N30519_000286
NFD POINT MOLATE
SSIC NO. 5090.3

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N30519_000286
NFD POINT MOLATE
SSIC NO. 5090.3.A

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN II)
Northern and Central California, Nevada, and Utah
Contract No. N62474-94-D-7609
Contract Task Order 379

Prepared for

DEPARTMENT OF THE NAVY
Naval Facilities Engineering Command
Southwest Division
San Diego, California

# FINAL
# FIELD WORK PLAN

## SITE 3 SAMPLING AND FIELD PILOT TESTING

## NAVAL FUEL DEPOT POINT MOLATE
## RICHMOND, CALIFORNIA

DS.0379.15002

May 14, 2001

Prepared by

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# TETRA TECH EM INC.

## TRANSMITTAL/DELIVERABLE RECEIPT

**Contract No. N62474-94-D-7609** Document Control No. DS . 0379 . 15002

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LOCATION:
NFD Point Molate, Richmond

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DOCUMENT TITLE AND DATE:

**FINAL FIELD WORK PLAN FOR SITE 3 SAMPLING AND FIELD PILOT TESTING**

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July 12, 2001

Ms. Michelle Gallice Sondrup
Department of the Navy
Southwest Division
Naval Facilities Engineering Command
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**Subject: Title Page Corrections, Naval Fuel Depot (NFD) Point Molate, Richmond, California**
**CLEAN II Contract No. N62474-94-D-7609, Contract Task Orders (CTOs) 277, 280, 379, and 384**

Dear Ms. Gallice Sondrup:

Tetra Tech EM Inc. (TtEMI) has identified a formatting error on the cover pages of a number of recent final documents. Enclosed are four copies of the corrected cover pages for these documents. The documents for which corrected cover pages are being included are:

- Final Site 1 Engineering Evaluation and Cost Analysis
- Final Work Plan for Site 3 Sampling and Field Pilot Testing
- Field Sampling Plan for Sampling and Field Pilot Testing at Site 3 (Appendix A of the Final Work Plan for Site 3 Sampling and Field Pilot Testing)
- Quality Assurance Project Plan for Sampling and Field Pilot Testing at Site 3 (Appendix B of the Final Work Plan for Site 3 Sampling and Field Pilot Testing)
- Final Field Work Plan for Screening Level Human Health and Ecological Risk Evaluation, Installation Restoration Site 4
- Final Quality Assurance Project Plan for Installation Restoration Site 4 (Appendix B of the Final Field Work Plan for Screening Level Human Health and Ecological Risk Evaluation, Installation Restoration Site 4)
- Final Field Work Plan for Additional Investigation and Field Work, Phase II Environmental Baseline Survey
- Final Field Sampling Plan for Additional Investigation and Field Work, Phase II Environmental Baseline Survey (Appendix B of the Final Field Work Plan for Additional Investigation and Field Work, Phase II Environmental Baseline Survey)
- Final Quality Assurance Project Plan for Additional Investigation and Field Work, Phase II Environmental Baseline Survey (Appendix C of the Final Field Work Plan for Additional Investigation and Field Work, Phase II Environmental Baseline Survey)

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If you have any questions or comments, please contact me at 303-441-7912.

Sincerely,

Brian Schuller

Brian Schuller
Installation Coordinator

BS/jd

Enclosures

cc: Ms. Marianna Potacka, SWDIV
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Ms. Rebecca Ng, CCHS, Site 1 EE/CA only
Mr. Peter Janicki, CIWMB, Site 1 EE/CA only
Mr. Phillip Ramsey, EPA
TtEMI File

