map presents the gravity readings that have been corrected for instrument drift and earth-tide effects. A free-air gravity map is the raw data corrected for station elevations (reduced to a common elevation datum). A simple Bouguer map is the free-air gravity values corrected for the Bouguer slab. A complete Bouguer map is the simple Bouguer values corrected for terrain variations. Residual anomaly map is the residual gravity values after regional gravity affects have been separated. Data processing procedures to prepare each of the above mentioned maps include assumptions that may or may not be true and may bias the interpretation of the gravity data. Therefore, the preparation and qualitative analysis of these maps may be necessary to identify any bias or anomalies that may be created due to the data processing calculations.

Interpreted gravity results are presented as 2-D, 2 1/2-D or 3-D profiles or maps. The 2-D results assume infinite lengths in the 3rd dimension, 2 1/2-D results have a finite length in the 3rd dimension and 3-D modeling results have 3 dimensional geometric shapes.

3. Interpretation

The complete Bouguer anomaly map represents the contribution of all earth materials that exist beneath the ground's surface. Therefore, the first step in the interpretation of gravity data is to separate the anomaly components arising from the source of interest from the sources of no interest. This step is called the regional residual separation and it is the residual values that are of primary interest.

The residual or shorter wavelength gravity data can be separated and modeled independent of the deeper-seated, longer wavelength regional gravity data. The residual data can be separated from the regional data in a number of ways. The averaging method, polynomial fitting, and upward continuation and wavelength filtering regional residual separation methods are a few. Text books such as Telford (1976), Nettleton (1976) etc. explain in detail regional residual separation methods.

There is extensive literature on the subject of and significant problems involved in regional residual separation. The techniques listed above are some of the more common techniques used. The choice of the method used for removing the regional, depends upon many factors, the most important being the total labor involved, the complexity of the gravity map, the density and distribution of the stations and quality of the data.

The residual gravity maps are a by-product of the regional residual separation. These maps are used to predict the physical characteristics and proximity of near surface anomalous bodies.

Before a quantitative interpretation is attempted, a qualitative analysis of the data should be made to determine the presence of anomalous sources and to get a general idea of depth, strike, and density of sources. Qualitative analysis includes an evaluation of the polarity, magnitude, gradient and trends of residual anomalies, as well as a comparison with other available geophysical (magnetic, seismic, electrical) and geological data.

Based on the qualitative analysis of the regional map a quantitative interpretation to determine possible individual sources of the anomalies can be undertaken. The quantitative interpretations are accomplished using 2 and 3 dimensional computer modeling techniques. Each anomaly body is assigned a geometric shape and a value which represents the bodies contrasting density values. All gravity interpretations benefit from incorporation of geologic constraints. Such constraints can come from surface geology, geomorphology, subsurface geology, boring logs, seismic reflection and refraction data, magnetic surveys, and geochemical data.

Interpretation of gravity data is subject to two limitations:

- The inherent ambiguity in the possible source of a given gravity anomaly.
- The complete dependence of gravity anomalies on the existence and magnitude of horizontal variations in the density of the rocks.

For a given distribution of gravity there is no single, unique distribution of mass which will have a calculated effect that corresponds to the observed gravity. That is, for a given width of anomaly there is a corresponding maximum depth and a cone of possible sources, as illustrated in Figure 3.

F. Advantages and Limitations

The advantages of a gravity survey are:

- Field work can be carried out by one to three persons in any accessible area, including highly developed urban and industrialized sites, over pavements, fills, landfills, on lake ice, inside buildings, etc.
- Instrumentation is portable, the work can be silent and produce no visible disturbance to an environment other than stakes or other station markings.

- The method lends itself well to areal coverage. Contour maps of bedrock or other features have obvious advantages over information at points or along profiles.
- Used appropriately, it is highly cost effective either by itself or in combination with other exploration methods.

The limitations of a gravity survey are:

- Applications are limited to mapping of density - dependent interfaces
- Accurate station locations and elevations are necessary.
- Calibration with geological "knowns" such as outcrops, borings, seismic profiles, etc. is necessary for quantitative work.
- Excessive topography, access problems, and certain bedrock complexities may seriously limit the accuracy of data interpretation.

VI. Quality Assurance Records

All data will be recorded in log books under the following format: date, start and end time (military time), personnel on site, Contract Task Order number, and weather.

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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.

STANDARD OPERATING PROCEDURE

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 stetting 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.

STANDARD OPERATING PROCEDURE

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 Check Items

Be sure appropriate preservatives are used.

STANDARD OPERATING PROCEDURE

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

Field Filtering

I. Purpose

To provide a general guideline for the field filtering of water samples for dissolved metals analysis.

II. Scope

This is a general discussion of the standard method of field filtering techniques. Operating manuals should be consulted regarding specific procedures.

III. Equipment and Materials

- Geotech® filtering apparatus or equivalent
- Pump
- Nitric acid (HNO_3) solution - high grade - reagent grade not acceptable
- Glass fiber prefilters
- Vacuum source
- 45 µm cellulose acetate filters
- Inline filters

IV. Procedures and Guidelines

A. REAGENT PREPARATION

1. Prepare 10% HNO_3 solution: Add about 900 ml of ASTM Type II water to a 1 liter Erlenmeyer flask. Using a graduated cylinder, ASTM Type II, add 100 ml concentrated HNO_3 to the DI water while stirring.

B. PROCEDURE

1. Attach a vacuum source (pump, syringe, etc.) or a QED® online filter or equivalent to the receiver assembly.

2. Flush the entire filter system with 10% HNO_3 solution. Open assembly, discard rinsate, and reassemble unit.

3. Flush the entire filter system with 60 ml ASTM Type II water. Open assembly, discard rinsate and reassemble unit (not required when using QED® online filter).

4. Filter sample and transfer to polyethylene bottle (with preservative) for shipment.

5. Discard filter assembly and prefilter.

V. Attachments

None.

VI. Key Checks and Items

- 10% HNO_3 solution for cleaning
- All water must be ASTM Type II
- Prefilter with glass fiber filters if sample is turbid
- Record lot number of nitric acid and water
- Note monitoring wells with high concentrations of suspended solids in field notebooks
- The equipment blank collected with the sample is called a filtration blank and is collected through the filter.

STANDARD OPERATING PROCEDURE

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.

Packaging and Shipping Procedures

I. Low-Concentration Samples

A. Prepare coolers for shipment:

- Tape drains shut.
- Affix "This Side Up" labels on all four sides and "Fragile" labels on at least two sides of each cooler.
- Place mailing label with laboratory address on top of coolers.
- Fill bottom of coolers with about 3 inches of vermiculite.

B. Arrange decontaminated sample containers in groups by sample number. Consolidate VOC samples into one cooler to minimize the need for trip blanks.

C. Affix appropriate adhesive sample labels to each container. Protect with clear label protection tape.

D. Seal each sample bottle within a separate ziplock plastic bag or bubble wrap, if available. Tape the bag around bottle. Sample label should be visible through the bag.

E. Arrange sample bottles in coolers so that they do not touch.

F. If ice is required to preserve the samples, cubes should be repackaged in zip-lock bags and placed on and around the containers.

G. Fill remaining spaces with vermiculite.

H. Complete and sign chain-of-custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or the courier.

I. Separate copies of forms. Seal proper copies (traffic reports, packing lists) along with a return address label within a large zip-lock bag and tape to inside lid of cooler.

J Close lid and latch.

K. Carefully peel custody seals from backings and place intact over lid openings (right front and left back). Cover seals with clear protection tape.

L. Tape cooler shut on both ends, making several complete revolutions with strapping tape. **Do not** cover custody seals.

M. Relinquish to Federal Express or to a courier arranged with the laboratory. Place airbill receipt inside the mailing envelope and send to the sample documentation coordinator along with the other documentation.

II. 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. First, a special airbill including a Shipper's Certification for Restricted Articles is required. Second, "Flammable Liquid N.O.S." or "Flammable Solid N.O.S." (as appropriate) labels must be placed on at least two sides of the cooler. Third, sample containers are packaged in metal cans with lids before being placed in the cooler, as indicated below:

- Place approximately ½ inch of vermiculite in the bottom of the can.
- Position the sample jar in the zip-loc bag so that the sample tags can be read through the plastic bag.
- Place the jar in the can and fill the remaining volume with vermiculite.
- Close the can and secure the lid with metal clips.
- Write the traffic report number on the lid.
- Place "This Side Up" and "Flammable Liquid N.O.S." or "Flammable Solid N.O.S." (as appropriate) labels on the can.
- Place the cans in the cooler.
- For medium concentration samples, ship samples with ice or "blue ice" inside the coolers. (Double bag ice in zip-lock plastic bags.)

III. Special Instructions for Shipping Medium and High Concentration Samples by Federal Express

A. Label cooler as hazardous shipment:

- Write shipper's address on outside of cooler. If address is stenciled on, just write "shipper" above it.
- Write or affix sticker saying "This Side Up" on two adjacent sides.
- Write or affix sticker saying "ORM-E" with box around it on two adjacent sides. Below ORM-E, write NA#9188.
- Label cooler with "Hazardous Substance, N.O.S." and "liquid" or "solid," as applicable.

B. Complete the special shipping bill for restricted articles.

- Under Proper Shipping Name, write "Hazardous Substance, N.O.S." and "liquid" or "solid," as applicable.
- Under Class, write "ORM-E.
- "Under Identification No., write NA No. 9188.

C. For high concentration samples, ship samples with "blue ice" only inside coolers.

STANDARD OPERATING PROCEDURE

Chain-of-Custody

I Purpose

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

II Scope

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

III Definitions

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

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

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

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

IV 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.

V.1 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);
- 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.

V.1.1 Sample Label

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

- Project - Contract Task Order (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 identify of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site).

V.2 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.

V.2.1 Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.

- 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.

V.2.2 Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. A Chain-of-Custody Record Form example is shown in Attachment B. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below.

- Enter header information (CTO number, samplers, and project name).

- Enter sample specific information (sample number, media, sample analysis required and analytical method grab or composite, number and type of sample containers, and date/time sample was collected).

- Sign, date, and enter the time under "Relinquished by" entry.

- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used in this space (i.e., Federal Express).

- If a carrier is used, enter the airbill number under "Remarks," in the bottom right corner;

- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample shipping package. Retain the copy with field records.

- Sign and date the custody seal, a 1- by 3-inch white paper label with black lettering and an adhesive backing. Attachment C is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to

prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.

- Place the seal across the shipping container opening so that it would be broken if the container were to be opened.
- Complete other carrier-required shipping papers.

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

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

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

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

Sample Label
Chain of Custody Form
Custody Seal

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.

Field Documentation

Field Logbook

Records of field operations, sampling, and measurement will be maintained by field personnel in bound notebooks for each site. Notes in the notebooks will be made with indelible ink, and the notebook pages will be sequentially numbered. Documentation in field notebooks may include the following:

- Location
- Date and time
- Names of field crew
- Names of subcontractors
- Weather conditions during field activity
- Sample type and sampling method
- Location and depth of sample
- Sample identification number
- Sample description (such as color, odor, clarity)
- Amount of sample
- Field measurements
- Calibration results
- Equipment specifications
- Depth to groundwater
- Zones of caving
- Well installation specifications, materials specifications and dimensions
- Drilling rates
- Development water volume calculation
- Product thickness
- Stream geometry and flow rates
- Surface water conditions
- Locations of pipes, discharge pipes and tributaries
- Percent recovery
- Identification of sampling device(s) and conditions that might affect the representativeness of a sample (such as refueling operations, damaged well casing)
- Decontamination and health and safety procedures

If entries in the field notebooks need to be corrected or changed, corrections will be made by crossing out mistakes with a single line, writing the corrections and initialing and dating the entry. The use of correction fluid is not permitted.

In addition to the field notebooks, various forms will also be used to document field efforts. Forms that will be used include Chain of Custody Form, Soil Boring Log, and Groundwater Sampling Log. Soil boring logs and groundwater sampling logs will be kept to record information during boring drilling and groundwater sampling activities.

STANDARD OPERATING PROCEDURE

Decontamination of Drilling Rigs and Equipment

I. Purpose and Scope

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

II. Equipment and Materials

- Portable steam cleaner and related equipment
- Potable water
- Phosphate-free detergent such as Alconox® or Liquinox®
- Buckets
- Brushes
- Distilled organic-free water
- Methanol, pesticide grade
- 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 before the onset of drilling, prior to drilling through permanent isolation casing, and between boreholes. This will include, but is not limited to, rods, split-spoons or similar samplers, coring equipment, augers, and casing.

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

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

C. Field Analytical Equipment

1. Water Level Indicators

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

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

2. Probes

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

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. The total number of equipment blanks will be at least 5 percent of the number of samples collected during large-scale field sampling efforts.

At least one piece of field equipment shall be selected for this procedure each time equipment is washed. An attempt should be made to select different pieces of equipment for this procedure.

STANDARD OPERATING PROCEDURE

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized ("DI") water (specifically, ASTM Type II water)
- Distilled water
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) Alconox® and water solution
- Concentrated (V/V) pesticide grade methanol (DO NOT USE ACETONE)
- Large plastic pails or tubs for Alconox® and water, scrub brushes, squirt bottles for Alconox® solution, methanol and 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 Alconox® solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with Alconox® solution, remove, and discard into DOT-approved 55-gallon drum.

2. Wash outer gloves in Alconox® 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 Alconox® solution through the sampling pump.

5. Rinse with 1 gallon of 10% methanol solution pumped through the pump. (DO NOT USE ACETONE).

6. Rinse with 1 gallon of tap water.

7. Rinse with 1 gallon of deionized water.

8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.

9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.

10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Before entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with Alconox® solution.
5. Rinse with potable water.
6. Rinse with distilled or potable water and methanol solution (DO NOT USE ACETONE).
7. Air dry.
8. Rinse with deionized water.
9. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
10. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
11. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with Alconox® solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT-approved 55-gallon drum.

E. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with Alconox® 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 Navy
2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of Alconox®, methanol, and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

STANDARD OPERATING PROCEDURE

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. The drums will be filled with the drilling and well installation wastes, capped, sealed, and moved to the onsite drum storage area by the drilling subcontractor. The full drums will separate types of wastes by media. The drums will be labeled as they are filled in the field and labels indicating that the contents are potentially hazardous affixed.

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

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

B. Labels

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

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

C. Fluids

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

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

D. Solids

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

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

E. Storage and Disposal

The wastes generated at the site at individual locations will be transported to the fenced drum storage area by the drilling services subcontractor.

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

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

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

Check that representative samples of the containerized materials are obtained.

STANDARD OPERATING PROCEDURE

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

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).

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.

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.*

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.

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

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

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.

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

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 upon its removal. Should a drum contain a 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 which 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 safely 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 grapper, 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; i.e., physical condition, leaks, bulges, labels, etc. Label each drum with a unique identifying number.

3. If possible, stage drums for easy access.

4. If necessary, attach groundstrap to drums and grounding point.

5. Remove any standing material (water, etc.) from container top.

6. Using nonsparking tools, carefully remove the bung or lid while monitoring air quality with appropriate instruments. If necessary (and as a last resort), the nonsparking 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 a 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, 3 to 4 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; i.e., liquid, solid, color, viscosity, percent layers, etc.

11. When possible, sampling equipment (like glass tube) 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 is 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 has hazardous. Samples will be placed in appropriate containers and packed with ice in a cooler. Packaging, labeling, and preparation for shipment will follow procedures specified in the field sampling plan.

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

<u>Drum</u>

Glass tube	–	Procedure 1
COLIWASA	–	Procedure 2

<u>Storage Tank and Tank Trailer</u>

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

VII. Contamination Control

Sampling tools, instruments and equipment will be protected from sources of contamination prior to use and decontaminated after use as specified in SOP Decon. 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 Sample

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 which 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 safely-gloved thumb or stopper.
6. Carefully remove the capped tube from the drum and insert the uncapped end in 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 smokey 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 Sample (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 waste, it would therefore be advisable to eliminate the use of PVC materials and use samplers composed of glass or Teflon.

The major drawbacks associated with using a COLIWASA concern 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 necessary 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 replacement 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 which 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 that of the substrate and 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 as 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 constructed of forged steel with an alloy steel blade and is designed to cut the lid of a drum off or part way

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

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

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

C. Hand Pick or Spike

When a drum must be opened and neither a bung wrench nor a drum deheader is suitable, then it can be opened for sampling by using a hand pick, pickaxe, or spike. These tools are usually constructed of brass or a non-sparking alloy with a sharpened point that can penetrate the drum lid or head when the tool is swung. The hand picks or pickaxes that are most commonly used are commercially available: whereas, the spikes are generally uniquely fabricated four 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 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 which 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 and 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-day, 2-stage regulator. A high pressure air line of desired length delivers compressed air to a pneumatic drill, which 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

Civil Surveying

I. Purpose and Scope

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

II. Records and Definitions

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

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

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

III. Surveying

Horizontal Survey

Horizontal angular measurements shall be made with a 20-second or better theodolite or transit. When using a 20-second instrument the horizontal angles shall be turned four times (two each direct and inverted) with the mean of the fourth

angle being within 5 seconds of the mean of the second angle. When using a 10-second or better instrument the angles shall be doubled (once each direct and inverted), with the mean of the second angle within 5 seconds of the first angle. The minimum length of any traverse courses shall be 300 feet.

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

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

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

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

Vertical Survey

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

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

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

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

Traverse Computations and Adjustments

Traverses will be closed and adjusted in the following manner:

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

Level Circuit Computations and Adjustments

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

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

Piezometer and Monitoring-Well Surveys

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

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

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

Grid Surveys

Selected soil boring locations may be located by the survey crew after the soil borings are complete. The selected borings will be staked in the field by the field team leader. The stake will be marked with the boring number for reference. The

horizontal plane survey accuracy is ± 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

Fish Community Sampling Using Electroshocking Method

I. Purpose

To provide a general guideline for conducting fish community surveys using electroshocking equipment.

II. Scope

A standard fish survey method is provided using electroshocking methods. Site-specific details are discussed in related sections of the field sampling plan.

III. Equipment and Materials

- Field log book
- Data sheets
- Backpack electroshocker
- Boat-mounted electroshocker
- Seines
- Hip boots or chest waders
- Outer and inner rubber gloves
- Plastic bottles or containers
- Measuring board
- Cooler/Ice
- Water buckets
- Site Health and Safety Plan
- Instrument operation manuals
- Gasoline
- Formalin solution
- Waterproof labels
- Fish taxonomy keys

IV. Procedures and Guidelines

1. Fish in ponds should be collected with a boat-mounted electrofishing unit.

2. Fish in wetlands and stream habitat should be collected with a backpack electrofishing unit.

3. Sample intervals to be conducted at sample station should consist of approximately 30 minutes of shocking time or until no new fish species are collected in 10 minutes of shocking. Actual shocking time is to be recorded for each sample.