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| API | American Petroleum Institute |
| BCT | BRAC Cleanup Team |
| BRAC | Base Realignment and Closure |
| BTEX | Benzene, toluene, ethylbenzene, and xylenes |
| C | Celsius |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CLEAN | Comprehensive Long-term Environmental Action Navy |
| CPR | Cardiopulmonary resuscitation |
| CLP | Contract laboratory program |
| cst | Centistokes |
| CTO | Contract task order |
| 1,2-DCE | 1,2-Dichloroethene |
| DQO | Data quality objective |
| EE/CA | Engineering evaluation and cost analysis |
| EPA | U.S. Environmental Protection Agency |
| F | Fahrenheit |
| FID | Flame ionization detector |
| FPALDR | Fuel Product Action Level Development Report |
| FRF | Fuel reclamation facility |
| FSP | Field sampling plan |
| GWTP | Groundwater treatment plant |
| HASP | Health and safety plan |
| HDPE | High-density polyethylene |
| HPC | Heterotrophic plate counts |
| HSA | Hollow-stem auger |
| IC | Installation coordinator |
| IDW | Investigation-derived waste |
| IR | Installation Restoration |
| MEK | Methyl ethyl ketone |
| MNA | Monitored natural attenuation |
| MPE | Multiphase extraction |
| MS/MSD | Matrix spike and matrix spike duplicate |
| µg/L | Micrograms per liter |
| NFD | Naval Fuel Depot |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| O&M | Operation and maintenance |
| OHSO | On-site health and safety officer |
| OSHA | Occupational Safety and Health Administration |

## ACRONYMS AND ABBREVIATIONS (Continued)

| | |
|---|---|
| PAH | Polynuclear aromatic hydrocarbon |
| PCE | Tetrachloroethene |
| PID | Photoionization detector |
| PPE | Personal protective equipment |
| ppmv | Parts per million by volume |
| PRC | PRC Environmental Management, Inc. |
| PRG | Preliminary remediation goals |
| QA | Quality assurance |
| QAPP | Quality Assurance Project Plan |
| QC | Quality control |
| QIP | Quality Improvement Plan |
| QMP | Quality Management Plan |
| RAB | Restoration Advisory Board |
| RF | Radio frequency |
| RI | Remedial investigation |
| RPM | Remedial Project Manager |
| RTC | Response to comments |
| SAP | Sampling and analysis plan |
| SOP | Standard operating procedure |
| SOW | Statement of work |
| SVE | Soil vapor extraction |
| SVOC | Semivolatile organic compound |
| SWDIV | Southwest Division of the U.S. Navy |
| TCE | Trichloroethene |
| TDS | Total dissolved solids |
| TKN | Total Kjeldahl nitrogen |
| TPH | Total petroleum hydrocarbon |
| TtEMI | Tetra Tech EM Inc. |
| VOC | Volatile organic compound |

# 1.0 INTRODUCTION

This document describes field work Tetra Tech EM Inc. (TtEMI) will conduct to evaluate remedial options to recover free product and address contamination in soil and groundwater at Installation Restoration (IR) Site 3 of Naval Fuel Depot (NFD) Point Molate in Richmond, California. This work plan describes areas where further characterization of contamination in soil and groundwater is necessary and discusses field pilot testing of potential remediation technologies. Additional site characterization is necessary to obtain a more complete and current data set on the volume of soils that contain concentrations of contaminants that exceed agreed-upon action levels, as well as the volume of industrial waste disposed of at the former fuel reclamation facility. Field pilot testing is necessary to evaluate technical effectiveness and cost-related parameters associated with specific remediation technologies. This work plan is authorized under U.S. Navy Comprehensive Long-term Environmental Action Navy (CLEAN) contract number N62474-94-D-7609, contract task order (CTO) 379. The tasks in this work plan are ultimately intended to support a non-time critical removal action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

The results of the tasks described in this work plan will be used to support an engineering evaluation and cost analysis (EE/CA) for Site 3. The EE/CA will be completed to evaluate remediation alternatives for a removal action that will be conducted in accordance with CERCLA. The U.S. Environmental Protection Agency (EPA) has classified removal actions into three types based on the circumstances that surround the release or threat of release: emergency, time-critical, and non-time-critical. The removal action at Site 3 is non-time-critical because an on-site action will occur more than 6 months after the planning period begins. Consistent with CERCLA Section 120 and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the Navy is following the CERCLA removal action process for this action.