4. Fish will be collected with a long-handled dip net and placed in to a live tank or bucket.

5. Information on species, size class, location and physical condition will be recorded for each fish captured. Any physical abnormalities will be noted.

6. As soon as possible after captured measurement fish specimens will be returned to the water.

7. As necessary, selected fish will be retained and stored frozen for taxonomic verification and documentation of physical abnormalities.

8. Sampling equipment including the fish measuring board will be cleaned and rinsed between each sample station.

9. Sample stations will be mapped and information on habitat condition of each sample station will be recorded including water depth, substrate type, shoreline profile or vegetation and degree of shading.

10. Photographs of sample stations in ponds, wetlands and creek habitats should be taken to supplement written descriptions.

V. Attachments

None

VI. Key Checks and Items

- Follow recommended safety precautions in operating the fish electroshocking equipment.
- Clean sample equipment between sample stations.

STANDARD OPERATING PROCEDURE

Fish Population Sampling Using Seining Procedures

1.0 Purpose

The purpose of this SOP is to provide general reference information and technical guidance on the procedure to sample and characterize fish communities using seining procedures. The collected samples provide information used in the determination of population statistics of the fish community and can be used to collect fish samples for chemical analysis of tissues. This information will be used in the assessment of risks to human health and the environment.

2.0 Scope

This guideline provides information on proper sampling equipment and techniques for the collection of fish in shallow streams, ponds, and nearshore areas of lakes, impoundments, bays, estuaries, and ocean shoreline. This technique is more suited for use in smoothbottomed, low-sloped areas.

This procedure is not very effective when the seine is pulled over weeds and other obstructions as they may tend to roll up, and allow the fish to pass under the seine.

Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The technique described should be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methods.

3.0 Definitions

Abiotic	Non-biological components of the environment, including water body structure and
natural	or manmade disturbances.
Biotic	Biological components of the environment, including organisms and vegetation.
Bow	The front of the boat.
Reach	The designated portion of a stream or river.
Riffles	A stretch of water flowing over, rocks, debris, or shallow sediments causing a disturbance of the water.
Riparian	Along the bank of a river or lake.

Runs	A stretch of water flowing without any disturbances.
Stern	The back of the boat.

4.0 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 that deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the specific sampling techniques and equipment to be used, and documenting these in the Sampling and Analysis Plan. 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 follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager.

5.0 Procedures

The primary considerations for collecting fish for population studies include identifying sampling locations, proper sampling techniques for the haul seine and proper documentation of samples. Detailed procedures for conducting fish populations utilizing the haul seine are described in the sections to follow.

5.1 Equipment

The following list is an example of the type of equipment that generally must be on hand when collecting fish samples with a haul seine:

Seine

- Fish Measuring Board
- 0-16 oz scale, 1-4 lb scale, 1-15 lb scale
- Appropriate sampling keys for species to be sampled, and any required instruments to aid in the identification
- Live Well (large tub) with overflow pipe to outside of boat
- Field sampling data sheets
- Glass jars for storage of fish
- Formalin
- Black Permanent Marker
- Camera
- Required Personal Protective Equipment
- Portable Air Pumps

5.2 Preliminary Activities

Apply for and receive applicable scientific collection permits as required by the state. Contact local fish or game officials and inform them of your activities.

Collect and determine all information pertinent to the fish sampling project, including water depth, station locations, nearby boat access locations, known sediment contamination, any waterway obstructions or inconsistencies (e.g. shallow or grassy areas, low structures, pipe crossings), any other biological studies previously conducted on or near the site, species used locally for human consumption and the degree of such consumption, species most likely present, and the most appropriate sampling method for the species of interest that is permitted by law.

Before sampling occurs, conduct a site reconnaissance using a site map. The objective of this exercise is to categorize habitats, and map dividing lines and descriptors identifying the various types of habitats available. Make notations on the map depicting the "abiotic" characteristics of the reach including features such as pools, riffles, runs, substrate, water depth, channel shape, degree of bank erosion, tidal variations shade/sun exposure, and relative current velocity and direction. Also make notations on the site map to show "biotic" characteristics of the reach including fish species observed, evidence of fisherman use, and aquatic and riparian vegetation including wetlands. In addition, identify station locations at this point, along with the total area to be sampled. Choose the station locations, where possible, to represent ecologically similar aquatic environments.

Ensure adequate number of sample collection jars and volume of FormalinO for entire trip.

Set up a continuous flow through water system using the live wells and the pumps. Place the overflow pipes about five inches from the top of the well. Attach a mesh/screen over the inlet of the overflow pipe to prevent loss of small fish species.

5.3 Operating Procedure

Determine the area to be sampled, and mark it with flagging, if possible. Stretch the seine across the area to be sampled, with a minimum of one field personnel on either side of the seine. Ensure that the weighted side of the seine is at the bottom. Best results are achieved when the water level is no deeper than two thirds the height of the slack net.

Rapidly walk through the water at the same speed, while keeping a constant distance apart. If sampling in a stream, walk upstream against the current. As the end of the sampling area approaches, Pull the seine rapidly toward the shore, and lift the weighted end out of the water. Place the collected fish into the live wells.

If other field personnel are present, have them walk towards the seine to chase the fish in that direction. In addition, have them help to lift the seine when the sampling effort is complete.

Conduct sampling in areas that will ensure adequate qualitative and/or quantitative representation of the fish community, whichever is necessary. These areas should

include riffles/runs, shorelines, snags, natural fish holding areas, vegetation beds and other habitats.

At the end of a sampling reach, identify, measure, weigh and release the specimens. Record the proportion of individuals as hybrids and the proportion of individuals with disease, tumors, fin damage, skeletal anomalies, and any other pertinent information on a field data sheet.

At a minimal, preserve one representative fish from each species in 10% Formalin, as a voucher specimen. Record the station location, date sampled, and species name on the label.

6.0 Quality Assurance Records

Quality Assurance records will be maintained for each sample that is collected. The following information will be recorded in the Field Logbook:

- Sample identification (site name, location, project no.; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Field observations and measurements (sample setting, appearance of substrate, sampling method, and photograph descriptions).
- Additional remarks, as appropriate.

Record all observations in the Field Logbook as described in SOP F202. Complete field sheets for the collected samples.

7.0 References

Brower, 1977. James E. Brower and H. Jerrold Zar. *Field and Laboratory Methods for General Ecology*. Wm. C. Brown Company Publishers. 1977.

Ricker, 1971. Ricker, W.E. *Methods for Assessment of Fish Production in Fresh Waters*. International Biological Programme Handbook No. 3. 1971.

U.S. EPA, 1987. U.S. Environmental Protection Agency. *A Compendium of Superfund Field Operations Methods*. Office of Emergency and Remedial Response, Office of Waste Programs Enforcement. December 1987.

U.S. EPA, 1989. Warren-Hicks, William, Parkhurst, Benjamin R., Baker, Samuel S. Jr. *Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference*. U.S. EPA, Environmental Research Laboratory, Corvallis, OR 97333. March 1989.

STANDARD OPERATING PROCEDURE

Fish Population Sampling Using Gill Net Procedures

I. Purpose

The purpose of this SOP is to provide general reference information and technical guidance on the procedure to sample and characterize fish communities using gill net procedures. The collected samples provide information used in the determination of population statistics of the fish community and can be used to collect fish samples for chemical analysis of tissues. This information will be used in the assessment of risks to human health and the environment.

II. Scope

This guideline provides information on proper sampling equipment and techniques for the collection of fish in streams, ponds, and nearshore areas of lakes, impoundments, bays, and estuaries, and the ocean shoreline. This technique is most effective in slow moving streams and rivers, and open areas in lakes and impoundments. Swift moving water bodies tend to tangle the nets.

Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The technique described should be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methods.

III. Definitions

Abiotic	Non-biological components of the environment, including water body structure and natural or manmade disturbances.
Bow	The front of a boat.
Biotic	Biological components of the environment, including organisms and vegetation.
Reach	The designated portion of a stream or river.
Riffles	A stretch of water flowing over, rocks, debris, or shallow sediments causing a disturbance of the water.
Riparian	Along the bank of a river or lake.
Stern	The back of a boat.
Runs	A stretch of water flowing without any disturbances.

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 that deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the specific sampling techniques and equipment to be used, and documenting these in the Sampling and Analysis Plan. 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.

Sampling Personnel - It is the responsibility of the field 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.

V. Procedures

The primary consideration for collecting fish using gill nets is identifying sampling locations where there is a steady traffic of fish. Accurate and timely deployment and retrieval of the gill nets is a key variable in the success of the fish collection effort. Detailed procedures for conducting fish populations utilizing gill nets are described in the sections to follow.

A. Equipment

The following list is an example of the type of equipment that generally must be on hand when collecting fish samples with gill net:

- Sampling boat
- Gill nets (the size mesh is dependent on the size fish desired for collection)
- Flotation and weights to properly set the nets
- Fish Measuring Board
- 0-16 oz scale, 1-4 lb scale, 1-15 lb scale
- Live Well (large tub) with overflow pipe to outside of boat
- Appropriate sampling keys for species to be sampled, and any required instruments to aid in the identification
- Field sampling data sheets
- Glass jars for storage of fish
- Formalin
- Black Permanent Marker
- Camera
- Required Personal Protective Equipment
- Portable Air Pumps
- Field log book

- Fish scale envelopes
- Tweezers
- Additional line and couplings
- Tools (pliers, variable wrench, hammer)

B. Preliminary Activities

Apply-for- and receive applicable scientific collection permits as required by the state. Contact local fish or game officials and inform them of your activities.

Collect and determine all information pertinent to the fish sampling project, including water depth, station locations, nearby boat access locations, known sediment contamination, tidal variation, any waterway obstructions or inconsistencies (e.g. shallow or grassy areas, low structures, pipe crossings), any other biological studies previously conducted on or near the site, species used locally for human consumption and the degree of such consumption species most likely present, and the most appropriate sampling method for the species of interest that is permitted by law.

Before sampling occurs, conduct a site reconnaissance using a site map. The objective of this exercise is to categorize habitats, and map dividing lines and descriptors identifying the various types of habitats available. Make notations on the map depicting the "abiotic" characteristics of the reach including features such as pools, riffles, runs, substrate, water depth, channel shape, degree of bank erosion, shade/sun exposure, and relative current velocity and direction. Also make notations on the site map to show "biotic" characteristics of the reach including fish species observed, evidence of fisherman use, and aquatic and riparian vegetation including wetlands. In addition, identify station locations at this point, along with the total area to be sampled. Choose the station locations, where possible, to represent ecologically similar aquatic environments.

Ensure adequate number of sample collection jars and volume of Formalin for entire trip.

Set up a continuous flow through water system using the live wells and the pumps. Place the overflow pipes about five inches from the top of the well. Attach a mesh/ screen over the inlet of the overflow pipe to prevent loss of small fish species.

C. Operating Procedure

Determine the area to be sampled, and mark it with flagging, if possible. Field personnel that are setting the net should be standing on the platform on the bow of the boat. Place one end of the gill net with a weight attached to the bottom and a buoy attached to the top into the water, stretch the gill net (do not leave slack) across the area to be sampled by pulling it along with the boat. If there is a discernible flow, the net will be set in the upstream direction.

The net should remain in the sample location for 8 to 12 hours before retrieving. Field personnel that are collecting the fish should be standing on the platform on the bow of the boat. The net should be pulled slowly from the water and the collected

fish removed as the net is being removed from the water. Place the collected fish into the live wells.

Conduct sampling in areas that will ensure adequate qualitative and/or quantitative representation of the fish community, whichever is necessary. These areas should include riffles/runs, shorelines, snags, natural fish holding areas, vegetation beds and other habitats.

Upon retrieval of a gill net, identify, measure, weigh and release the specimens. Collect fish scales for aging. Record the proportion of individuals as hybrids and the proportion of individuals with disease, tumors, fm damage, skeletal anomalies, and any other pertinent information on a field data sheet.

To the extent possible, process all species in the field and return them to the stream alive. If specimens present taxonomic difficulties, or are too numerous for effective field processing, preserve them in 10% Formalin, and transport them to the office or lab for taxonomic work and measurements.

At a minimum, preserve one representative fish from each species in 10% Formalin as a voucher specimen. Record the station location, date sampled, and species name on the label.

VI. Quality Assurance Records

Quality assurance records will be maintained for each sample that is collected. The following information will be recorded in the field logbook:

- Sample identification (site name, location, project no.; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Field observations and measurements (sample setting, appearance of substrate, sampling method, and photograph descriptions).
- Additional remarks, as appropriate.

Record all observations in the field logbook. Complete field sheets for the collected samples.

VII. References

Brower, 1977. James E. Brower and H. Jerrold Zar. *Field and Laboratory Methods for General Ecology*. Wm. C. Brown Company Publishers. 1977.

Ricker, 1971. Ricker, W.E. *Methods for Assessment of Fish Production in Fresh Waters*, International Biological Programme Handbook No. 3. 1971.

U.S. EPA, 1987. U.S. Environmental Protection Agency. *A Compendium of Superfund Field Operations Methods*. Office of Emergency and Remedial Response, Office of Waste Programs Enforcement. December 1987.

U.S. EPA, 1989. Warren-Hicks, William, Parkhurst, Benjamin R., Baker, Samuel S. Jr. *Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference*. U.S. EPA, Environmental Research Laboratory, Corvallis, OR 97333. March 1989.

STANDARD OPERATING PROCEDURE

Qualitative Terrestrial Vegetation Sampling

I. Purpose

To provide a general guideline for conducting a qualitative terrestrial plant community survey.

II. Scope

A standard terrestrial plant community survey method is provided. Site-specific details are discussed in related sections of the field sampling plan.

III. Equipment and Materials

- Topographic and site area maps
- Aerial photographs
- Compass
- Data sheets
- Hand lens
- Field guides or keys
- Species list, if available
- DBH (diameter at breast height) tape
- Tape measure
- Appropriate safety equipment
- Camera
- Site Health and Safety Plan
- Field log book

IV. Procedures and Guidelines

1. Subjectively select a representative sample point within each major plant community of the site. These points may be located along preestablished transects or simply by initially cruising the site area. Selected sample points should be no closer than 50 ft. from the nearest perceptible change in the plant community.

2. Establish an appropriate size sample plot. In forested areas a sample plot of approximately 30 ft in radius will be sufficient. Other size plots may be used depending on characteristics of the community being sampled.

3. Identify the dominant species in each strata or size class as follows:

   Trees - >10 cm dbh and >20 ft tall.

Saplings - <10 cm dbh and >20 ft tall.

Shrubs - <20 ft. tall.

Herbaceous plants - nonwoody plants and ground covers.

4. Estimate the percent areal cover of saplings, shrubs, and herbaceous plants at each sample point. Determine the dbh of tree species.

5. Record information on prepared data sheets and plot the location of the sample point on a map of the site.

6. Record any signs of plant stress or other effects of possible contaminants such as wilting, discoloration, abnormal growth form or shape.

7. Photograph major plant community types and any observed signs of plant stress.

V. Attachments

None.

VI. Key Checks and Items

- Record signs of plant stress or other effects of possible site contaminants on vegetation.
- Have appropriate keys and field guides for plant identification.

STANDARD OPERATING PROCEDURE

Qualitative Mammalian Species Survey

I. Purpose

To provide a general guideline for conducting a qualitative mammal community survey.

II. Scope

A standard procedure for conducting a qualitative terrestrial mammal community survey. Site specific details are discussed in related sections of the SAP.

III. Equipment and Materials

- Topographic and site area maps
- Aerial photographs
- Compass
- Data sheets
- Hand lens
- Field guides or keys
- Species list, if available
- Appropriate safety equipment
- Camera
- Binoculars
- Site Health and Safety Plan
- Field log book

IV. Procedures and Guidelines

1. Proceed along a series of preestablished sample transects over the site, being sure to include every major plant community or habitat type.

2. Search additional areas or locations that may provide areas of mammal concentration or opportunities for observation of mammal signs such as tracks.

3. Record direct observations of mammals and any signs of mammal activity on the site including but not limited to the following:

   Tracks or foot prints

   Scats, droppings or other fecal material

   Burrows or holes in stream banks, hill sides or den trees

Leave, grass, or stick nests on the ground or in trees

Ridges, mounds, or tunnels in the ground or in vegetation

Trails or runways through the study area

Signs of grazing, browsing, rubbing, or clawing on trees, shrubs, or other vegetation

4. Photograph representative signs of mammal activity and plot the location of nests, burrow, etc., on a map of the site.

V. Attachments

None

VI. Key Checks and Items

- Look for mammal signs on the ground, in trees and other vegetation, and along wetlands and water bodies.

STANDARD OPERATING PROCEDURE

Qualitative Herpetofauna Community Survey

I. Purpose

To provide a general guideline for conducting a qualitative herpetofauna community survey.

II. Scope

A standard procedure for conducting a qualitative herpetofauna survey. Site-specific details are discussed in the SAP.

III. Equipment and Materials

- Topographic and site area maps
- Aerial photographs
- Compass
- Data sheet
- Hand trowel, hand rake, or other tool to over turn rocks and logs
- Hand lens
- Field guides or keys
- Species list, if available
- Appropriate safety equipment
- Camera
- Portable tape player and prerecorded tape recording of regional herpetofauna vocalizations
- Site Health and Safety Plan

IV. Procedures and Guidelines

1. Proceed along a series of preestablished transects over the site. Be sure transects occur within each major plant community or habitat on the site.
2. Search areas that provide specific habitats and/or opportunities for reptile and amphibian observations such as wetlands, stream banks, and pond borders.
3. Search for herpetofauna by overturning rocks, logs, and other objects, being

sure to carefully replace the objects.

4. Record direct observations of amphibians and reptiles including their sign such tracks, burrows, tunnels, etc.

5. Record observations on premade data sheets and plot significant sittings on maps of the site.

6. Schedule special observation periods following precipitation events and at evening hours to record herpetofauna vocalizations.

V. Attachments

None

VI. Key Checks and Items

- Possess appropriate field guides and keys.
- Record herpetofauna vocalizations.

STANDARD OPERATING PROCEDURE

Avian Community Survey

I. Purpose

To provide a general guideline for conducting a qualitative avian species community survey.

II. Scope

A standard avian community sampling procedure is provided. Site specific details are discussed in related sections of the SAP.

III. Equipment and Materials

- Topographic and site area maps
- Aerial photographs
- Binoculars
- Data sheets
- Species code list
- Compass
- Field guides or keys
- Species list, if available
- Appropriate safety equipment
- Camera
- Site Health and Safety Plan
- Field log book

IV. Procedures and Guidelines

1. Conduct avian surveys at preestablished sample points over the site. Sample points should be located in each major plant community or habitat type of the survey area and should be far enough apart to avoid counting the same birds twice.

2. Record all birds heard or seen from the sample point for a period of approximately 20 minutes. Shorter time intervals may be used under some circumstances.