Site 3 is located between the hillside area and the shoreline at NFD Point Molate (Figure 2-1), in a flat area that surrounds three treatment ponds. Previous investigations and routine monitoring have revealed the presence of several petroleum hydrocarbon fuels, primarily bunker fuel and diesel, in soil and groundwater at Site 3. Several plumes of free product have also been identified at Site 3.

This work plan outlines the proposed technical approach, including the tasks, assumptions, and deliverables necessary to complete field work to support the EE/CA for Site 3. Along with the accompanying field sampling plan (FSP) included as Appendix A and the quality assurance project

plan (QAPP) included as Appendix B, the work plan discusses the anticipated schedule, management, staffing, health and safety measures, sampling and analysis, and quality assurance (QA) measures necessary to complete the tasks for further evaluation of Site 3.

The FSP and QAPP, which together constitute the project sampling and analysis plan (SAP), describe in detail the field and analytical work to be completed for the project. The QAPP describes the data quality objectives (DQOs) for the project developed through the seven-step DQO process (EPA 1999, 2000) following EPA guidance for preparation of QAPPs (EPA 1998a).

## 1.1 OBJECTIVES AND DATA GAPS

The primary objective of the tasks presented in this work plan is to obtain data to support the EE/CA for Site 3. The EE/CA will be created with the objective of identifying the best remediation technologies for Site 3. Although several investigations have been conducted previously at Site 3, none have been undertaken to evaluate the final action. Therefore, existing data gaps require attention to support a complete EE/CA. Activities needed to meet the primary objective of this work plan are as follows:

(1) Evaluate the extent of free product and residual saturation in soil at Site 3.

(2) Delineate the concentrations of hydrocarbons in soil at Site 3 relative to preliminary risk-based action levels.

(3) Collect and analyze groundwater samples from existing monitoring wells to obtain additional data to assess the current concentrations and distribution of dissolved total petroleum hydrocarbon (TPH) and volatile organic compounds (VOC) in groundwater at Site 3.

(4) Delineate the concentrations of dissolved TPH and VOCs in groundwater at locations in Site 3 where monitoring wells have not been installed.

(5) Delineate the concentrations of metals in soil and groundwater for the area of discarded industrial waste within the former fuel reclamation facility (FRF).

(6) Delineate the area of discarded industrial waste in the FRF.

(7) Conduct field pilot tests to evaluate air sparging, soil vapor extraction (SVE), and multiphase extraction (MPE) in the area of the diesel plume. Pilot test data will be used for the EE/CA.

(8) Evaluate natural attenuation of hydrocarbons in saturated soil and groundwater at Site 3.

The data collected based on this work plan will be used to support the EE/CA for Site 3, as follows:

- Filling data gaps with respect to the extent of the distribution of free product and potential contaminants of concern
- Supporting delineation of the vertical and horizontal extent of soils that may require remediation based on risk-based action levels for soil
- Allowing for a current interpretation of the extent of groundwater that requires remediation based on risk-based action levels for groundwater
- Delineating the extent and volume of discarded industrial waste
- Providing baseline data for evaluating the status of natural attenuation at Site 3
- Providing data to support a technical and cost evaluation of several remediation technologies, including excavation, air sparging, SVE, and MPE

## 1.2 TECHNICAL APPROACH

The technical approach involves several specific tasks, including project planning, soil sampling, monitoring well installation, groundwater sampling, and field pilot testing. A summary of the basic tasks covered by this work plan is presented below.

### 1.2.1 Project Planning

Project planning includes preparation of internal draft, draft, and final versions of the work plan, FSP, and QAPP; as well as responses to regulatory comments. Project planning will also include reviewing and evaluating existing documents, obtaining permits as required for site access, and further developing a conceptual site model.

### 1.2.2 Field Investigation

Field investigation tasks include all efforts related to field work to further characterize contamination in soil and groundwater at Site 3. All work will be completed in accordance with applicable Navy, federal, state, and local guidance, and will include the following:

- Mobilization
- Utility clearance

- Surveying boring locations
- Sampling surface soils in specified locations
- Advancing soil borings and sampling subsurface soil
- Installing and developing 14 monitoring wells
- Collecting groundwater samples from the 14 new monitoring wells and 22 existing monitoring wells
- Completing exploratory trenching in the area of disposed industrial waste in the FRF

Field project management, quality control (QC), and disposal of investigation-derived waste (IDW) are also part of the field investigation tasks. As with any field effort at NFD Point Molate, TtEMI and the Navy will carefully review health and safety issues before work begins.

### 1.2.3 Field Pilot Testing

Field pilot testing tasks involve the following activities:

- Designate locations for test wells and monitoring points
- Install test wells and monitoring points
- Mobilize and set up equipment
- Conduct field tests
- Demobilize equipment
- Survey locations of new test wells and monitoring points

A more extensive description of the field pilot testing to be conducted is presented in Section 5.0 of this work plan.

### 1.2.4 Data Evaluation and Reporting

This work plan includes data reduction, tabulation, and management. Data validation, to be completed by an independent third-party subcontractor, is also part of this work. The results of the site investigation and pilot testing will be summarized in a letter report.

## 1.3 ORGANIZATION OF WORK PLAN

This work plan is organized as follows:

- Section 1.0 provides an introduction to the purpose, objectives, and technical approach to be used in the investigation and field pilot testing effort at Site 3.
- Section 2.0 presents brief descriptions of the installation and site history, climate, topography, geology, and hydrology, as well as site-specific information from previous investigations.
- Section 3.0 describes the DQOs and the work proposed to achieve them.
- Section 4.0 describes the site investigations to be conducted under this study.
- Section 5.0 describes the individual field pilot tests to be conducted under this work plan.
- Section 6.0 discusses data management.
- Section 7.0 covers health and safety issues.
- Section 8.0 presents information on sampling and analysis.
- Section 9.0 addresses QA.
- Section 10.0 details the primary deliverables for the investigation at Site 3.
- Section 11.0 describes community relations associated with the investigation at Site 3.
- Section 12.0 includes details of project management, technical meetings, staffing, and schedules for the 3-month duration of technical work.
- Section 13.0 lists the references cited.
- Tables, figures, and appendices follow Section 13.0.
- Plates are presented at the end of the document, after Appendix C.

# 2.0 SITE BACKGROUND AND PHYSICAL SETTING

NFD Point Molate covers approximately 413 acres in the Potrero Hills along the northeastern shore of San Francisco Bay on the San Pablo Peninsula. The facility is located in Richmond, California, about 1.5 miles north of the Richmond-San Rafael Bridge, as presented in Figure 2-1. NFD Point Molate is bordered to the north, south, and east by the Chevron Corporation, and to the west by San Francisco Bay. San Pablo Peninsula divides San Francisco and San Pablo Bays. Chevron uses most of the land near NFD Point Molate for oil refining and storage; the land east of NFD Point Molate is used for storage,

shipping, and pipeline distribution of petroleum products, and the land immediately north and south is unused open space.

## 2.1 DESCRIPTION OF INSTALLATION

A brief description of the installation is presented in the following sections. A more detailed description of the site, specifically involving geology and hydrogeology, is presented in the Phase II Remedial Investigation (RI) Report (TtEMI 2000a).

### 2.1.1 Topography

Topography at NFD Point Molate ranges from flat, filled areas (reclaimed tidal flats) near the bay to steep, dissected hillsides of nearly 500 feet elevation in the San Pablo Hills. Site 3 is located along the shore in a relatively flat, filled area at an elevation of approximately 15 to 20 feet above mean sea level. With the exception of some existing dikes installed as secondary containment around former Tanks E, F, and G, Site 3 is relatively flat.