3. Scan for birds at all levels of vegetation and take care not to record the same bird more than once.

4. Record the species, number, sex, and age if possible for all birds observed. If birds occur in flocks to large to be counted estimate the number of birds by

counting the number of birds in a portion of the group and estimating the number of portions in the entire flock.

5. Record the activity, habitat, and type of observation (i.e. seen, heard, or both) using the codes on the data sheet.

6. Birds flying over the site but not actually landing within a specific habitat type should be recorded as "fly overs." If, however, a bird flies through an area and never lands, but the observer feels it is using the particular habitat type, then record that type.

7. Record bird species using the appropriate AOU four letter code. Unidentifiable birds should be recorded with an "unknown code."

8. Surveys should be conducted between daybreak and 9:30 a.m., if possible. Surveys should not be conducted in high winds, heavy rains, or heavy fog. Weather conditions at the time of survey should be recorded on the data sheets.

9. Record other signs of bird use of the site such as stick nests, nest or roost cavities, droppings or pellets, tracks, and signs of foraging.

V. Attachments

- Standard abbreviations for common names of birds.

VI. Key Checks and Items

- Avoid counting the same bird more than once.
- Record all birds even those that cannot be identified accurately
- Record signs of bird use of the site such as nests in trees and cavities, droppings or pellets, and tracks.

STANDARD OPERATING PROCEDURE

Fish Sample Collection Procedures

I. Purpose and Scope

To provide general guidelines on collecting, preserving, and shipping fish samples for chemical analysis. Fish samples will be collected using an electroshocker. Selected fish will be analyzed as whole fish or edible tissues for parameters of interest at the site.

II. Equipment and Materials

- Sample containers: teflon baggies, sample jars, aluminum foil
- Stainless steel knife
- Stainless steel tray, fillet board
- Personal protective equipment
- Coolers
- Dry ice
- Buckets
- Labels
- Masking tape

III. Procedures and Guidelines

After being collected, fish will be placed in a live-well or equivalent until they can be processed. Processing of fish includes identification, measuring weight and length, and determining if they will be retained for analysis. Fish retained for analysis will be killed by suffocation.

Fish will be collected for both whole fish and selected tissue analysis. Fish selected for tissue analysis will be evaluated using Attachment 1 to determine if the skin should be removed. The fish will be filleted according to the attached procedure. Wastes generated during filleting will be disposed of as potentially hazardous materials. Between each fillet, the sample handling equipment will be decontaminated according to SOP Decontamination of Personnel and Equipment.

Samples for organics will be wrapped in aluminum foil with the shiny side out. The aluminum foil will be taped shut using masking tape. The samples for inorganic analysis will be sealed in a teflon baggie. All of the samples will be stored and shipped to the analytical laboratories on dry ice.

IV. Attachments

- Standard edible portions of fish.
- Fillet guidelines.

V. Key Checks

- Decontaminate fillet equipment between samples.
- Samples should be stored on dry ice after they are killed.

STANDARD OPERATING PROCEDURE

Fish Population Sampling Using Otter Trawl Procedures

I. Purpose

The purpose of this SOP is to provide general reference information and technical guidance on the procedure to sample and characterize fish communities and benthic macrofaunal using otter trawl procedures. The collected samples provide information used in the determination of population statistics of the fish community and can be used to collect fish samples for chemical analysis of tissues.

II. Scope

This guideline provides information on proper sampling equipment and techniques for the collection of fish in lakes, impoundments, bays, and estuaries, and the ocean shoreline. This technique is most effective in open areas in lakes and large impoundments, estuaries, and the ocean.

Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The technique described should be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methods.

III. Definitions

Abiotic	Non-biological components of the environment, including water body structure and natural or manmade disturbances.
Bow	The front of a boat.
Biotic	Biological components of the environment, including organisms and vegetation.
Reach	The designated portion of a stream, river, lake, estuary, or ocean.
Stern	The back of a boat.

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 that deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the specific sampling techniques and equipment to be used, and documenting these in the Sampling and Analysis Plan. 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.

Sampling Personnel - It is the responsibility of the field 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.

V. Procedures

The primary consideration for collecting fish using an otter trawl is identifying sampling locations where submerged obstacles, pipelines are known prior to initiating a trawl. This can be accomplished by the use of side scan sonar in areas likely to contain submerged obstacles that can tangle, snag, or destroy the sampling gear, or endanger the field team and boat. Accurate and timely deployment and retrieval is a key variable in the success of the fish collection effort. Detailed procedures for conducting fish populations utilizing the otter trawl are described in the sections to follow.

A. Equipment

The following list is an example of the type of equipment that generally must be on hand when collecting fish samples with gill net:

- Sampling boat
- Otter trawl nets with other boards (the size mesh is dependent on the size fish desired for collection)
- Line (wire, polypropylene, rope with bridle)
- Fish Measuring Board
- 0-16 oz scale, 1-4 lb scale, 1-15 lb scale
- Live Well (large tub) with overflow pipe to outside of boat
- Appropriate sampling keys for species to be sampled, and any required instruments to aid in the identification
- Field sampling data sheets
- Glass jars for storage of fish
- Formalin
- Black Permanent Marker
- Camera
- Required Personal Protective Equipment
- Portable Air Pumps
- Field log book
- Fish scale envelopes
- Tweezers
- Additional line and couplings
- Tools (pliers, variable wrench, hammer)

B. Preliminary Activities

Apply-for- and receive applicable scientific collection permits as required by the state. Contact local fish or game officials and inform them of your activities.

Collect and determine all information pertinent to the fish sampling project, including water depth, station locations, nearby boat access locations, known sediment contamination, tidal variation, any waterway obstructions or inconsistencies (e.g. shallow or grassy areas, low structures, pipe crossings), any other biological studies previously conducted on or near the site, species used locally for human consumption and the degree of such consumption species most likely present, and the most appropriate sampling method for the species of interest that is permitted by law.

Before sampling occurs, conduct a site reconnaissance using a site map. The objective of this exercise is to categorize habitats, and map dividing lines and descriptors identifying the various types of habitats available. Make notations on the map depicting the "abiotic" characteristics of the reach including features such as substrate, water depth, channel shape, degree of bank erosion, piers, boat traffic, commercial trawling, potting activities, and relative current velocity and direction. Also make notations on the site map to show "biotic" characteristics of the reach including fish species observed, evidence of fisherman use, and aquatic and riparian vegetation including wetlands. In addition, identify station locations at this point, along with the total area to be sampled. Choose the station locations, where possible, to represent ecologically similar aquatic environments.

Ensure adequate number of sample collection jars and volume of Formalin for entire trip.

Set up a 50-gallon container with water from the site.

C. Gear Type Specifications

Select a trawl design to meet the needs of the waterway being sampled. Trawls are characterized as semi-balloon. They consist of: a lead line (bottom line) with chain or weight attached for keeping bottom of net on bottom during tow; a float line (top line) with cork/bouyant floats to keep top line up (net open) during tow; trawl nets treated with netcoat tearing compound; other boards are pine and have an iron shore mount to the front and bottom of boards; mesh size (varies by need) scientific type for nearshore open waters usually 1.5 inch stretched nylon mesh; cod end with 0.25 inch stretched nylon mesh bag.

Tie a plastic jug as a float to a line attached to the cod end. Line should be two or three times the water depth. This serves as a surface marker for other boat navigating behind the boat and may be used to aid in retrieval if net becomes snagged.

D. Operating Procedure

Field personnel (2) slowly deploy trawl while boat under in direction of tow. Cod end released first. One person required on each side to release entire net. Make sure

other boards and net tangled with bridle line as they are released to the water. Release other boards overboard and bridle evenly.

Trawls should be fished for a set period of time (5 to 15 minutes duration) at a forward boat speed of 51 to 103 cm/sec (1-2 knots).

Bottom trawls are fished so that the entire length of each iron shore on the other boards (when fully spread) is on the bottom. Techniques to ensure that other boards are firmly on the bottom include: a bridle length equal to three and four times the station depth is deployed for cable and rope bridles, respectively. Drag force is used as an additional criterion for determining whether the other boards are on the bottom. An additional increment of bridle equal to the station depth is deployed when the draw force indicates that other boards are not on the bottom.

Time of tow commences at the moment the trawl starts to actively fish the desired depth. At end of trawl duration, boat engine can be placed in neutral and line/cable retrieved. When other boards near stern, retrieve both ends at an even pace. Empty code-end contents into the 50 gallon container for processing.

Upon retrieval of the other trawl, identify, measure, weigh and release the specimens. Collect fish scales for aging. Record the proportion of individuals as hybrids and the proportion of individuals with disease, tumors, fm damage, skeletal anomalies, and any other pertinent information on a field data sheet.

To the extent possible, process all species in the field and return them to the water alive. If specimens present taxonomic difficulties, or are too numerous for effective field processing, preserve them in 10% Formalin, and transport them to the office or lab for taxonomic work and measurements.

At a minimum, preserve one representative fish from each species in 10% Formalin as a voucher specimen. Record the station location, date sampled, and species name on the label.

VI. Quality Assurance Records

Quality assurance records will be maintained for each sample that is collected. The following information will be recorded in the field logbook:

- Sample identification (site name, location, project no.; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Field observations and measurements (sample setting, appearance of substrate, sampling method, and photograph descriptions).
- Additional remarks, as appropriate.

Record all observations in the field logbook. Complete field sheets for the collected samples.

VII. References

Brower, 1977. James E. Brower and H. Jerrold Zar. *Field and Laboratory Methods for General Ecology*. Wm. C. Brown Company Publishers. 1977.

U.S. EPA, 1987. U.S. Environmental Protection Agency. *A Compendium of Superfund Field Operations Methods*. Office of Emergency and Remedial Response, Office of Waste Programs Enforcement. December 1987.

U.S. EPA, 1989. Warren-Hicks, William, Parkhurst, Benjamin R., Baker, Samuel S. Jr. *Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference*. U.S. EPA, Environmental Research Laboratory, Corvallis, OR 97333. March 1989.

STANDARD OPERATING PROCEDURE

Aquatic Macroinvertebrate Sampling

I. Purpose

To provide a general guideline for sampling benthic macroinvertebrate communities.

II. Scope

A standard benthic macroinvertebrate sampling procedure is described. Site-specific details are discussed in related sections of the field sampling plan.

III. Equipment and Materials

- Data sheets
- Ponar or Ekman grab sampler
- Benthic wash buckets or U.S Standard No. 30 screens
- Standard No. 30 dip net
- Outer and inner rubber gloves
- Plastic bottles or containers with labels
- Rinse bottles
- Cooler
- Water buckets
- Brushes
- Large wash tub
- Site Health and Safety Plan
- Alcohol solution
- Field log book
- Metered line
- Sampling boat

IV. Procedures and Guidelines

1. Identify appropriate sample station locations in ponds, wetlands, and rivers, estuaries, and map these locations.

2. Collect samples starting from downstream locations, when sampling in flowing systems.

3. Select the appropriate sampling device (i.e. petite Ponar, Ekman, Surber, etc.) and collect the number of replicate samples at each station specified in the Project Instructions/Work Plan.

4. Sieve the contents of the sampler through a U.S. Standard No. 30 (0.5 mm) mesh screen or bucket with screened bottom.

5. Characterize the contents of the sample by species, if possible, and relative abundance and record this information on a appropriate data sheet.

6. Transfer contents of the screen to a labeled sample container and fix with alcohol or formalin solution.

7. Areas of wetland or stream habitat may be sampled with a dip net (U.S. Standard No. 30 mesh). Sweep the net in a standardized motion through rooted vegetation or stream areas to collect a single composite invertebrate sample. Follow procedures for other methods described above.

8. Characterize substrate conditions including color, odor, relative organic content, and physical condition.

9. Wash and rinse sampling equipment between stations to avoid contamination.

10. Photograph sample stations to supplement written descriptions.

V. Attachments

None

VI. Key Checks and Items

- Wash and rinse sampling equipment between sample stations.

STANDARD OPERATING PROCEDURE

Aquatic Macroinvertebrate Sampling Using Hester-Dendy Multiplate Samplers

I. Purpose

To provide a general guideline for sampling benthic macroinvertebrate communities using a Hester-Dendy multiplate sampler.

II. Scope

A standard benthic macroinvertebrate sampling procedure using Hester-Dendy Multiplate Samplers is described. Site-specific details are discussed in related sections of the field sampling plan.

III. Equipment and Materials

- Data sheets
- Hester-Dendy (H-D) Multiplate sampler
- Benthic wash buckets or U.S Standard No. 30 screens
- Standard No. 30 dip net
- Outer and inner rubber gloves
- Plastic bottles or containers with labels
- Weighting block - with appropriate connections to sampler
- Crimper and fasteners
- Permanent marker
- Metered line - stainless steel cable or similar

IV. Procedures and Guidelines

1. Identify appropriate sample station locations in ponds, wetlands, and rivers, estuaries, and map these locations.

2. Attach the H-D to the weighting block and place the block at a depth of one meter. Be sure to place the sampler in a position so that the sampler will not go dry during the incubation period or will not clog with sand and shifting substrates. Attach the metered line/stainless steel cable to a point on the bank sufficiently high to enable recovery even if the water level increases.

3. Collect samples starting from downstream locations, when sampling in flowing systems.

4. After the required incubation period (typically 28 days) , recover the H-D samplers. Approach the sampler carefully, without disturbance, from a downstream position. Wade or use a boat to retrieve the sampler; do not pull the block up from the shore. In a deliberate, gentle manner lift the block straight up from the bottom and immediately place on a flat surface or in a benthic wash bucket.

5. Quickly place bags over all of the H-Ds and remove them from the restraining device. If an organism is observed crawling off a H-D, capture it and place it in an appropriate container.

6. Sieve the contents of the sampler through a U.S. Standard No. 30 (0.5 mm) mesh screen or bucket with screened bottom.

7. Characterize the contents of the sample by species, if possible, and relative abundance and record this information on a appropriate data sheet.

8. Transfer contents of the screen to a labeled sample container and fix with alcohol or formalin solution. Place all of the samples on ice after properly labeling all pertinent information.

9. Characterize substrate conditions including color, odor, relative organic content, and physical condition.

10. Wash and rinse sampling equipment between stations to avoid contamination.

11. Photograph sample stations to supplement written descriptions.

V. Attachments

None

VI. Key Checks and Items

- Wash and rinse sampling equipment between sample stations.

Decontamination Procedures

Decontamination Procedures

Heavy equipment, such as drilling, well construction, and well development equipment, will be decontaminated. The equipment surfaces that contact potentially contaminated media will be washed with high pressure hot water and a laboratory grade detergent, such as Alconox. It will be scrubbed until visible dirt, grime, grease, oil, loose paint, rust flakes, and so forth have been removed. Inside surfaces of equipment that contact environmental media will also be washed in this manner. After the washing, the equipment will be rinsed with potable water. This procedure will be followed before equipment is initially used, between uses, and before removal of the equipment from the site.

Reusable sampling equipment such as split spoons and bailers will be decontaminated. It will be scrubbed with a solution of potable water and Alconox or equivalent laboratory grade detergent, then rinsed with copious quantities of potable water and a final Type II Reagent Grade Water rinse. Next, the equipment will be rinsed with isopropanol. Finally, the equipment will be air dried on a clean surface such as Telfon®, stainless steel, or aluminum foil. The equipment may be stored, wrapped in aluminum foil if it is not needed immediately after being decontaminated. Decontamination liquids (reagent grade water, methanol, hexane) will be purchased, stored and dispensed only in glass, stainless steel, or Telfon® containers. The containers will have Telfon® caps or cap liners.

The PVC slug will be decontaminated by rinsing with distilled water, wiping with isopropanol, and rinsing again with distilled water.

Any disposable equipment (e.g., gloves, aluminum foil, etc.) will be disposed of after one use.

Field Surveying

1.Identify locations of USGS or NGS benchmarks proximal to the study area.

2.Establish at least two bench marks on or near the study area; these are typically established by driving a spike into a telephone pole or by clearly marking a permanent landmark.

3.Establish the relationship between bench marks established near the study area and any identified USGS or NGS benchmarks both vertically and horizontally.

4.Establish horizontal control points throughout the area of interest at key locations. Establish relationship between control points using the direct and reverse horizontal and vertical angle methods.

5.Survey desired points (e.g. soil sample locations, monitoring well measuring points) using the direct and reverse horizontal and vertical angle methods. Obtain an accuracy of plus or minus 0.1 feet vertically and plus or minus one foot horizontally.

6. Record all data collected in a standardized format in the project field book.

1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP) deals primarily with the assessment of gaseous matrix samples. The Sentex Scentograph Gas Chromatograph (GC) can work in two detector configurations: the Electron Capture Detector (ECD) or the Argon Ionization Detector (AID). When the ECD is employed, volatile chlorinated compounds will be analyzed, as the ECD is very sensitive to electrophilic compounds such as chlorinated organics. The AID is a more universal detector, responding to most compounds with ionization potentials at or below 11.7eV. As such, it will respond to most aromatic compounds and many chlorinated compounds of environmental interest.

At present, only vapor phase samples (i.e., soil gas samples, Tedlar gas sampling bags, and ambient air samples) are being analyzed through the activation of the instrument's internal sampling pump. The Sentex GC unit does have a syringe injection port, but this is not being employed for any ERT applications at present. An optional purge and trap unit is available to determine purgeable organics in soil or water matrices. However, this SOP does not cover that capability.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required dependent on site conditions, equipment limitations or limitations imposed by the procedure or other procedure limitations. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. EPA endorsement or recommendation for use.

2.0 METHOD SUMMARY

The initial step in Sentex Scentograph Gas Chromatograph sampling is to boot up the Toshiba T 1100 computer. The computer runs the data acquisition program and stores all parameters and data. Begin by inserting the program "A" and data "B" disks into the appropriate upper and lower disk drives of the computer. Next, turn on the Sentex GC, and following the menu prompts, enter the GC parameters into the computer. Calibration analysis is then performed and stored. Calibration standards can be run either in the field, or in the laboratory prior to field sampling. In the latter case, a field calibration run must still be conducted to ensure that the lab calibrations are valid. A Tedlar bag containing a standards mixture can be attached to the Sentex GC upper inlet port at this point, or the internal calibration gas cylinder can be used.

Once calibration analysis is validated and stored, a Tedlar bag containing an unknown sample is attached to the Sentex GCs lower sampling inlet port, and the bag valve is opened. By selecting Function #3, a manual analysis can be run.

Once the sampling pump stops, the sample bag's valve is closed, and the entire bag is removed from the inlet port and stored for future laboratory analysis.