### 2.1.2 Regional Geology

The bedrock along San Pablo Ridge is composed primarily of sedimentary rocks of the late Jurassic and Cretaceous-aged Franciscan Formation. Regionally, the Franciscan Formation is a heterogeneous assemblage consisting of sequences of submarine sandstone, shale, and lesser amounts of volcanic rocks, thin-bedded chert, and rare limestone (Irwin 1990). The Franciscan bedrock that underlies San Pablo Ridge is part of a northwest-southeast trending belt of rocks bounded on the west by the San Andreas Fault and on the east by the Hayward Fault.

The regional geology of San Francisco Bay also includes a young, unconsolidated sedimentary sequence. The units in the San Pablo peninsula area that overlie the Franciscan Formation bedrock are the Older Bay Mud, sand deposits (correlating to the Merritt Sand of the East Bay Area), and the Younger Bay Mud (Goldman 1969). The Older Bay Mud is described as generally firm, dark greenish-gray, silty clay with varying amounts of sand and fine gravel. The unit locally contains lenses of clayey sand, pebbly sand, or sandy clay from 5 to 50 feet thick. The unit blankets and fills old stream channels cut in the surface of the bedrock. This unit is overlain by either sand deposits or the Younger Bay Mud. These sand deposits are recognized as a distinctive unit that overlies and interfingers with the Older Bay Mud. The unit is described as a fine sand 50 to 60 feet thick. The unit is dissected by mud-filled channels and is overlain by 0 to 35 feet of Younger Bay Mud (Trask and Rolston 1951).

The Younger Bay Mud is the youngest sedimentary unit in San Francisco Bay. The unit covers most of the bay bottom. It is described as a soft, uniform, gray, silty clay that contains 45 to 95 percent clay-sized particles, silt, minor fine sand, and fragments of shells. The unit tends to be firmer and contain less water with depth. The clay is soft and plastic when wet and tends to harden and shrink when it dries. The Younger Bay Mud was deposited on an erosional surface cut to depths as great as 200 feet below present sea level into the Older Bay Mud. The Younger Bay Mud attains a thickness of as much as 130 feet. The thickness of the Younger Bay Mud along the southwest shore of the San Pablo peninsula at NFD Point Molate is mapped as zero to approximately 40 feet thick offshore (Goldman 1969).

### 2.1.3 Geology of Site 3

The contact between bedrock and overlying unconsolidated deposits in most areas of NFD Point Molate is transitional; that is, fresh bedrock grades upward into moderately weathered bedrock composed of broken and weathered bedrock fragments. A generalized depositional sequence for Site 3 is shown in Figure 2-3, and the unconsolidated deposits are described in the following paragraphs (TtEMI 2000a).

At NFD Point Molate, an unconsolidated deposit known as colluvium usually overlies bedrock or weathered bedrock. Colluvium is predominantly clayey and silty sand with weathered bedrock fragments. The thickness of colluvium ranges from a veneer of weathered bedrock fragments on the slopes to accumulations up to 25 feet thick within ravines. Despite the poor sorting and numerous bedrock fragments within the colluvium, the clayey matrix makes it a dense, low-permeability deposit (TtEMI 2000a).

Downslope from the colluvium, Bay Mud (Younger Bay Mud) was encountered in borings beneath emplaced fill or alluvium in Site 3 and adjacent shoreline areas. In these areas, Bay Mud overlies bedrock and ranges in thickness from 5 and 30 feet, depending on distance from the shoreline. Bay Mud is a very dark brown to black clayey or sandy silt or silty sand. The formation is typically soft, plastic, and moist or saturated, but contains sufficient clay or silt to serve as an aquitard.

As indicated above, both alluvium and emplaced fill overly the Bay Mud. Alluvium that overlies the Bay Mud (and other consolidated deposits) consists of moderately sorted, fine-to-medium grained, unconsolidated sand. In general, grain size increases with depth, and coarse intervals that contain granules or pebbles become more prevalent with depth.