While this procedure is standard for all Sentex GC sampling, actual operating conditions (i.e., detector used, column packing material, oven temperature) will vary as required by the sample matrix encountered, and by the physical and chemical nature of the samples analyzed. Appendix A lists the operational parameters menus for entering and storing different GC conditions in the Sentex. New operating parameters are determined as new target compounds are selected for analysis.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The vast majority of Sentex applications are for soil

gas analysis. These soil gas samples are collected and stored in dark plastic bags and placed in coolers to protect the bags from any damage that may occur in the field or in transit.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Since the Sentex units employ gas chromatography, target compounds are identified by retention time indices (RTI). If the RTI of the sample peak(s) match the RTI of the standard peak(s), they are assumed to be identical. If any non-target compounds has the same RTI, it can be misidentified as a target compound. This problem occurs more frequently with the AID, since it will respond to any compound at or below 11.7eV. Often soil gas samples will have very high (ppm) levels of C_1 to C_6 hydrocarbons as well as low (ppb) levels of target compounds. The AID will respond to these hydrocarbons, whose signal often can "swamp" or obscure the signal of the lower level target compounds. In this case, it is better to use the ECD. If this is not possible, a different GC column (one able to separate the target compounds from the interference of the sample matrix) must be utilized. Moisture within the Tedlar bags will yield interference peaks that can obscure the resolution of the target compounds. It has not been determined whether it is the moisture itself, or contaminants in the moisture, that yield these contamination peaks, but the effect is seen on both the AID and the ECD. Typically, when water is found in the Tedlar bags the results of that bag's analysis is considered questionable. Typical ambient air relative humidity seems to have no appreciable effect on the signal response.

5.0 EQUIPMENT/APPARATUS

A Sentex model Scentograph GC can be configured for AID or ECD. Interfaced with the unit is a Toshiba model T 1100 lap top computer which runs the data acquisition program and stores all parameters and data. The Sentex unit has an internal battery pack which is charged from a Power Sonic Corp. model PSC-12400, (115 VAC to 12 VDC) charger. Attached to the T 1100 is a Hewlett-Packard model 2225 P Think Jet printer. This produces hard copies of chromatograms and peak data information. No other equipment is required to operate the Sentex Scentograph unit.

6.0 REAGENTS

The Sentex AID requires ultra high purity (99.99% or above) Argon as carrier gas. The ECD can use either ultra high purity Argon or Helium (these can be ordered from Scott Gas, Matheson or any other reliable vendor). Gas standards are purchased as certified mixtures from Scott Gas or Matheson, at fairly high concentrations (i.e., 1-50 ppm). These concentrations are for subsequent dilution to various concentrations that enable construction of a standard calibration curve. If the internal calibration cylinder is to be used a low level standard, 0.5-1.0 ppm-v should be used.

If liquid phase reagents are required to make vapor phase standards, they must also be of the highest purity, such as Aldrich Gold Label or Supelco Environmental standards kits. If air is to be used for sample/standards dilutions, it must also be ultra high purity gas.

7.0 PROCEDURES

All operational parameters are entered via the T 1100 computer. This is accessed from the operations Menu, Function #1, which appears once the Sentex unit is turned on (Appendix A). Once the parameters are entered, a calibration run, Function #4, must be run. This is not a true calibration, since the Sentex calculates a pseudo-concentration against only one concentration. The calibration function is used only when operating parameters under Function #1 are changed. In all other cases, it is ignored. The run is typically aborted after the first "junk" or noise peak is identified in the calibration run. Occasionally, a Tedlar bag or the internal calibration gas cylinder can be sampled in the calibration mode but this would be for peak identification only and semi-quantification purposes, since it is only a single point calibration.

7.1 Calibration Procedures

The generation of calibration standard to be run in the field can be performed either in the field or in the laboratory prior to entering the field. If the latter is done, field standards must still be run to ensure calibration runs stored on the data disks are valid and close to standards run in the lab. Dilutions are typically made from the certified gas standards cylinders using Hamilton 500, 1000, and 1500cc model "Super syringes" and Tedlar sampling bags.

Simple volumetric dilutions are made and the set of standards are analyzed as if they were typical samples.

At least three concentrations of each standard must be run. It is preferable that more standards be run to establish the minimum ranges for the linear response of the Sentex detectors for each individual target compound. In the laboratory, a Multi-Channel Mass Flow Control can be used to meter selected flow rates from two to four separate compressed gas cylinders. A continuous flow of selected concentration of mixtures can be established to either fill Tedlar bags for analysis or to create a flow-through-cell from which the Sentex GC can sample. This has been used extensively to establish minimum and maximum detection levels in an efficient and timely manner.

The Sentex GC software does perform a single point calibration on up to 16 compounds contained in the internal calibration cylinder. This is adequate for most field screening needs. A linear calibration curve will be developed on a daily basis while analyzing in the field. Consequently, three concentrations of each standard, per target compound will be analyzed by the Sentex GC as if they were samples, and their GC response will be used to construct a linear regression curve.

7.2 Analytical Procedures

The following are stepwise procedures for analyzing vapor phase samples via the Scentograph Sentex GC:

1. Insert Disks "A" and "B" into upper and lower T 1100 disk drives, respectively, and turn on Sentex GC.

2. Follow menu prompts and input GC parameters as per Appendix A (Scentograph Operating Parameter Menu).

3. Select Function #4 to run and store calibration analysis. A Tedlar bag of a standards mixture may be attached to lower inlet.

4. Attach Tedlar bag with unknown sample to the lower sample inlet port and slide the bag valve down to open.

5. Select Function #3 to run a manual analysis, at prompt enter sample name, press "ENTER" a second time to inject.

6. Immediately after sampling pump stops, pull bag valve out to close, remove bag from inlet port.

7. Sample and calibration analysis can be aborted by holding down the reset key on the GC panel until "RETURN" prompt appears.

8. Any changes in operating parameters entered in Function #1 must be followed by a calibration run prior to an analysis run.

8.0 CALCULATIONS

A calibration curve of at least three concentrations must be constructed for each target compound. A straight line equation in the form of $y = (m)(x) + b$; (where: x = concentration, y = area counts, m = slope and b = the intercept) is fit to the standards raw data. The (y), or the unknown concentration for the sample, is determined from the above straight line equation. Non-linear data is indicative of erroneous detector response, alternatively sample concentration can be calculated as below:

$$\textit{Sample Conc.} = \frac{(\textit{standard conc.})}{(\textit{standard area})} \times (\textit{sample area})$$

The Sentex does perform a one point calibration for compounds present in the internal calibration cylinder that were entered in the library. If the samples and library standard are in the linear range, this one point calibration is considered valid for field screening purposes.

9.0 QUALITY ASSURANCE / QUALITY CONTROL

The following QA/QC protocols are applicable:

1. A complete calibration curve must be run daily.

2. Replicates of a gas standard, in the mid-range of the calibration curve and preferably close to sample results, should be run every 10 samples to ensure detector response is constant.

3. Two or three replicates for each sample and

standard should be run. In terms of area count and retention time values, these replicate responses should be within 10-20% of each other.

4. Matrix spikes, or spiking samples with known levels of standards, are not typically required as the same Tedlar bag may be analyzed by other field instrumentation (i.e., Photovac, organic vapor analyzer [OVA], etc.) and/or collected onto traps for GC/MS confirmation. If Tedlar bags are used to prepare standards, the time of preparation should be noted.

5. During sample analysis, one of the standards should be periodically re-analyzed to ascertain if any sample loss occurs in the bag over time since many compounds will degrade or permeate Tedlar sample bags.

6. A performance evaluation sample (PE) is typically sent along with the sampling efforts to determine if any loss or contamination occurs from transit or handling during sampling.

7. A trip blank, consisting of a Tedlar bag filled with zero air, is also sent along and is analyzed at the end of the sampling run to determine if any contamination of the Tedlar bags occurred during transit.

10.0 DATA VALIDATION

As mentioned previously, peak identification is by Retention Time Index (RTI). Sample spikes, using known levels of target compounds, can be prepared to identify the absence/presence of target compounds in the samples if peaks are eluting close to the target compounds. Typically, only the RTI is needed to identify the peaks of interest. Quantification is determined from the linear calibration curve, and solving for concentration (y) from the straight line equation. The coefficient of variation on the straight line equation should have an R squared, (R^2), of 0.95 or better. The confirmation of the identity of any particular target compound must be done by other analytical methods, typically GC/MS. Standards must be run along with the samples, and should bracket the levels found in the field samples.

Alternatively, a statistical approach to data validation can be sought. Once the linear range is established an appropriate standard, either a low or midrange concentration, will be analyzed 10 or more times throughout the day. The standard deviation of the mean [F(n-1)] for the response of the standard selected is determined. The statistical method detection limit (MDL) will be three times the standard deviation (3F). The method quantitation limit (MQL) will then be 10 times the standard deviation (10 F). Results below the MDL will be considered nondetects (ND). Results above the MDL but below the MQL will be considered detected but below the quantitation limit and will be ascribed a "J" value. This "J" value will flag the data to let the user know the results are questionable. Results above the MQL are considered statistically reliable data.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials follow U.S. EPA, OSHA and corporate health and safety guidelines. More specifically, analysis should be performed in a well ventilated room. When liquid reagents are used to prepare standards etc., disposable protective gloves should be worn, and work should be performed under a vented hood.

12.0 REFERENCES

This section is not applicable to this SOP.

APPENDIX A

Scentograph Main Menus

Operation Menu

Scentograph **	Operating Parameters	1
Scentograph **	Automatic Operation	2
Scentograph **	Manual Operation	3
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Scentograph **	Utility Menu	6
	Enter Function	?

APPENDIX A (con't)

Example of Typical Scentograph Operating Parameter Menu

** Scentograph	Operating Parameters	
1 - Calibration Sample Name	(enter up to 8 letters)	... REAC
2 - Sample Time	(1-300 sec)	... 15
3 - Delay Time	(0.1-4.0 sec)	... 1.0
4 - Desorption Time	(0.1-4.0 sec)	... 4.0
5 - Inhibit Time	(10-999 sec)	... 50
6 - Oven Temperature	(30-140 °C)	... 50
7 - Chart Duration	(1,3,5,10,15,20,30 min)	... 30
8 - Analysis per Calibration	(1-99)	... 99
9 - Auto Analysis Duration	(0-120 min)	... Manual
10 - Backflush Option	(0=off, 1=on)	... BCKFL OFF
11 - Detector	(1-AID, 2-ECD, 3-TCD, F-PID)	... A.I.D.
12 - Column	(enter up to 8 letters)	... 6'10%CP5
13 - Column Pressure	(5-40)	... 20
14 - # of Calibration Peaks	(1-16)	... 1
15 - Peak Number 1		
Substance Name	(enter up to 8 letters)	... U1/AID
Concentration Range	(PPM=0, PPB=1)	... PPM
Calibration Conc	(99.9 ppm, 9999 ppb)	... 1.00
Peak alarm values	(0-99.99 ppm, 9999 ppb)	... 99
16 - Upload Scentograph parameters		

Enter field to be UPDATED?

X-RAY FLUORESCENCE
"A QUALITY PERSPECTIVE OF METALS ANALYSIS IN THE FIELD"

WHY: This standard operating procedure (SOP), Region I, EPA-New England Standard Operating Procedure for Elemental Analysis Using the X- MET 920 Field X-Ray Fluorescence Analyzer, was written by the QA Unit Staff to promote and provide a framework for regulatory acceptance of a technology that has innovative applications in environmental testing. On-site field analysis technologies, such as X-ray fluorescence (XRF), can offer project managers "real-time" results at a fraction of the cost and time required for conventional laboratory analyses.

Although this SOP is directed at the field unit owned and operated by Region I, EPA-New England, it contains generic analytical and quality assurance (QA) guidance that can be applied to any field XRF analyzer. In addition, the intent of this document is to provide the project planner with the guidance and information required to develop a comprehensive approach to using field XRF for environmental applications.

WHAT: XRF is a non-destructive analytical technique used to determine the elemental composition of a sample. Synonymous with metals analysis, a field XRF analyzer can determine the concentration of several desired metals in as little as 30 seconds. This ability to collect considerable site data in a relatively short amount of time, can greatly assist project managers to characterize site contamination and monitor site clean-up.

This SOP is directed at maximizing the potential of XRF technology for use in environmental site investigation and cleanup activities. It provides a basic understanding of XRF operation and guides the project planner/chemist in utilizing field XRF to achieve the data quality objectives (DQOs) of a project. In addition, the SOP discusses the critical elements of an environmental quality assurance/quality control program that are necessary to assure quality data for its intended purpose. This document addresses the following concepts and processes:

- Project planning for environmental XRF,
- XRF theory and field unit application,
- Key Quality Control elements necessary to ensure quality XRF analyses,
- Laboratory confirmation analysis as part of the Quality Assurance Program, and
- Comparing and using project data generated for environmental decisions.

WHO: This SOP is intended for use by numerous stakeholders, including EPA and its contractors, States, Tribes, other Federal Agencies, PRPs, industry, and the public. This document, in combination with an XRF user's manual, can help project planners, project chemists, and field samplers to plan successful XRF projects that produce quality metals data for use in critical project decisions.

REGION I, EPA-NEW ENGLAND

STANDARD OPERATING PROCEDURE FOR ELEMENTAL ANALYSIS USING THE X-MET 920 FIELD X-RAY FLUORESCENCE ANALYZER

U.S. EPA-NEW ENGLAND
Region I
Quality Assurance Unit Staff
Office of Environmental Measurement and Evaluation

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Branch Chief

Region I, EPA New England

Standard Operating Procedure for Elemental Analysis Using the X-MET 920 Field X-ray Fluorescence Analyzer

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Standard Operating Procedure for Elemental Analysis Using the X-MET 920 Field X-ray Fluorescence Analyzer

1.0 Scope and Application

The following Standard Operating Procedure (SOP) describes the procedures used to operate the EPA Region I X-MET 920 portable X-ray Fluorescence (XRF) analyzer for the analysis of metals in soils and sediments. The SOP describes two methods of calibration and analysis, quantitative analysis and semi-quantitative screening, to be used depending on the data quality objectives (DQOs) of the project. For example, projects involving comprehensive extent of contamination studies or site clean-up to a defined action level will require the quantitative technique of analysis, while the semi-quantitative screening technique would be more appropriate for site investigation work or initial delineation of site hot spots.

Whichever calibration technique is chosen, the analyst should always strive to prioritize the number of elements under investigation (typically 1 - 3 elements are recommended). This strategy will not only simplify instrument calibration, but will minimize the time, effort, and cost of the project. If the precision, accuracy, and detection limits of the field XRF analyzer meet the project DQOs, then XRF is a fast, powerful, cost effective technology for site characterization.

This SOP should be uses in conjunction with the X-MET 920 Reference Manual supplied by the instrument manufacturer.

1.1 Practical Planning for Projects Using Field XRF

Figure 1 depicts a decision tree, which outlines the process that project planners should follow to plan environmental projects utilizing XRF. There are three basic steps which must be followed when planning projects that will utilize XRF analysis techniques:

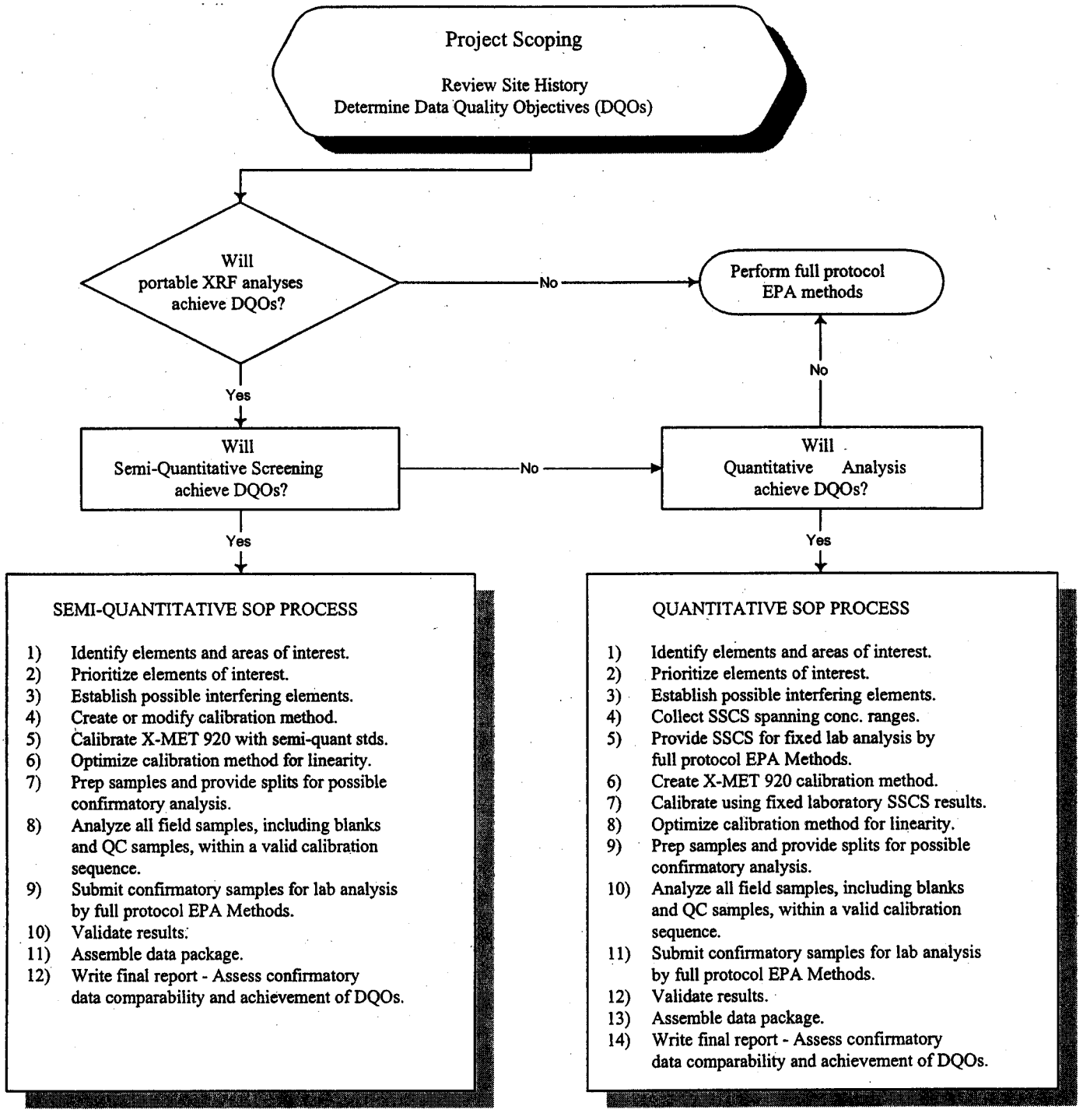
1. Project scoping and determination of project DQOs

2. Ascertaining XRF needs

3. Developing the project Quality Assurance Project Plan/Sampling and Analysis Plan (QAPjP/SAP)

Performing these three steps prior to sample collection will enable the project planner to ensure that the XRF analyses are correctly executed on site and that the resultant XRF data are suitable for their intended use in site decision making.

Figure 1 Project Planning Decision Tree



1.1.1 Project Scoping and Determination of Project Data Quality Objectives

Before Field XRF analysis can be integrated into a project's sampling and analysis scheme, the project planner must establish the project DQOs. Prior to DQO development, the project planner should obtain and evaluate as much historical information as possible about the site conditions and history, including the results of any previous investigations at the site, so that the following questions can be answered:

- What and where is the contamination on the site?
- What is the source of contamination on the site?
- What is the purpose of sampling and analysis (data collection)?
- What are the target elements of interest?
- What are the Action Level concentrations for the elements of interest?
- What non-target metals or site conditions may be present that could create possible interference problems?
- What is the intended use of the data?

If the project planner can answer these questions completely, then the project DQOs have been developed properly and are understood. For assistance, refer to the Agency document Guidance for the Data Quality Objective Process, EPA QA/G-4, which describes the informational needs and critical decision processes that must be addressed during DQO development.

1.1.2 Ascertaining XRF Needs

Once the project target elements, action levels, and intended data uses have been established during DQO development, the project planner can proceed with ascertaining XRF needs for the project. The project planner should first determine whether the project DQOs can theoretically be met using XRF techniques. If the project planner decides that XRF techniques may be applicable to project DQOs, then the planner must answer the following questions:

- What type of XRF data are required: quantitative or semi-quantitative?
- What detection levels and/or action levels must be met for each target element?
- What full protocol EPA methods will be used for confirmatory and/or site-specific calibration standard (SSCS) analyses?
- Will the resultant XRF data meet project objectives?

Section 2.0 discusses the basic principles of XRF analysis so that project planners will be familiar with the technology.

1.1.3 Developing the QAPjP/SAP

The XRF project planner must develop a QAPjP/SAP that details the following:

- Project description and DQOs,
- Project personnel and their responsibilities,
- Sampling protocols; sampling locations and numbers of samples to be collected,
- Quality Assurance (QA) and Quality Control (QC) elements required, including frequency requirements, acceptance criteria, and corrective actions (refer to Section 8.0),

amplitudes which is the basis of qualitative X-ray analysis. The number of counts at a give n energy per unit o f time is representative of the element concentration in a sample and is the basis for quantitative analysis.

2.1.1 Fluorescent X-rays

During interaction of the primary source X-rays with samples, they may either underg o scattering or absorption by s ample atoms in a process known as the photoelectric effect. This latter analytical phenomenon, illustrated in Figure 2, occurs when incident radiation knocks an electron from the inner most shells of an atom. The atom, now in an excited state, releases its surplus energy almost instantly by filli ng the vacancy created with an electron from one of the outer energy shells. This rearrangement of electrons is associated with the emission of an X-ray with a wavelength characteristic (in terms of energy) of the given atom.

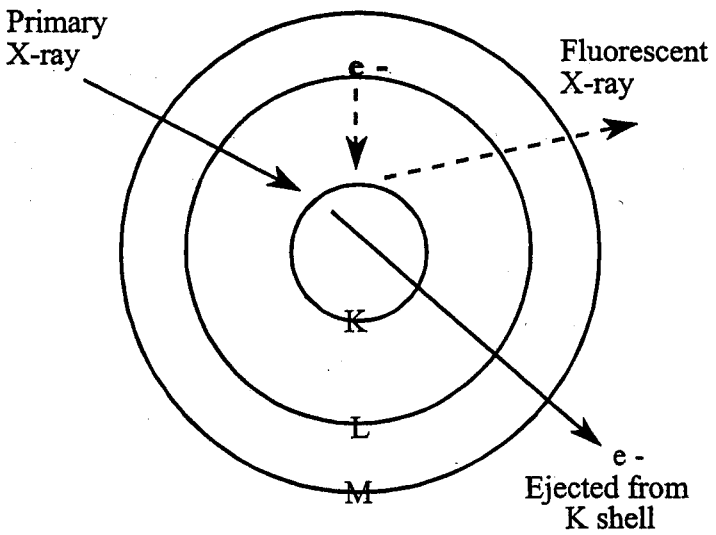


Figure 2 Electron rearrangement in an atom exposed to X-ray radiation generating a characteristic fluorescent X-ray.

X-rays are created in the inner most shells of an atom, the K, L, and M atomic shells. Each characteristic X-ray line i s defined with the letter K, L, or M, which signifies which shell had the original vacancy and by a subscript alpha (α) or beta (β), which indicates the higher shell from which an electron fell t o fill the vacancy and produce the X-ray. For example, a K_α line is produced by a vacancy in the K shell filled by an L shell electron, whereas a K_β line is produced by a vacancy in the K shell filled by an M shell electron. Figure 3 is a schemati c which illustrates of the production of K and L X-rays. Since the electrons producing th e fluorescent X-rays are not valence (outer) shell electrons, the X-ray energy is not affected by the chemical or physical form of the atom. Thus, elemental sulfur and $CaSO_4$ give the same sulfur X-ray. Since there are few allowed transitions, and thus relatively few X-ray lines, the X-rays for a specific element are well defined. K lines have the shortest wavelengths and ,

- SSCS analytical protocols for quantitative analysis, including frequency requirements, QC acceptance criteria, and corrective action measures,
- Confirmational analytical protocols with frequency requirements, QC acceptance criteria, and corrective action measures (note, these protocols should be the same as the SSCS protocols when quantitative analysis is performed),
- Split sampling comparability acceptance criteria, and
- How the QC and field sample data will be used to determine whether project DQOs have been met (Data Quality Assessment).

The QAPjP/SAP should reflect the complexity of the XRF project. It must sufficiently address all of the relevent elements detailed in the Region I, EPA New England Quality Assurance Project Plan Guidance, Draft October 1996.

Detailed standard operating procedures (SOPs) for the sampling and analysis protocols can be referenced in the QAPjP/SAP as long as the applicable SOPs are appended to that QAPjP/SAP. All SOPs that are pertinent to project operations should be developed in accordance with EPA QA/G-6, Guidance for the Preparation of Standard Operating Procedures for Quality-related Operations.

The QAPjP/SAP must describe or reference documentation requirements for the resultant XRF and split sample confirmation data. Documentation that all key QC elements were performed and met project requirements is essential, regardless of intended data use. For XRF techniques, the preparation and analysis of each batch of samples, including related standards, QC samples and blanks, should be recorded in a field or laboratory notebook, run logs, and/or tabulated forms. Section 13.0 of this SOP offers a detailed reporting format for XRF projects. For conventional full protocol analytical methods, complete data packages should be produced in accordance with the Region I, EPA-NE specifications contained in the Training Manual for Reviewing Laboratory Data Package Completeness, dated June 1994.

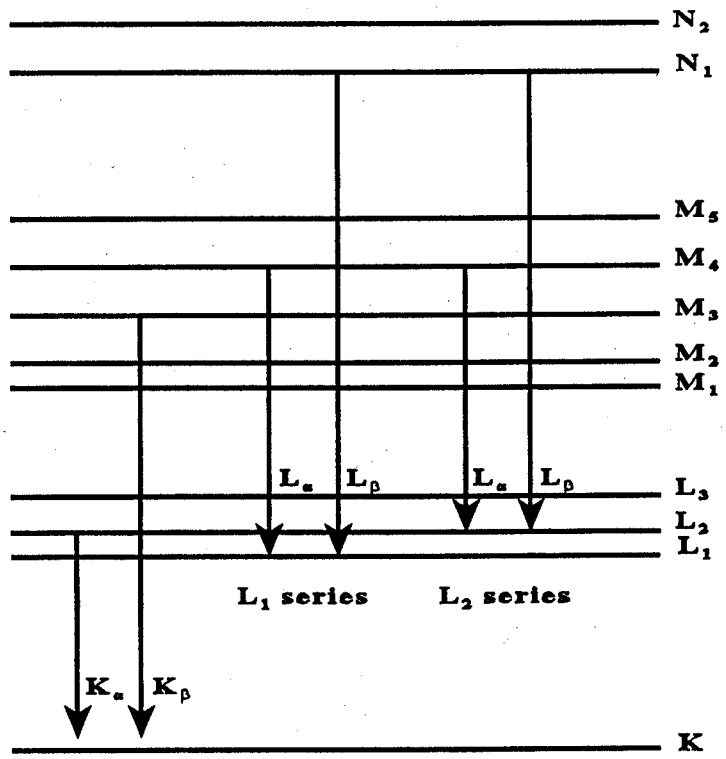
Used properly, with the appropriate QC procedures and a definitive QA program, XRF can be a very effective tool. Used without regard to QC requirements and QA process controls, the resultant XRF data may be unusable or may not be able to be interpreted.

2.0 Method Summary

2.1 Principles of Operation

XRF is a nondestructive qualitative and quantitative analytical technique used to determine the chemical composition of a sample. In an XRF analysis, primary X-rays emitted from an X-ray tube or a sealed radioisotope source are utilized to irradiate a sample. The primary X-rays incident on the sample cause the elements present in the sample to emit (that is, fluoresce) their characteristic X-ray line spectra. The elements may be identified by the energies of the wavelengths of their spectral lines. The unit of energy of an X-ray is the kilo electron volt (keV). The X-ray energy is proportional to the frequency of the X-ray waves and is inversely proportional to the wavelength. Since it is a fluorescent process, the energy of the fluorescent X-rays will always be of lower energy than the primary X-ray energy. In addition to the fluorescent X-rays, there will be a backscattering of the primary X-rays. Energies of the fluorescent and scattered X-rays are converted (within the detector) into a train of electric pulses, the amplitudes of which are linearly proportional to the energy. An electronic multichannel analyzer measures the pulse

Figure 3 Production of K and L X-rays



therefore, the highest energies. L lines have longer wavelengths and thus lower energies and M lines have very long wavelengths and thus even lower energies.

An X-ray source can excite characteristic X-rays from an element only if the source energy is greater than a threshold energy associated with a particular line group (K, L, or M). This energy threshold, called the a bsorption edge (i.e., K absorption edge, L absorption edge, or M absorp tion edge) is greater than the corresponding line energy. (Actually, the K absorptio n edge energy is approximately equal to the sum of the K, L and M line energies. The L absorption edge energy is approximately equal t o the sum of the L and M line energies.) Also, the closer the absorp tion edge energy of an element is to the source energy (but not greater than th e source energy), the more efficient is the excitation and the more sensitive is the element' s detec tion. For example, if a source energy is sufficient enough to excite the K lines for both Zn (atomic number 30) and Ni (atomic number 28), then the Zn K lines will be more sensitive than the Ni K lines (i.e., the higher the atomic number, the higher the line energies, and th e closer th e line energy is to the source energy). If the source energy is sufficient to excite the K lines, then they will always be accompanied by the L and M lines of the same element. If there is i nsufficient energy to excite the K lines, but enough to excite the L line, then just the L and M lines will appear. XRF analyzers most commonly measure X-ray lines originating from the K and L shells; only elements with an atomic number greater than 57 hav e measurable M shell emissions.

2.1.2 Scattered X-rays

Scattered or backscattered radiation is simply the reflection of the primary X-rays off the sample. The source radiation is scattered from the sample by two physical reactions: coherent scattering (no energy loss) and incoherent or Compton scattering (small energy loss). Thus, for each line of primary radiation incident on the sample, two scattered X-ray lines close together are returned. The coherent scatter lines being equal to the source energy and the Compton scatter lines being slightly less than the source energy. The amount of scattering is due to the sample matrix. The two primary factors are particle size and average atomic number of the sample. Larger particle sizes and lighter matrices (lower average atomic number), produce more backscatter. The scattered X-rays have the highest energies in the spectrum.

2.2 X-MET 920 XRF Analyzer

The EPA Region I X-MET 920 XRF analyzer has two radioisotope sources, Cadmium-109 and Americium-241, available for the production of primary X-rays. Each source emits a specific energy range of primary X-rays that cause a corresponding range of elements in a sample to produce their fluorescent X-rays. Table 1 provides a listing of the recommended source and analysis line energies for typical environmental elements. The K_α or L_α line is always the most intense line in their respective line group and, for that reason, is usually the line of choice for analysis (note, the intensity ratio between K_α and K_β lines is approximately 7:1, respectively, while the ratio between L_α and L_β lines is approximately 3:2, respectively). When more than one source can excite the same element of interest, the appropriate source is selected according to the excitation efficiency of the elements of interest.

2.2.1 Sample Preparation Summary

Samples are prepared in one of two ways depending on the type of analysis. For semi-quantitative screening analysis, sticks, stones, and other matter that is non-representative of the sample are removed, the sample is then thoroughly homogenized, and an aliquot is placed directly in a plastic XRF sample cup. The sample cup is capped with a clear polypropylene film and the sample identification is clearly labeled prior to analysis.

For quantitative analysis, sticks, stones, and other matter that is non-representative of the sample are removed, and the sample is thoroughly homogenized. The sample is dried and then sieved through a No. 60 mesh sieve. The fraction of the sample that passes the No. 60 sieve is then re-homogenized and aliquoted into the XRF sample cup. The sample cup is capped with a clear polypropylene film and the sample identification is clearly labeled prior to analysis. Refer to section 11.0 for a complete discussion of sample preparation.

2.2.2 Sample Analysis Summary

For measurement, the cup is positioned in the sample holder and exposed to primary X-rays from the selected radiation source. The sample fluorescent and backscatter X-rays are detected and the results are recorded by the data system. Qualitative determinations of the elements present in the sample are based on the locations of characteristic peaks produced by individual

Table 1

Recommended Source and X-ray Line Selection
for Typical Elements of Environmental Concern

Isotope	Half Life	Primary Radiation	Element	Recommended Analysis Lines			
				K Line (keV)		L Lines (keV)	
				K_α	K_β	L_α	L_β
Cd-109	1.3 Years	Ag K X-ray, 22.1 keV	Cr	5.41	5.95		
			Mn	5.89	6.49		
			Fe	6.40	7.06		
			Co	6.92	7.65		
			Ni	7.47	8.30		
			Cu	8.04	8.94		
			Zn	8.63	9.61		
			As	10.5	11.8		
			Hg			9.98	11.9
			Tl			10.3	12.3
			Pb			10.5	12.6
Am-241	433 Years	Gamma Radiation, 59 keV	Mo	17.4	19.8		
			Ag	22.1	25.2		
			Cd	23.1	26.4		
			Sn	25.2	28.8		
			Sb	26.2	30.1		
			Ba	32.0	36.8		

elements in the energy spectra. Quantitative determination of an element present is made by comparing the intensity of a characteristic peak in the sample to a calibration curve of the same peak developed from standards of similar matrix and known concentrations.

The analysis can either be performed in a quantitative or semi-quantitative fashion depending on the DQOs of the project. Quantitative analysis is performed by matching the matrix of the standards to that of the site. These standards, called "site specific calibration standards (SSCS)" are actual samples taken from the site that are representative of the matrix present and span the concentration range of the elements of interest. The samples are sent to a fixed laboratory, acid digested, and analyzed by AA or ICP in accordance with a full protocol EPA methods. It should be noted that confirmatory results will vary depending on whether a partial digestion procedure or a total digestion procedure is used. Confirmatory full protocol EPA methods should be chosen in the project scoping phase and meet the data quality objectives of the project. It is essential that all SSCS and confirmatory sample analyses be performed using the same EPA methods for sample preparation and analysis. These methods should be documented in the Quality Assurance Project Plan (QAPjP)/Sampling and Analysis Plan (SAP) and DQO Summary Form. Once the SSCS results are validated in accordance with Region I, EPA New England Data Validation Functional Guidelines for Evaluating Environmental Analyses and deemed usable, they are considered the true values of the SSCS and can be used in calibrating the XRF analyzer. SSCS are discussed in further detail in Section 7.1.

For semi-quantitative screening, standards used to calibrate the analyzer are obtained from sources other than the project site. These standards may be SSCS from another site, standards prepared in-house, or NIST certified standard reference materials. Screening standards are discussed further in Section 7.2.

3.0 Definitions

3.1 SSCS - Site Specific Calibration Standards

3.2 STCS - Site Typical Calibration Standards

3.3 LPCS - Laboratory Prepared Calibration Standards

3.4 SRM - Standard Reference Material

4.0 Health and Safety

The X-Met 920 Solid State Probe Set (SSPS) contains two nuclear radiation sources; cadmium 109 and Americium 241. During all measurements the sample lid on the probe must be closed over the sample to shield the user from exposure to nuclear radiation. The probe must not be opened except by authorized personnel.

Proper training for the safe operation of the instrument and radiation training should be completed by the analyst prior to field operations. Radiation safety information for the X-MET 920 can be found in the operators manual. Protective shielding should never be removed by the analyst or any personnel other than the manufacturer. The analyst should be aware of the local, state and national regulations that pertain to the use of radiation-producing equipment and radioactive materials with

which compliance is required. Licenses for radioactive materials are of two types; (1) general license which is usually provided by the manufacturer for receiving, acquiring, owning, possessing, using, and transferring radioactive material incorporated in a device or equipment, and (2) specific license which is issued to named persons for the operation of radioactive instruments as required by local state agencies. The radiation safety officer is responsible for properly instructing all personnel, maintaining inspection records and monitoring X-ray equipment at regular intervals. A copy of the radioactive material license and leak tests should be present with the instrument at all times and available to local and national authorities upon request.

Radiation monitoring equipment should be used with the handling of the instrument. The operator and the surrounding environment should be monitored continually for analyst exposure to radiation. Thermal luminescent detectors (TLD) in the form of badges and rings are used to monitor operator radiation exposure. The TLDs should be worn in the area of most frequent exposure. The maximum permissible whole-body dose from occupational exposure is 5 Roentgen Equivalent Man (REM) per year. Possible exposure pathways for radiation to enter the body are ingestion, inhaling, and absorption. The best precaution to prevent radiation exposure is distance and shielding.

5.0 Interferences and Potential Problems

Generally, the instrument precision is the least significant source of error in XRF analysis. User or application related error is more significant and will vary with each site and the completeness of instrument calibration. The components of user or application error are the following:

5.1 Sample Representativeness

To accurately characterize site conditions, samples collected must be representative of the site or area under investigation. Variables affecting sample representativeness include: geologic variability, contaminant concentration variability, and sample collection and preparation variability. Geologic variability can occur when more than one type of matrix exists on site (i.e., one part of the site is a rich organic soil while the other part of the site is a course sand). In this case, quantitative analysis may require two sets of site-specific calibration standards to minimize error.

Contaminant concentration variability is an issue that must be dealt with at each site. For example, if the contamination on site is due to a liquid waste dumped in the soil, the dispersion in the area of concern is more likely to be uniform, and thus the samples more likely to be representative of the area. If, however, the contamination is due to a solid waste of varying size and shape, the likelihood of samples being representative of the area is lower and thus the error in results is greater. In this latter case, the error can be minimized by homogenizing a large volume of sample prior to analyzing an aliquot, or by analyzing several samples at each sampling point and averaging the results.
Preparation and analytical variability are minimized by using consistency in technique and by matching standard and sample matrices.