With the exception of the Diesel Road area, most of the overburden at Site 3 consists of fill that was transported to the Treatment Ponds Area from other locations at NFD Point Molate. In contrast to the alluvium previously described, the fill material is composed of heterogeneous materials generally consisting of poorly sorted gravel, silt, sandy silt, and sandy clay, and angular bedrock fragments. The fill typically contains areas of disturbed colluvium, but is generally unconsolidated and heterogeneous and creates unpredictable preferential flow pathways for groundwater and contaminant migration.

### 2.1.4 Hydrogeology at Site 3

Groundwater at NFD Point Molate flows generally to the west-southwest, following surface topography toward San Francisco Bay. However, measurements of groundwater elevation indicate a mounding effect from surface water infiltration at the treatment ponds. The mounding is enhanced by the presence of a containment wall installed along the shoreline side of the former sump pond, as presented in Plates 2-1 and 2-2. The mounding causes localized reversals of gradient at Site 3. Analysis of results for aquifer tests indicated widely ranging values of hydraulic conductivity, as would be expected based on the heterogeneous fill at Site 3.

Although many wells are tidally influenced by San Francisco Bay, enhanced salt water intrusion caused by pumping was not evident, even after approximately 10,000 gallons of groundwater was discharged from well MW11-27, located 175 feet from the bay. Concentrations of sodium and chloride measured in groundwater samples did, however, increase proportionally with proximity to the bay, particularly within 200 feet of the bay.

An extraction trench was installed as a removal action to capture and remove floating fuel and contaminated groundwater for treatment (PRC 1996a). Plate 2-1 shows the location of the containment wall and extraction trench. The extraction trench is 1,100 feet long and 19 to 26 feet deep and is keyed to Bay Mud. It has four 12-inch diameter stainless-steel extraction wells (EW-A, -B, -C, and -D). It contains groundwater migrating toward the bay via a continuous high-density polyethylene (HDPE) liner and sheet piling installed on the downgradient side of the extraction trench. A sheet pile extension was constructed on the southern portion of the trench in 1997 to further contain product in the vicinity of well MW11-54.

The effectiveness of the containment wall and extraction trench in controlling migration of free product has been demonstrated by the elimination of shoreface seepage of petroleum hydrocarbons and a

reduction in the depth to water in the vicinity of the trench (PRC 1996b). Subsurface cross sections are presented in Plates 2-5 through 2-8.

## 2.2 SITE BACKGROUND AND PREVIOUS INVESTIGATION

NFD Point Molate was a fuel storage facility for jet turbine fuels (JP-5 and JP-8) and marine diesel fuel (F-76) and had a storage capacity of more than 40 million gallons. Other fuels have historically been stored at the facility, including bunker fuel, gasoline, and aviation gasoline. Fuel storage and supply ceased in May 1995, and NFD Point Molate became a closing base under the Base Realignment and Closure (BRAC) IV Program on September 30, 1995.

Site 3, the Treatment Ponds Area, includes three unlined, 6-foot deep aeration (treatment) ponds, a groundwater treatment plant (GWTP), the FRF (including oil-water separators, associated piping and storage, an aboveground fractionation tank, and an area of disposed industrial waste), an inactive sewage treatment plant, and a groundwater extraction system and containment wall. The treatment ponds are located on a flat area adjacent to the shoreline (see Figure 2-2), built over a former sump pond. The former sump pond, constructed in the 1940s, was used to contain contaminated fuels, tank bottom sludges, bunker fuel, leaking drums, and possibly other liquid wastes. A sheet pile cutoff wall associated with the sump pond was also installed in the 1940s to impede migration of oil from the pond to San Francisco Bay, although it was only moderately effective. The location of the cutoff wall is shown in Plate 2-1. When the sump pond was closed in 1974, liquids were pumped out and some of the sludge and waste was excavated and removed. The remaining residual sludge was tilled with soil used to fill the pond. Shortly after closure of the sump pond in 1974, the three aeration treatment ponds (which are still in use today) were installed. In 1986, the Navy installed five dual-phase extraction wells along the shoreline in an effort to capture floating hydrocarbons that originated from the former sump pond, but these wells were only moderately effective. Then, in 1995, the Navy conducted an interim removal action at Site 3 using a more comprehensive subsurface containment wall and groundwater extraction system to prevent floating free product from migrating to either San Francisco Bay or the near-shore sediments, as described above. A more detailed description of the history of Site 3 is presented in the Phase II RI Report (TtEMI 2000a).

Industrial wastes were discovered during the March 2001 removal of sumps and an aboveground storage tank within the former FRF. These wastes include batteries (approximately the size that would be used in a motor vehicle), steel cables, wood (including pilings), glass bottles (including food containers),

brick, concrete, 5-gallon unlabelled steel containers, and one 55-gallon drum. Some additional exploratory excavation was conducted and the extent of the waste area was estimated as 120 feet long and 60 feet wide (Plate 2-4). The maximum vertical extent of waste was estimated as extending from 2 feet to 9 feet bgs; only a thin (approximately 1 foot thick) layer of waste was found in some areas. Currently, the waste volume is estimated as 1,900 cubic yards.

### 2.2.1 Past Investigations

Investigations at Site 3 have included a Site Inspection (PRC 1992), a Phase I RI (PRC 1994c), four quarterly groundwater monitoring events (PRC 1994a, 1994b, 1994d, and 1995), and a Phase II RI (TtEMI 2000a). TPH, benzene, toluene, ethylbenze, and xylene (BTEX), polynuclear aromatic hydrocarbons (PAHs) and (sporadically) low concentrations of chlorinated VOCs have been detected in soil and groundwater samples during these investigations. The presence of floating fuel products (diesel and bunker fuel) was also monitored during these investigations. Semiannual groundwater sampling was completed at Site 3 during late October and November 1997, April 1998, and January and February 1999 (TtEMI 1998a, 1998c, 2000a). Additionally, between January 1999 through September 2000, depth to water and free-product thickness have been monitored on a monthly to quarterly frequency.

Free-Product Summary

Bunker fuel was the most predominant free product detected during past investigations at Site 3. Diesel has been the second-most widely distributed and concentrated fuel detected at Site 3. The current estimated distribution and thickness of free product at Site 3, based on the last 2 years of monitoring, is presented in Plate 2-1.

Several intrinsic characteristics of bunker fuel as free product make it unique to address as a target contaminant. Because bunker fuel is composed primarily of large hydrocarbon molecules (alkanes ranging from approximately 12 to 30 carbons), it is relatively low in volatility. Bunker fuel also has a relatively high specific gravity, 0.94 to 0.99 in samples collected from Site 3 wells MW11-36 and P86-11/2. The viscosity of samples of bunker fuel collected from wells at Site 3 ranges from 208 centistokes (cst) to 4,679 cst, at wells MW11-36 and P86-11/2. For comparison, the specific gravity and viscosity of diesel fuel measured at Site 3 was 0.86 and 5.8 cst in a sample from well MW11-54. The high specific gravity and viscosity of bunker fuel, combined with its relatively low volatility, limits the effectiveness of typical remedial options, including free product pumping, air sparging, SVE, and MPE.

Summary of Groundwater Data

The distribution and concentration of aqueous-phase constituents, including TPH, VOCs, and semivolatile organic compounds (SVOCs), were limited to near or directly downgradient of the treatment ponds and former sump pond. The primary dissolved-phase contaminant detected in Site 3 groundwater has been TPH as bunker fuel and diesel. A summary of historical groundwater data for Site 3 is presented in Table 2-1.

As expected, the highest levels of TPH have been detected in samples collected from areas where free product is present, which is primarily between the shoreline and the location of the former sump pond (see Plate 2-1).