5.2 Physical Matrix Effects

Physical matrix effects are the result of variations in the physical characteristics of the sample, including particle size, uniformity, homogeneity and surface condition. Thorough and consistent sample preparation is critical to minimizing these effects. For example, consider a sample composed of a mix of fine and coarse particles in which the element of interest is in the fine

particles. If two separate aliquots of the sample are prepared in such a manner that one sample receives a greater portion of the fine particles, then the relative volume of the element of interest in each sample will be different. Thus, when these samples are analyzed, a larger amount of the element of interest will be exposed to the source X-rays in the sample containing the larger volume of fine particles. This will then result in a higher intensity reading and a measured concentration in the sample that is biased high.

5.3 Chemical Matrix Effects

Chemical matrix effects result from differences in concentrations of interfering elements. These interelement effects appear as either X-ray absorption or enhancement phenomena. Both effects are common in soils contaminated with heavy metals. For example, consider a series of samples containing nickel (Ni) and chromium (Cr). Ni in the sample will absorb the fluorescent X-ray of Cr. If the concentration of Cr remained constant and the Ni concentration increased, then the detected signal for Cr would decrease. Thus, basing the concentration solely on the Cr signal, the Cr concentration would appear to decrease. In order to correct for this absorption effect on Cr, a term must be added to the regression equation for Ni. (Information on developing regression equations for instrument calibration is discussed at length in the X-MET 920 reference manual.) As a general guideline, elements that may cause chemical matrix effects are:

1) near the target element (± 4 or 5 atomic numbers),
2) excited by the source,
3) at a concentration greater than 10% of the target element's concentration, and
4) present in varying concentrations in the area under investigation.

It is essential to define the chemical matrix effects on the elements of interest prior to instrument calibration.

5.4 X-ray Spectrum Overlap

Certain emitted X-ray lines from different elements, when present in the sample, can be very close in energy and, therefore, interfere by producing an overlapping spectrum. Typical spectrum overlaps are caused by the K_β line of element Z-1 overlapping the K_α line of element Z, where Z = the atomic number of the element. (Note, in heavier elements, the K_β line of elements Z-2 or Z-3 may create the spectral overlap of the K_α line of element Z.) This is called the K_α/K_β interference. Since the K_α:K_β intensity ratio for a given element usually varies from 5:1 to 7:1, the interfering element must be present at a large concentration to disturb the measurement of element Z.

For example, a large concentration of vanadium (Z = 23) could interfere with chromium (Z = 24). Vanadium (V) has K_α and K_β energies equal to 4.951 and 5.427 keV, respectively. Chromium (Cr) has a K_α energy equal to 5.41 keV. Since the resolution of the Si(Li) detector in the X-MET 920 is approximately 0.170 keV, large amounts of vanadium in the sample will result in spectral overlap of the V K_β with the Cr K_α peak and the measured X-ray spectrum will include total counts for Cr plus V lines.

Other spectral interferences can occur between K/L, K/M, and L/M lines. An example is the As K_α/Pb L_α interference. In this case the lead can be measured from the Pb L_β line, and arsenic from either the As K_α or As K_β line; in this way the interference can be overcome. The X-MET 920 uses correction factors obtained from the analysis of single element standards to correct for spectrum

overlap. It is essential to define all possible spectral overlaps for the target elements and create and/or update the overlap correction factor table during instrument calibration (refer to Section 9.2.3 and the X-MET 920 reference manual for further details). Note, whenever spectral overlap is an issue, measurement sensitivity is reduced.

5.5 Moisture Content

Sample moisture content will affect the accuracy of the sample results. The measurement error may be minor when the moisture content is small (5-20 %), or it may be significant when measuring the surface of soils that are saturated with water. For quantitative analysis, moisture content will not be an issue because all samples are dried as part of the sample preparation. However, for semi-quantitative screening analysis, drying is not required, therefore, moisture content should be a practical concern in sample preparation. In general, air drying, oven drying, or some other mechanical technique of drying is recommended to reduce moisture content to within 5% of the calibration standard's moisture content. Microwave drying is <u>not</u> recommended.

6.0 Personnel Qualifications

Sample analysis must be performed by qualified personnel either experienced in the operation of the XRF analyzer and knowledgeable in X-ray fluorescence, or under the direct supervision of an experienced and knowledgeable individual. The analyst must be thoroughly familiar with this SOP and the X-Met 920 Reference Manual supplied by the instrument manufacturer.

7.0 Equipment and Supplies

7.1 Instrument Description

The X-Met 920 is a PC based energy dispersive X-ray analyzer which consists of three major units:

1.) Computer and Software
2.) X-Met PC Unit (XPCU)
3.) Solid State Probe Set (SSPS).

The X-MET 920 software (version 1.33), is MS-DOS based and provides total control of the instrument. The minimum computer configuration recommended for operation of the software is a 33 MHZ 486 DX computer with 2 MB RAM, 1 floppy drive, and an 80 MB hard drive. The XPCU board goes into an expansion slot inside the computer. It is the interface between the analysis probe and the computer and software. In addition to other electronic functions, this board contains a 2048 channel Multi Channel Analyzer (MCA) that records the spectra during measurements. The SSPS houses the sample holder, the Cd-109 and Am-241 radioisotope sources, and the Si(Li) detector. The Si(Li) detector is a silicon (drifted with lithium) semi-conductor crystal diode which is reversely polarized and cooled by liquid nitrogen. The detector is capable of resolution equal to 0.170 keV.

7.1.1 Instrument Transport

The X-MET 920 (computer, monitor, probe etc.) MUST be handled wi th care during transport. The original shipping containers should be used at all times to avoid damage in transit. The shipping container for the SSPS must be properly labeled in accordance with regulation s governing the shipment of radioactive materials.

7.2 Supplies

7.2.1 Sieve: No. 60 (250 µm) stainless steel, Nylon, or equivalent mesh sieve

7.2.2 Polyethylene XRF sample cups

7.2.3 Film for sample containment: Mylar, Kapton, Spectrolene, polypropylene or equivalent; 2.5 or 6.0 µm thick

7.2.4 Stainless steel spoons

7.2.5 Mortar and pestle: glass, agate, or aluminum oxide

7.2.6 Aluminum drying pans

7.2.7 Drying oven

8.0 Calibration Standards

The appropriate choice of calibration standards is made based on the project DQOs. Whe n definitive quantitation is required, site-specifi c calibration standards must be used (refer to Section 7.1). When semi-quantitati ve results are required, the choice of the appropriate semi-quantitative calibration standards is made (refer to Section 7.2).

The first step in selecting the calibration standards is to determine the target elements of interest. The basic rule is to prioritize the target elements and then reduce the number of elements to b e analyzed in the field to the minimum a mount required to perform the task. For example, suppose the site requiring cleanup was a metals plating facility which contained a waste lagoon known to be contaminated with high concentr ation of several metals, and cadmium was the element present with the highest risk (i.e., lowest action level). Inthis case, the amount of target elements required to monitor the cleanup could be reduced to 1 element, cadmium. Here, by simplifying th e calibration procedures and using only one radioisotope source, sample throughput for the project can be maximized. Note, confirmatory samples taken throughout the cleanup and a final round of confirmatory sampling followi ng completion of the project will help ensure that cleanup action levels for <u>all</u> target elements of interest were obtained.

Another reason to reduce the number of ta rget elements to be analyzed in the field applies directly to quantitative analysis using site-specific calibration standards (SSCS). In order to properly model the regression equation for an element, additional SSCS must be included for each element that may cause possible chemical matrix effects (approximately five per interfering element). Thus, by reducin g the number of target elements, the number of required SSCS can be significantl y reduced, the complexity of the calibration can be simplified, and a large cost savings can b e

realized by reducing the number of samples that require fixed laboratory analysis using full protocol EPA methods.

Note, the X-MET 920 can only analyzed ten (10) elements at one time in a calibration method. Of those 10 elements, only 6 elements may be reported quantitatively and of the remaining four elements, one must always be the backscatter peak (the Compton K_{α} peak from the source radiation).
Figure 1 (Section 1.1) illustrates the typical sampling and analysis scheme for both quantitative and semi-quantitative analyses.

8.1 Quantitative Analysis Using Site-Specific Calibration Standards

Site-specific calibration standards (SSCS) are actual samples from the site under investigation that span the range of concentrations found on site for the elements of interest. Elements of interest not only include the target elements under investigation, but also those elements present that may create possible interference effects. SSCS must be representative of the matrix under investigation (refer to Section 5.1). If there are distinctly different matrices on site that require analysis, separate SSCS must be sampled for each matrix.

The concentration of all target elements, and any elements present that may cause chemical matrix effects (refer to Section 5.3), must be determined by independent AA or ICP analysis in accordance with the full protocol EPA methods specified in the QAPjP/SAP. (The same method must be used to perform all confirmatory analyses to ensure data comparability.) Independent SSCS analyses must be performed in triplicate and the average result for each element is to be used in the instrument calibration. SSCS data must be validated in accordance with the most recent version of the Region I, EPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses prior to use and all raw data and information must be provided with the data package to ensure the scientific defensibility of the calibration standards.

The X-MET 920 reference manual uses the term "modeling" to describe the process of modifying the regression equation of an element's calibration curve to correct for chemical matrix effects and backscatter from the X-ray source. To properly model a regression equation and compensate for these effects, a series of SSCS, containing both interfering and target elements at known and varying concentrations, are required. The total number of SSCS required increases significantly with each target and interfering element. (Again, by reducing the number of target elements in the analysis, the number of SSCS required may be greatly reduced.)

8.1.1 Site-Specific Calibration Standard Sampling

Collect sufficient SSCS to generate a minimum 5-point calibration curve for each target element, that spans the range of concentrations found in the area under investigation. The high and low SSCS for each target element will determine that element's linear calibration range. The remaining standard concentrations should be roughly distributed throughout this range. Note, additional SSCS near the concentration range of interest or site action level will improve the accuracy of the calibration at that level. For each interfering element present, increase the number of SSCS for the element being interfered with, by 5.

For example, consider an analysis in which Pb and Cr are the target elements. To develop the two 5-point calibration curves, it required a combination of 7 SSCS to span the range of

concentrations found on site. Unfortunately, Ni was also present in high enough concentrations to cause a chemical matrix effect with the Cr X-ray. In order to improve the calibration model and reduce the chemical matrix effects, 5 more Cr SSCS which contain Ni, are added to the Cr calibration curve. Thus, a total of 12 SSCS are now needed to calibrate the instrument for the two target elements.

SSCS collected for an interfering element should reflect the variability of that element's concentration found in relation to the concentration of the target element. (Note, mixing of high and low concentration soils to provide a full range of target element concentrations is not recommended because the ratio of the interfering element to the target element will remain the same and the interelement effect in the calibration will be skewed in one direction.) All target and interfering element concentrations, in each of the SSCS collected, should be included as calibration points. Outliers can later be eliminated when the regression equations are being developed (refer to "developing regression equations" in the reference manual).

To assist in determining appropriate SSCS for laboratory analysis, sample points may be pre-screened with the instrument calibrated using semi-quantitative calibration standards (refer to Section 7.2).

8.1.2 Site-Specific Calibration Standard Preparation

The SSCS samples collected in the field must be oven-dried at < 150 °C for 2 to 4 hours to remove moisture. The entire sample should be spread out in a drying pan and clumps broken up with a stainless steel spoon. If mercury is to be analyzed, a separate sample must be air dried until the moisture content is < 20 %, as heating may volatilize the mercury. After drying, all large organic debris and non-representative material (sticks, twigs, leaves, roots, insects, asphalt, rocks, etc.) are removed and the sample is transferred to a mortar and ground with a pestle to a uniform consistency.

The dried and ground sample is then sieved through a No. 60 (250 µm) mesh stainless steel sieve. At no time should the material be forced through the sieve. Pebbles and organic matter remaining on the sieve should be discarded. The under-sieve fraction of the material constitutes the sample. (Although a maximum final particle size of 60-mesh is normally recommended, a smaller sieve size may be used if the physical characteristics of the sample or DQOs of the project dictate. Note, the identical sieve size must be used to prepare all SSCS and samples. Deviations in the sieve size and the reason for the change should be documented in an amendment to the QAPjP/SAP and must be recorded in the sample preparation log and noted in the final report.)

Homogenize the sieved sample by placing 150 - 200 grams of sample on a piece of kraft or butcher paper about 1.5 by 1.5 feet in size. Each corner of the paper should be lifted alternately, rolling the soil over on itself and toward the opposite corner. The soil should be rolled on itself 20 times.

Fill one or more XRF sample cups approximately 3/4 full with sample. Cut and tension (wrinkle-free) a piece of polypropylene film over the top of the cup and seal using the plastic film securing ring. Label the sample cups appropriately. The remainder of the sample is then split into two portions and placed in clean labeled glass or plastic containers. One portion of the sample is submitted to the approved laboratory for analysis of the requested element(s) by

the full protocol EPA methods, and t he other portion is archieved for possible future use. The stainless steel sieve and spoons must be decontaminated between samples by washing wit h soap and water and drying.

8.2 Semi-Quantitative Calibration Standards

When the site objectives require semi-quantitative measurements, the choice of an appropriat e calibratio n standard must be determined (Sections 7.2.1 - 7.2.3). Depending on the relativ e accuracy of the screening desired, one or more calibratio n standards may be used. Note, due to the differences in representativene ss between standards and samples, as well as the other interference factors described in Se ction 6.0, semi-quantitative calibrations may generate false positive and/or negative results.

8.2.1 Site Typical Calibration Standards (STCS)

STCS are SSCS from a different site that contain the target elements of interest in th e approxi mate range and matrix as the site under investigation. If possible, STCS should b e chosen to reflect any chemical matrix effects that may be present in the samples on site. A new instrument calibration must be performed in ac cordance with Section 9.1 each time STCS are employed. STCS data must be validated in accordance with the most recent version of the Region I, EPA-NE Data Validation Functional Guidelines for Evaluating Environmenta l Analyses prior to use and all raw data and inform ation must be provided with the data package to ensure the scientific defensibility of the calibration standards.

8.2.2 Laboratory Prepared Calibration Standards (LPCS)

If satisfactory STCS are not available f or all elements at appropriate concentrations, it may be necessary to prepare quantitative standards from laboratory stock chemicals. Such standards may be prepared b y mixing finely ground dry chemicals or liquid standards with a clean soil, silica sand or other inert material (e.g. Somar Mix, from Somar Laboratories, NY, NY, o r equivalent).

8.2.2.1 Solid Chemical Prepared LPCS

Prepare the high LPCS first, by adding a known weight of dry chemical(s) to a know n weight of clean dry soil or inert material. The clean soi l or inert material must first be pre-dried and sieved through a No. 60 (250 µm) sieve. Following the addition of the dr y chemical, the combined mixture must be ground in a mortar and pestle to thoroughl y homogenize the standard to a uniform consistenc y and particle size. Serial dilutions of the high standard may then be prepare d to establish the calibration range for the analysis. All serial dilutions must mixed in the identical manner as the initial standard.

For example, to prepare a 10,000 mg/kg antimony standard, add 0.60 g of Sb_2O_3 to 49.4 g of dry clean soil and mix/grind thoroughly.

$$\frac{(600 \text{ mg } Sb_2O_3)\ (83.5\ \%\ Sb)}{(0.050 \text{ kg})} = 10{,}000 \text{ mg/kg Sb}$$

Note, if the purity of the dry chemical is < 97%, then the amount of chemical added or final concentration must be adjusted to reflect this.

The clean soil or inert material used in LPCS preparation must be analyzed as a control blank, following instrument calibration, to verify that the elements of interest are not present. If the soil or inert matrix contains an element of interest, its concentration must be determined by the method of standard addition and the actual LPCS concentrations must be corrected for this amount. A minimum of 3 LPCS and the unspiked matrix are required to perform the method of standards addition. Once the base level concentration of the soil or inert matrix is determined, the instrument must be recalibrated using the unspiked matrix as an additional calibration point along with the corrected LPCS concentrations.

8.2.2.2 Liquid Chemical Prepared LPCS

Alternatively, a standard may be prepared by adding a known amount of an aqueous standard to a known amount of clean soil or inert material. The clean soil or inert material must first be pre-dried and sieved through a No. 60 (250 µm) sieve. The volume of aqueous metals standard used must be sufficient to create a standard/soil slurry where all parts of the soil come in contact with the liquid standard. The slurry is then thoroughly mixed and dried at ≤ 105 °C. The dried standard must be ground in a mortar and pestle to thoroughly homogenize the standard to a uniform consistency and particle size. To establish a calibration range for the analysis, additional standards may be prepared from aqueous standards of different concentrations, or by preparing serial dilutions of the first standard. All serial dilutions must mixed in the identical manner as described in Section 7.2.2.1.

For example, to prepare a 10,000 mg/kg antimony standard, pipet 10 mL of a 10,000 mg/L antimony AA/ICP standard into a beaker containing 10 g of dry clean soil or inert material. Mix to a uniform slurry, dry in an oven at ≤ 105 °C, and re-mix/grind until the standard is thoroughly homogenized.

$$\frac{(10{,}000 \text{ mg/L Sb})\ (0.010 \text{ L})}{(0.010 \text{ kg})} = 10{,}000 \text{ mg/kg Sb}$$

The clean soil or inert material used in LPCS preparation must be analyzed as a control blank, following instrument calibration, to verify that the elements of interest are not present. If the soil or inert matrix contains an element of interest, its concentration must be determined by the method of standard addition and the actual LPCS concentrations must be corrected for this amount. A minimum of 3 LPCS and the unspiked matrix are required to perform the method of standards addition. Once the base level concentration of the soil or inert matrix is determined, the instrument must be recalibrated using the unspiked matrix as an additional calibration point along with the corrected LPCS concentrations.

8.2.3 Standard Reference Material (SRM)

NIST or other commercially available certified standard reference materials may be used. A copy of the certified results must be included in the final data package.

9.0 Calibration and Operation

9.1 Instrument Calibration

The X-MET 920 may be calibrated using one of several techniques available depending on the data quality objectives of the project.

- For quantitative field analysis, empirical calibration procedures must be used that incorporate site-specific calibration standards.

- For semi-quantitative screening, one of three calibration procedures, empirical calibration, fundamental parameters calibration, or Compton peak normalization calibration, may be used to calibrate the instrument depending on the standards and instrument software available.

Empirical Calibration - The standard software package supplied with the X-MET 920 supports the empirical calibration technique. This calibration technique is used for all quantitative analyses and for semi-quantitative analysis using a series of either site-typical calibration standards, laboratory prepared calibration standards, or standard reference materials. Refer to Instrument Operation, Section 9. 2 of this SOP, and X-MET reference manual for information on performing an empirical calibration.

Fundamental Parameters - Alternatively, an optional software package called ACES (Automated Contaminant Evaluation Software), is available which uses a modified fundamental parameter approach to generate a calibration. This calibration technique may only be used for semi-quantitative screening analyses. This calibration relies on the ability of the liquid nitrogen cooled, Li(Si) solid state detector to separate the coherent (Rayleigh) backscatter peaks from the incoherent (Compton) backscatter peaks of primary radiation. These peak intensities are known to be a function of sample composition, and the ratio of the Compton to Rayleigh peak is a function of the mass absorption of the sample. The calibration procedure is explained in detail in the ACES user's manual. The ACES program is not presently available on the Region I X-MET 920, and thus, the fundamental parameters calibration procedure is beyond the scope of this SOP and will not be addressed further.

Compton Peak Normalization - The last calibration technique, Compton peak normalization, is a manual calibration technique used for semi-quantitative screening analyses. It is based on the analysis of one or more certified standards, where the intensities of the lines of interest (i.e., target elements) in the sample are ratioed against those in the standard, following normalization of the Compton peaks. The Compton peak intensity changes with differing matrices. Generally, matrices dominated by lighter elements produce a larger Compton peak, and those dominated by heavier elements produce a smaller Compton peak. Normalizing to the Comptom peak is similar to using internal standard calibration and can reduce the problems associated with varing sample matrices. Use Equation 5 to calculate Compton peak normalized sample results.

Equation 5

$$\text{Sample Concentration (mg/Kg)} = \frac{(A_I)\ (S_K)\ (S_C)}{(A_K)\ (S_I)}$$

Where:

A_I = Baseline corrected sample intensity
A_K = Baseline corrected sample Compton K_α intensity
S_K = Baseline corrected standard Compton K_α intensity
S_I = Baseline corrected standard intensity
S_C = Standard concentration (mg/Kg)

Certified standards, used in Compton peak normalization calibrations, may include either SSCS, STCS, LPCS, or SRM. For optimum results, the certified reference standards should be of similar matrix as the samples and should contain the elements of interest at concentrations near those expected in the samples. Although the X-MET 920 software can be adapted to supply the line intensities to manually calculate Compton peak normalized results, it is not a routine procedure accomadated by this instrument and will thus not be addressed further in this SOP.

9.1.1 Instrument Performance Check

Prior to the analysis of any standards or samples, the peak calibration of the X-MET 920 must be verified. The channel for the Pb L_β line (on the multi-channel analyzer of the XPCU board) must be verified at the beginning of the day (prior to the initial calibration) and at the end of the analysis sequence or every 8 hours, whichever is more frequent. If the initial peak calibration check at the beginning of the day for the Pb L_β line is not at 990 ± 2 channels, re-set the peak calibration, verify that it is correct, and perform an initial calibration. If the peak calibration check performed at the end of the analytical sequence (or after eight hours) does not meet the above criteria, then re-set the peak calibration, re-perform the initial calibration and re-analyze all samples since the last compliant peak calibration check. All samples must be analyzed within a valid analytical sequence.

9.1.2 Initial Calibration (ICAL)

This SOP is specific to the use of empirical calibration. The other calibration techniques for semi-quantitative analysis, fundemental parameters and Compton peak normalization, are acceptable for use, but will require modifications to this SOP (Sections 9.1.2 and 9.2.3) and documentation of these changes in the QAPjP/SAP. All other procedures discussed in this SOP are valid for these other calibration techniques and should remain implemented.

After the peak calibration check criteria are met, and prior to the analysis of any samples, the X-MET 920 must be calibrated empirically for quantitative or semi-quantitative analysis. The instrument must be calibrated at a minimum of once every seven (7) days for the Cd-109 source, once every thirty (30) days for the Am-241 source, and any time the continuing calibration verification criteria below are not met. The correlation coefficient of the calibration curve for each target element must be ≥0.98. If the correlation coefficient is less than 0.98, the problem must be identified and corrected prior to sample analysis. If a correlation coefficient of ≥ 0.98 is unattainable due the chemical matrix effects, the best possible calibration must be established for analysis and the problems associated with the calibration documented in the report narrative.

9.1.3 Initial Calibration Verification (ICV)

The ICV is an independent standard (or standards), from a source other than that used in the initial calibration, that contains all the target elements of interest. The ICV may be an STCS, LPCS, or SRM, or for quantitative analysis using SSCS, an additional SSCS not used in the ICAL may be used for the ICV. The ICV must be analyzed immediately after the initial calibration is completed. ICV target element concentrations should be near the site action levels, or if no action level has been determined, they should be near the level of interest or the mid-point of the initial calibration. Calculate the percent recovery for each target element in the ICV using Equation 6.

Equation 6

$$\text{Percent Recovery (\%)} = \frac{\text{Found Value}}{\text{True Value}} \times 100$$

The percent recovery for each element in the ICV must be 50 - 150 %, inclusive. If the true value of an ICV element is < 2 times the MDL, then the control limit is the true value ± MDL. If the ICV does not meet the control limits, then the analysis must be terminated, and the problem must identified and corrected. An acceptable ICV must be obtained prior to sample analysis.

9.1.4 Continuing Calibration Verification (CCV)

A CCV standard(s) must be analyzed at the beginning and end of an analysis sequence and after every 10 samples. The CCV standard(s) is an ICAL standard that contains all of the target elements. The concentration of the CCV should be near the site action level, or if no action level has been determined, the concentration should be near the level of interest or the mid-point of the initial calibration.

Calculate the percent recovery for each target element in the CCV using Equation 6. The percent recovery for each target element in the CCV must be 80 - 120 %, inclusive. If the true value of the CCV is ≥MDL and < PQL, then the control limit is the true value ±MDL. If the CCV does not meet the control limits, then the analysis must be terminated, the problem must be corrected, and the CCV must be reanalyzed. If the CCV reanalysis yields a result within the acceptance criteria, then the analysis may continue and all samples analyzed since the last compliant CCV must be re-analyzed. If the reanalysis of the CCV still does not meet the acceptance criteria, than the instrument must be recalibrated, the ICV verified and all affected samples reanalyzed within a valid analytical sequence.

9.2 Instrument Operation

9.2.1 Filling the Probe Dewar with Liquid Nitrogen

To operate the Solid State Probe Set (SSPS), the Si(Li) detector must be cooled with liquid nitrogen.

1. Place the probe on its side on a flat surface. Unscrew the dewar plug (brass screw) from the filling port.

2. Slide the L-shaped outlet tube of the funnel all the way into the filling port and hand tighten the brass knurled nut on top the filling port thread. Arrange the funnel so that its cone faces upward.

3. Pour liquid nitrogen slowly into a funnel and let it flow into the probe dewar. It usually takes approximately three funnel volumes of liquid N_2 to fill the probe dewar (0.45 liter capacity). The dewar is filled when you see a cone-like spray of liquid nitrogen from around the brass nut of the funnel connector.

4. After the probe dewar is filled, carefully unscrew the funnel nut (holding the insulated sleeve) and withdraw the funnel from the dewar port. Quickly screw back in the dewar plug and hand tighten. In a few seconds the pressure of the liquid nitrogen will build up inside the probe dewar and "hissing" sounds of escaping gas through relief valves will be heard. Press the green switch on the probe to secure the radioactive sources from use until the probe reaches the proper operating temperature.

5. Wait approximately thirty minutes for the probe to cool down before operating.

<u>NOTE:</u> The threads on the dewar filling port will require periodic lubrication on a semi-annual basis or as needed. Lubricate with DOW Corning 33 Lubricant, or equivalent.

While the Si(Li) Solid State Probe is cooling, turn on the computer and monitor. Type either SSPSA for the Cd-109 Source, or SSPSB for the AM-241 source. Follow the prompts and press ENTER. After thirty minutes the instrumentation is ready for use.

9.2.2 Instrument Performance Check

The Lead (Pb) L_β peak optimum must be checked before instrument calibration or analysis is performed, and at the end of the analytical sequence, or every eight hours, whichever is more frequent.

To assure proper peak assignment and identifications, you must check to make sure the Pb L_β peak (right side large Pb peak) is at channel 990 ± two channels. To do this, place the pure element Pb standard into the SSPS probe sample holder.

The Main Menu for X-Met 920 Software (Version 1.33, November 1994) consists of:

1.) ANALYSIS
2.) CALIBRATION
3.) MAINTENANCE

From the main menu of the computer, arrow down to MAINTENANCE and press ENTER.

Press F3 for Instrument
Press F3 for Test Measurement
Press F3 for Time
When in Time, type 30 (for 30 second analysis time) and press "ENTER".

The screen message says "Probe in Reference position. Press Start to begin"

On the base of the SSPS probe, push the red start button, and then Press F1 on the keyboard to start acquisition. When acquisition is complete, check to see that Pb L_β peak is at channel 990 ± two channels. To do this, move the yellow cursor to the Pb L_β peak (second large peak on screen which is shaded) and read the channel number where the area count is at the maximum. If the Pb L_β peak is at 990 ± two channels, press F8 to quit. If not, press F8 again and type the letter "O" to optimize. After optimization, repeat the above procedure to make sure the Pb L_β peak assignment is proper.

The Instrument is now ready for use. In order to perform sample analysis using empirical calibration, a new calibration method must be developed or an existing calibration method must be updated.

9.2.3 Empirical Calibration and Method Development

Refer to the reference manual for more complete information on software operation. Particular attention must be given to the calibration sections in the manual describing the setting of regression terms to establish the best possible instrument calibration for analyzing field samples.

NOTE: Since sources decay, net count rates for elements will vary as time passes. Therefore, calibration standards must be analyzed and the calibration updated at a minimum of once every seven (7) days for the Cd-109 source and once every thirty (30) days for the Am-241 source. Calibration records must be maintained during an ongoing project to insure that the X-MET 920 is calibrated at the proper frequency.

To perform an empirical calibration for either quantitative analysis or semi-quantitative screening, follow the steps below:

<u>Screen 1</u>: To begin a new calibration, follow the prompts:

1. At the Main Menu arrow down to CALIBRATION and press "ENTER"
2. Press "F1" for New Method

<u>Screen 2</u>: Answer the questions at the prompt which are as follows:

Method Name : (Up to 8 alphanumeric characters) "ENTER"

Calibration Date : (Computer fills this in for you) "ENTER"

Operator : (Type the two initials of your name) "ENTER"

Number of Measurement Windows : (Type the number of elements you will be analyzing for in this method and ADD one f or the backscatter peak. For example, if you were analyzing Pb and Cr, you would type 3) "ENTER"

Number of Standards : (Number of standards to be used in the calibration) "ENTER"

Probe : (Arrow down to SSPS) "ENTER"

Window 1 : (Computer automatically puts in BS [Backscatter] for you)

Window 2: (Type in one element symbol for an analyte of interest, i.e., Pb) . "ENTE R" Continue entering the remaining elements of interest, both targe t elements and matrix elements, in the additional window slots (up to 10 total).

Window Time : 60 (Leave at 60) "ENTER" This is the default analysis tim e used to measure single element st andards for setting each element's measurement window. From this informati on the software automatically calculates the overlap correction factors.

Standard Time : 120 "ENTER" The default time for standard analysis is 12 0 seconds.

Ana lysis Time : 120 "ENTER" The default time for sample analysis is 12 0 seconds. This time may be altered depending on the DQOs of the project . Analysi s times generally range from 60 - 300 seconds. Longer count time s improve the precision or reprod ucibility of the measurement, however increasing the count time by a fa ctor of 4 will provide only 2 times better precision, so there is a point of diminishing returns. Increasing the count time also decreases th e detection limit, and decreases sample throughput. Standard and sample analysis times should be identical.

If you are satisfied with all entries press F7 to continue. If you need to mak e changes to any entries, press Fl and arrow key down to the entries you need t o change. When you are satisfied, press F7 to continue.

Screen 3: Analytes selection. Move the high light bar with the arrow keys onto the elements you wish to analyze and press "ENTER" ea ch time. After the analytes are chosen press F7.

Screen 4: Units and standard concentrations. Enter the concentration units for each element selected. Then enter the high and low standard concentrations for each element. When completed, press F7.

Screen 5: The next step in the calibration sets the measurement windows for each element in the method using single element samples. The windows are set for target and matrix elements as well as for backscatter. The measurement windows identify areas in the spectrum where analytical signals are measured for each element. (Note, the spectra of the single element standards are also used to determine the interelement correction factors that are used to correct for spectral overlap. The X-MET 920 software automatically calculates these factors.) On the screen, you are asked if you want to use the spectra in memory. Press F1 for yes (you will see the location of the analytes) and then select the single element spectra. If all spectra needed for calibration are not selected or present in memory, the X-MET 920 will then list the elements that need to be measured. By pressing F1, the software will prompt for measurement of each single element standard. Based on the element measured, the software automatically selects the peak location (K_α, L_α, etc.) and the measurement window to the peak width at half height. (Refer to the reference manual for instructions on manually selecting the window location and limits, if required.) When measured, the spectra from the single element samples are automatically stored to disk for use a at a later time. If the measured spectrum is already in the library, the new spectrum will replace the old. X-ray emission on the energy scale is in kilo electron Volts (keV). Press F7 to continue.

Screen 6: The next screen prompts you to enter the assay value for each element for your first calibration standard. Type this information and press "ENTER". Press F1 to accept this information.

Screen 7: The next screen asks to place standard #1 in the SSPS and press "Start". To do this, take the standard #1 XRF cup, wipe the bottom of the cup with a dry tissue, and place it over measurement window. Close the cover (radiation shield) and press the small RED button at the base of the SSPS probe unit. This will start the analysis of standard #1. Repeat this for each standard in the method.

Screen 8: After running all standards in the calibration curve, the screen shows "Selection of Regression Term(s) for Analytes". Choose regression terms using the arrow keys and press "ENTER" on the chosen terms. Press F1 to perform the regression. You MUST press F4 (Residuals) to view and save calibration curve. If you need to, you can delete outlying points when viewing a calibration curve by pressing F1. Ideally, the regression term chosen will give a linear regression with a correlation coefficient (R) close to 1.00, a standard error of fit (S) which is very low, and a Fisher's factor (F) which is maximized. (Refer to reference manual for the discussion on choosing regression terms and establishing the best possible assay method.) When complete, print out the calibration curve by pressing F3. Press F7 to continue.

If satisfied with the calibration curve for an analyte, press F2 to move on to the "Next Analyte". Continue defining the regression terms for each target element's calibration. After the calibration of the last element is set, press F2 to save it to memory and move onto the next screen.

Screen 9: The final element screen will prompt you to "Insert check sample number." Choose a standard at the action level (if possible), or a mid-point standard from

the calibration curve and following the prompts. Analyze this standard. Note which standard is used. This check sample (standard) can be used later to manually update a calibration curve for source decay. After running the check standard, the screen will show "Calibration Finished". Press F8 to quit calibration mode.

9.2.4 Checking and Updating an Existing Method

Although the X- Met 920 automatically updates calibration curves for source decay, there are times when manual normalization may be needed. This could be the case if unexpected results are obtained on a known sample used to measure the reliability of the instrument. To do this, go to the X-Met 920 Main Menu, arrow down to Maintenance, and hit Enter. Hit F2 for Method Update and arrow key down to the method to be checked/updated. Hit F7 for Check Standard and follow the screen prompts. Place the Check Standard for the specific method into the probe, hit F1 and the red button on the probe to run the check analysis. At the end of the analysis a table of assay values and deviations will be displayed. If the difference in the results is within 3 standard deviations, no correction is required. If the difference in results is within the range of greater than 3 but less than 20 standard deviations, the regression equation is corrected. If the difference in results is off by more than 20 standard deviations, the instrument must be recalibrated.

10.0 Quality Assurance and Quality Control

10.1 Instrument Performance Check

The instrument peak calibration must be verified at the beginning of the day (prior to the initial calibration) and at the end of the analysis sequence or every 8 hours, whichever is more frequent. If the initial peak calibration check at the beginning of the day for the Pb L_β line is not at 990 ± 2 channels, re-set the peak calibration, verify that it is correct, and perform an initial calibration. If the peak calibration check performed at the end of the analytical sequence (or after eight hours) does not meet the above criteria, then re-set the peak calibration, perform an initial calibration and re-analyze all samples since the last compliant peak calibration check within a valid analytical sequence.

10.2 Sensitivity - Method Detection Limit and Practical Quantitation Limit

The site-specific method and quantitation limits must be determined for each target element during the initial stages of a project. Site-specific method detection limits (MDLs) and practical detection limits (PQLs) must be determined for each project, and on long term projects, must be repeated quarterly there after. If there are distinctly different matrices on site, MDLs and PQLs must be determined for each matrix. For quantitative analysis, the MDLs are generated by preparing and analyzing a minimum of seven aliquots (i.e., sample cups) of the lowest SSCS for each target element in accordance with 40 CFR Part 136, Appendix B. For semi-quantitative screening, a low concentration sample, STCS, LPCS, or SRM may be used. Element concentrations should be approximately 3 - 5 times the expected MDL to generate accurate MDLs and PQLs. Calculate the MDL using Equation 1.

Equation 1

$$MDL = t_{(n-1,\ 1-\alpha\ =\ 0.99)}\ (S)$$

Where:

$t_{(n-1,\ 1-\alpha\ =\ 0.99)}$ = the students' t value appropriate for a 99% confidence level and a standard deviation estimate with n-1 degrees of freedom. See Table 2.

S = standard deviation of the replicate analyses.

Table 2 - Students' t Values at the 99 Percent Confidence Level

Number of replicates	Degrees of freedom (n-1)	$t_{(n-1,\ 1-\alpha\ =\ 0.99)}$
7	6	3.143
8	7	2.998
9	8	2.896
10	9	2.821
11	10	2.764
16	15	2.602

Calculate the PQL for each element by multiplying the MDL by 3.

10.3 Precision

10.3.1 Analytical Precision Test

The precision of the analytical method is determined by performing multiple analyses on a field sample with low, moderate , or high concentrations of target elements. The frequency of precision measurements will depend on the DQOs of the project. At a minimum, one analytical precision test must be performed per day. The sample chosen for testing should be analyzed a minimum of 7 times in replicate (same sample cup 7 times). It is extremely important if the site action level(s) are known, that the sample used to determine method precision be at concentrations near the site action levels. If several precision measurements will be made over time, it is recommended that samples with varying concentration ranges be used to assess the effect of concentration on method precision. Samples at the site's action levels should, however, dominate the precision measurement process. Precision measurements must be made using the same analysis time as that used to analyze the other project samples.

To assess analytical precision, calculate the relative standard deviation (RSD) of the replicate analyses using Equation 2. Field XRF data, to be considered adequately precise, should be ≤ 20 % with the exception of chromium. RSD values for chromium should be ≤ 30 %.

Equation 2

$$RSD = \frac{S}{Mean} \times 100$$

Where:

S = Standard deviation of the analyte concentration with n-1 degrees of freedom

Mean = Mean concentration of the analyte

10.3.2 Laboratory Duplicates

The precision of the sample preparation and analytical methods is determined by performing a laboratory duplicate analysis Laboratory duplicates must be prepared and analyzed at a frequency of 1 per 20 samples or 1 per sample matrix, whichever is greater. Laboratory duplicates are two aliquots of the same sample that are prepared, homogenized and analyzed in the same manner. Note, proper sample homogenization is critical in producing meaningful results. Calculate the RPD between the sample and its duplicate using Equation 3.

Equation 3

$$RPD = \frac{|(S - D)|}{\frac{(S + D)}{2}} \times 100$$

Where:

S = Original sample result
D = Duplicate sample result

Laboratory duplicates must meet the following criteria.

- If both the original and laboratory duplicate values are ≥ PQL, then the control limit for RPD is ≤35%,
- If one or both values are < PQL, then do not assess the RPD.

If duplicate criteria are not met, then re-prepare and reanalyze both the original and laboratory duplicate samples. If duplicate criteria are still not met, then flag that target element with an "*" on the final report for both the original and duplicate samples. Note, report both the original and duplicate analyses; do not report the average. The sample ID for laboratory duplicate samples shall contain the suffix "LD".

10.3.3 Field Duplicates

Field duplicates measure cummulative effects of both the field and method precision and hence provide an indicator of overall precision. Sample field duplicates must be prepared and analyzed at a frequency of 1 per 20 samples or 1 per sample matrix, whichever is greater. Field duplicates are samples collected adjacent to each other at the same sample location (not

two aliquots o f the same sample). Calculate the Relative Percent Difference (RPD) between the sample and its duplicate using Equation 3.

If the field duplicate criteria spec ified below are not met, then flag that target element with an "*" on the final report f or both the original and field duplicate samples. Note, report both the original and field duplicate analyses; do not report the average. The sample ID for fiel d duplicate samples shall contain the suffix "FD".

- If both the original and field duplicate values are ≥ PQL, then the control limit for RPD i s ≤50%,
- If one or both values are < PQL, then do not assess the RPD.

If more rigorous field duplicate criteria are needed to achieve the project DQOs, then th e criteria should be documented in the QAPjP/SAP.

10.4 Blanks

Two types of blank samples, instrument blanks and method blanks, must be analyzed with every XRF analysis. A third type of blank, the control blank used in the preparation of laborator y prepared calib ration standards (LPCS), must be analyzed whenever LPCS are used in instrument calibration.

10.4.1 Instrument blank

The instrument blank is used to verify that no contamination exists in the spectrometer or on the probe window. The instrument blank can be silicon dioxide, a Teflon block, a quartz block, "clean" sand, or lithium carbonate. This instrument must be analyzed on each working day before and after analyses are conducted and once per 20 samples. In addition, an instrument blank should be analyzed whenever contamination is suspected by the analyst. The analysis time must match that of the other project samples. Element concentrations must be belo w their respective MDL s. If concentrations exceed these limits, then the probe window and the check sample should be checked fo r contamination. If contamination is not the problem, then the instrument must be "zeroed" by following the manufacturer's instructions. The instrument blank analyses must meet criteria in order for the analysis to continue. All samples analyzed since th e last compliant instrument blank must be re-analyzed in an analysis sequence which meets blank criteria.

10.4.2 Method blank

A method b lank is used to monitor for sample preparation-induced contaminants o r interferences. The method blank can be "clean" silica sand or li thium carbonate that undergoes the same pre paration procedure as the samples. Method blanks must be prepared at a frequency of 1 per group of samples prepared or 1 per 20 sam ples, whichever is more frequent. The method blank must not contain element concentrations greater than their respective MDLs. If concentrations exceed these limits, then the cause of the problem must be determined and corrected, and all samples associated with that method blank must be re-prepared an d reanalyzed.

10.4.3 Control Blank

The clean soil or inert material used in LPCS preparation must be analyzed as a control blank, in accordance with Sections 8.2.2.1 and/or 8.2.2.2, immediately after the initial calibration.

10.5 Confirmatory Sample Analyses

Confirmation of XRF sample results using standard EPA method protocols is required and should support the project's data quality objectives. Confirmatory samples are splits of the thoroughly homogenized material obtained following sample preparation. In general, a frequency of a minimum of 1 per 20 samples or 1 per sample matrix, whichever is more frequent, is recommended. The confirmatory samples should be selected to include samples with elements concentrations at or near site action levels. The choice of digestion and analysis methods, the frequency of confirmation sampling, and the comparability criteria for confirmatory analyses should be established at the scoping phase of the sampling and analysis event. Confirmation results should be validated in accordance with the most recent revision of the Region I, EPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses and accompany the XRF final report upon their completion.

XRF field data shall be compared to the confirmatory results using Equation 4.

Equation 4 Confirmatory Analyses

$$\% \text{ Difference} = \frac{|C_1 - C_2|}{C_1} \times 100$$

Where:

C_1 = Concentration determined by full protocol confirmatory analysis
C_2 = Concentration determined by XRF analysis

Comparability criteria for confirmatory analysis must be established and documented in the QAPjP or SAP. Samples that exceed the criteria should be discussed in the final report.

10.6 Performance Evaluation Samples

Performance evaluation (PE) samples should be submitted for analysis on the X-MET 920 and to the fixed laboratory performing the full protocol EPA methods to provide information on the quality of the individual data packages in accordance with the EPA Region I Performance Evaluation Program Guidance. PE samples are certified standard reference materials (SRMs) from a source other than that used to calibrate the instrument. At least one PE sample should undergo both XRF analysis and confirmatory full protocol EPA method analysis to facillitate data comparability. A a copy of the certified values for the SRM must be submitted with the final data packages to facilitate data evaluation.

10.7 Data Verification and Validation

Data should be verified daily, by a person other than that performing the work, to check for calculation and transcription errors and to ensure that all QC samples meet acceptance criteria.

All data must be validated in accordance with the Region I, EPA New England Data Validation Functional Guidelines for Evaluating Environmental Analyses.

10.8 Audits

10.8.1 Internal Audits

As part of the Quality Assurance/Quality Control Program for an XRF project, a series of internal audit checks should be instituted to monitor and maintain the integrity of the data. A daily QC review will insure that all QC samples met acceptance criteria and monitor any corrective actions taken and/or institute corrective action that should have been taken and were not. All corrective actions taken as part of an internal audit must be documented in the appropriate logbooks, and if these corrective actions impact the final data reported, then they must also be documented in the final report narrative.

10.8.2 External Audits

The Agency reserves the right to perform periodic field audits to ensure compliance with this SOP.

11.0 Sample Collection, Preservation, and Storage

Soil and sediment samples may be collected in either glass or plastic containers, or plastic zip-lock bags. Approximately 8 ounces of sample volume should be collected. This is equivalent to a sampling area approximately 4 inches by 4 inches square by 1 inch deep in size. Initial homogenization of the sample and removal of non-representative material should take place at the time of sampling.

To maintain sample integrity, chain-of-custody procedures must be implemented at the time of sampling to 1) document all sample locations and associated field sample identification numbers, 2) document all quality control samples taken, including field duplicates, split samples for confirmatory analyses, and PE samples, and 3) document the transfer of field samples from field sampler to field chemist and from field chemist to the fixed laboratory.

Samples may be stored at room temperature and have an indefinite shelf life. Mercury analysis has a six month holding time.

12.0 Sample Preparation and Analysis

12.1 Sample Preparation

12.1.1 Quantitative Analysis Preparation

Samples for quantitative analysis must be prep ared in the identical manner as the SSCS. Field samples are spread out in a dry ing pan, clumps are broken up with a stainless steel spoon, and the sample is oven-dried at < 150 °C for 2 to 4 hours to remove moisture. If mercury is to be analyzed, a separat e sample must be air dried until the moisture content is < 20 %, as heating may volatilize the mercury. After drying, all large organic debris and non-representativ e material (sticks, twigs, leaves, roots, insects, asphalt, rocks, etc.) are removed and the sample is transferred to a mortar and pestle and ground to a uniform consistency.

The dried and ground sample is then sieved through a No. 60 (250 µm) mesh stainless steel sieve. At no time should the material be for ced through the sieve. Pebbles and organic matter rema ining on the sieve should be discarded. The under-sieve fraction of the materia l constitutes the sample. (Although a maximum final particle size of 60-mesh is normall y recommended, a smaller sieve size may be used if the DQOs of the project dictate. Note, the identical sieve s ize must be used to prepare all samples and standards . Deviations in the sieve size and the reason for the change must be recorded in the sample preparation log and noted in the final report.)

Homogenize the sieved sample by placing 150 - 200 grams of sample on a piece of kraft or butcher paper about 1.5 by 1.5 feet in size. Each corner of the paper should be lifte d alternately, rolling the soil over on itself and toward the opposite corner. The soil should be rolled on itself 20 times.

Fill one or more XRF sample cups approximately 3/4 full with sample. Cut and tensio n (wrinkle-free) a pi ece of polypropylene film over the top of the cup and seal using the plastic film securing ring. Label the sample cups appropriately. Place the remaining sample in a clean labeled glass or plastic container for archival and possible confirmation analysis. The stainless steel sieve and spoons must be decontaminated between samples by washing wit h soap and water and drying.

12.1.2 Semi-Quantitative Screening Preparation

For semi-quantitative screening analysis, the collected sample is spread out in a pan, clumps are broken up with a stainless steel spoon, and sticks, stones, and other matter non - repres entative matter are removed from the sample. The sample is then thoroughl y homogenized in the pan by dividing it into quarters and physically mixing opposite quarters with a clean stainless steel spoon. Re-composite a nd repeat the quartering process three times.

Fill one or more XRF sample cups approximately 3/4 full with sample. Cut and tensio n (wrinkle-free) a pi ece of polypropylene film over the top of the cup and seal using the plastic film securing ring. Label the sample cups appropriately. The re maining sample may be placed in a clean labeled glass or plastic container to be archived or submitted for confirmator y

analysis. The stainless steel sieve and spoons must be decontaminated between samples by washing with soap and water and drying.

12.2 Sample Analysis

From the main menu, arrow up to ANALYSIS and press "ENTER". Arrow down to the method you wish to use. Press F5 to toggle the printer on. Press "ENTER" to chose the method.

On the top of the screen you will see NAME >. Near the bottom of the screen is the method name chosen, the probe type, the analysis time, and "print" if the printer is activated. At the very bottom of the screen there are numbers 1-8 with soft key functions.

To analyze the sample, after NAME > type the sample name and then "ENTER". Wipe the bottom of the sample cup to be analyzed with a tissue to remove any dirt, dust or moisture and place cleaned sample cup into SSPS probe sample holder. Close the sample holder protective cover.

On the computer, press F1 to start (screen says set probe in measurement position), then press the red start button on the base of the probe. This starts the acquisition. The screen shows "measurement in progress" and in the top right corner is the analysis time countdown. When sample acquisition is complete, assay results and standard deviations are shown on the screen.

12.3 Analysis sequence

1. Verify instrument peak calibration by checking the Pb L_β line (Section 9.2.2)

2. Perform initial calibration using either quantitative or semi-quantitative calibration standards (Secction 9.1).

3. Analyze the initial calibration verification (ICV) standard(s) (Section 9.1.2).

4. Analyze continuing calibration verification (CCV) standard(s) (Section 9.1.3).

5. Analyze 10 samples maximum. (Note, control blanks used in preparing LPCS, Section 7.2.2, should be analyzed at the beginning of the run sequence prior to sample analysis.)

6. Analyze CCV (continue 10 samples/CCV sequence)

7. Analyze last sample.

8. Analyze CCV

9. Verify instrument peak calibration by checking the Pb L_β line.

13.0 Documentation, Reporting Results, and the Final Report

13.1 Field XRF Final Report

13.1.1 Report Narrative

The final XRF data package must contain a report narrative that includes the following:

- The narrative must list all the sample numbers for the sample results being reported and include any pertinent information related to their sampling location (sampling map or written description).
- The narrative must identify the SSCS and field samples sent to the fixed laboratory for confirmation analysis and must reference the full protocol EPA digestion and analysis methods.
- The narrative must also include any comments related to problems encountered in sample preparation or analysis, any technical or administrative problems, and the corrective actions taken and/or the resolution of the problem.
- Discuss precision in terms of the daily precision tests performed and field duplicate analyses. Evaluate the impact on sample results.
- Discuss accuracy in terms of PE samples analyzed and confirmatory analysis results.
- Discuss sensitivity in terms of calibration response and evaluate the impact on sample results.
- Discuss data completeness in terms of the number of samples analyzed and successfully analyzed. Evaluate the impact on sample results.
- Discuss contamination in terms of blank contamination and evaluate the impact on sample results.

13.1.2 Sample Results

Tabulate all sample results. Quantitative results shall be reported in mg/Kg dry weight, and semi-quantitative results shall be reported in mg/Kg wet weight. Results < 1000 mg/Kg are reported to two significant figures and results ≥ 1000 mg/Kg are reported to three significant figures.

- All values < MDL shall be reported as the MDL and flagged with the letter "U".
- All values ≥ MDL and < PQL shall be reported as is and flagged with the letter "B".

13.1.3 Quality Control Results

13.1.3.1 Tabulate the initial calibration data for each target element, including the linear regression data indicating the correlation coefficient, standard error of fit, and the F-test value.

13.1.3.2 Tabulate all ICV and CCV percent recovery data. Include the true value, found value, % recovery, and control limits.

13.1.3.3 Tabulate all instrument and method blank results.

13.3.3.4 Tabulate all field and laboratory duplicate results. Include the original result, the duplicate result, the mean, the relative percent difference (RPD), the control limits, and the flag qualifier "*" for those results not meeting the control limits. Note, report duplicate results as separate field samples. The sample ID for the duplicate samples shall contain the suffix "FD" or "LD" for field duplicate or laboratory duplicate, respectively. Element results not meeting the control limits for duplicate analyses shall be flagged in the tabulated sample results, but only for the original and duplicate data result.

13.1.3.5 Tabulate all PE sample results. Include the true value, found value, % recovery, and control limits.

13.1.4 Raw Data

All raw data associated with the preparation and analysis of standards, QC samples, and field samples analyzed on the X-MET 920 must be submitted with the final report. The raw data shall include:

13.1.4.1 Instrument printouts from all standards, QC samples, blanks, and field samples analyzed. Instrument printouts shall include:

1. Energy Spectra. The energy spectra must be labeled with the appropriate standard or sample ID and be scaled appropriately such that the energy peaks of interest are easily visible.

2. Data. The data printout must indicate the standard or sample ID, the analysis date, and the peak energy information, including the associated target elements and intensity and/or concentration readouts.

13.1.4.2 Copies of all relevant standard, QC, and field sample Preparation Logbook pages. The logbook must include:

1. Site name, CERCLIS number (if available), and EPA Site Manager
2. Name and affiliation (EPA, Contractor company name, etc.) of analyst preparing the samples,
3. Preparation date,
4. IDs of all standards, QC samples, and field samples prepared (correlating to field location),
5. IDs of SSCS and field samples sent to a fixed laboratory for confirmation analysis, and

6. Pertinent comments. Comments shall include a description of the samples (color, particle size: course/fine/clay, organic vs. sand/sediment, etc.), any problems encountered in preparation, the resolution of those problems, any deviations from the methodology and the reasons why, and all pertinent information related to the preparation of Laboratory Prepared Calibration Standards.

13.1.4.3 Copies of all relevant Analysis Logbook pages. The Analysis Logbook must detail the exact sequence in which all standards,QC samples, blanks, and field samples were analyzed. The logbook must include:

1. Site name, CERCLIS number (if available), and EPA Site Manager,
2. Name and affiliation (EPA, Contractor company name, etc.) of analyst preparing the samples,
3. Analysis date,
4. Radioisotope source used,
5. Report peak calibration results for the Pb L_β line. Indicate the peak energy reading and any recalibration steps taken, including a list of any samples requiring reanalysis.
6. IDs of all standards, QC samples, and field samples analyzed (include pertinent concentrations of standards and QC samples),
7. Data file IDs (if different than samples IDs) and any data disk storage identification, and
8. Pertinent comments related to the analysis. Comments shall include any problems encountered during the analysis, the resolution of those problems, any deviations from the methodology and the reasons why, and all pertinent information related to analysis decisions made during the run sequence.

13.1.4.4 Copies of all other relevant Field Logbook pages,

13.2 ICP/AA Confirmatory Data Package and Data Validation Report for SSCS

For full protocol EPA method analyses, complete data packages should be provided in accordance with the Region I, EPA-NE specifications contained in the Training Manual for Reviewing Laboratory Data Package Completeness, dated June 1994. Confirmation results should be validated in accordance with the most recent revision of the Region I, EPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses. The complete confirmatory data package and validation report should accompany the XRF final report.

13.3 ICP/AA Confirmatory Data Package and Data Validation Report for Field Samples

Confirmation results should be provided and validated as specified in Section 12.4. In addition, confirmation results should be compared in tabular format against the XRF results as specified in Section 8.7 and these results checked against the comparability criteria established during the DQO phase of the project. The complete confirmatory data package, validation report and tabulated comparability results should accompany the XRF final report upon their completion.

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION II

GROUND WATER 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) ground water samples from monitoring wells. Low stress Purging and Sampling results in collection of ground water samples from monitoring wells that are representative of ground water 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 ground water 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 Ground-Water 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 ground water samples from monitoring wells that are representative of ground water 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 ground water during sample collection, which improves the sample quality for VOC analysis. Third, in most cases the procedure significantly reduces the volume of ground water 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; and 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, ground water 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 three 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 for 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 ground water 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 ground water 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

<u>Pre-Sampling Activities</u>

1. Start at the well known or believed to have the least contaminated ground water and proceed systematically to the well with the most contaminated ground water. 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 ground water 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 ground water.

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 ground water to flow from the tubing gently down the inside of the container.

    Ground water 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). Ground water purged from the well prior to sampling can be used for this purpose.

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 ground water 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, ground water 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 below).

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 (HNO_3).

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 ground water 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) Ground-water 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.

Attachment A

Example Sample Label

Attachment B

Example Chain-of-Custody Record

Attachment C

Example Custody Seal

Sample Designation Schema

First Segment	Second Segment		Third Segment
Facility, Station, and Site Number	Sample Type	Sample Location + Sample Qualifier	Additional Qualifiers (sample depth, sampling round, etc.)
AANN	AA	NN or NNN or NNNN	NN or NNA

Notes: "A"= alphabetic "N"= numeric

Facility:

L = Naval Amphibious Base Little Creek

Station Type:

S = IR Site
W = SWMU

Site Number:

03 = SWMU 3

08 = Site 8

Sample Type:

MW = Monitoring Well Sample
SB = Soil Boring Sample
SD = Sediment Sample
EB = Equipment Blank
FB = Field Blank
TB = Trip Blank

Sample Location:

1. Station Samples (NN or NNN)

NN or NNN - refers to sequential station number

2. QC Samples (NNNN)

NNNN – refers to the month and day of collection of blank (i.e., 0901 is September 1)

Additional Qualifiers:

1. Soil Boring Sample (NN) refers to the top sample collection depth in feet
2. QC Samples (NN) refers to the year of collection of blank
3. QC Sample (NN**A**)

A is a sample qualifier (i.e., D is a duplicate sample)