Concentrations of VOCs in groundwater samples are included on Plate 2-2. At least 75 groundwater samples were analyzed for VOCs using the contract laboratory program (CLP) volatile organic analysis or EPA organics methods. Of these samples, 29 samples resulted in detectable levels of VOCs. The most frequently detected non-BTEX compounds included acetone, 2-butanone (methyl ethyl ketone [MEK]), chloroform, trichlorethene (TCE), 1,2-dichloroethene (1,2-DCE), chlorobenzene, methyl-t-butyl ether (MTBE), and 1,4-dichlorobenzene. Only two of these 29 samples contained individual constituents at concentrations that exceeded 100 micrograms per liter (µg/L). A groundwater sample from well MW11-13 contained chlorobenzene at 110 to 180 µg/L, and a sample from well MW11-44 contained 1,2-DCE at 710 µg/L and vinyl chloride at 260 µg/L; therefore, groundwater samples from wells in the vicinity of monitor wells MW11-13 and MW11-44 will be analyzed for VOCs. Aside from samples from these two locations, the concentrations of VOCs detected were typically in the range of less than 1 µg/L to 20 µg/L. The VOCs detected (in particular, MEK, PCE, and TCE) were likely used in small quantities as cleaning solvents while the base was active and may have been incidentally disposed of in the former sump pond. Acetone, MEK, and methylene chloride are also known as common laboratory contaminants and frequently are identified in laboratory blanks. Over time, PCE and TCE have likely degraded to 1, 2-DCE and vinyl chloride.

Relatively low levels of PAHs were detected in samples of groundwater collected previously, with a single sample containing one compound, benzo(a)anthracene, at a level that exceeded preliminary action levels. A groundwater sample from boring SB11-95 yielded 10 µg/L of benzo(a)anthracene; however, this sample was unfiltered and was collected from an open soil boring. As such, it likely included higher levels of suspended solids and therefore elevated levels of adsorbed contaminants such as benzo(a)anthracene. Thus, data for SB11-95 was not included in the compilation of groundwater data in Table 2-1.

The estimated distribution of groundwater at Site 3 that contains at least one compound at concentrations that exceed the preliminary action levels presented in the preliminary draft Fuel Product Action Level Development Report (FPALDR) for groundwater is presented in Plate 2-2. An internal draft of the FPALDR was submitted to the BCT for review in January 2001, the final FPALDR is scheduled for submittal in August 2001.

Summary of Soil Data

The primary contaminants detected in soil samples collected from Site 3 included TPH as bunker fuel or diesel. Aside from several detections of BTEX constituents at low to moderate concentrations, only PCE, 1,2-DCE, 2-butanone, acetone, methylene chloride, and MTBE were detected in the 23 soil samples analyzed for VOCs. These non-BTEX compounds were detected in one (PCE) to 4 (acetone) of the 23 samples analyzed for VOCs. Soil boring locations from which samples were collected resulted in the detection of non-BTEX VOCs are presented in Plate 2-4. In addition, although several PAHs have been detected in soil samples (see Tables 2-2 and 2-3) only two PAHs (benzo(a)anthracene and benzo(b)fluoranthene) were detected above any preliminary action levels. Only one PAH in three samples (benzo(a)anthracene in samples from SB11-45, SB11-94, and SB11-95 at a depth of approximately 10 feet bgs) exceeded its preliminary action level within the depth below grade surface (0 to 10 feet bgs) where the action level applies. The sample that resulted in a concentration of benzo(b)fluoranthene exceeding its FPALDR criteria (as presented in Table 2-2) was collected from a depth of 14.5 feet bgs, below the applicable depth range of 0 to 10 feet bgs. The Phase II remedial investigation (TtEMI 2000a) presents a more complete discussion of results for Site 3 soil and groundwater samples.

A summary of the analytical data for soil samples collected throughout Site 3 is presented in Table 2-2 and for shallow soils (between 0 and 10 feet bgs) in Table 2-3. Locations of historical soil samples and cross section lines are presented in Plate 2-3. The distribution of VOCs in soil is presented on Plate 2-4. Residually saturated intervals and free-product fuels were observed in soil sampled across the site, as presented in the cross sections shown on Plates 2-5 through 2-8.

### 2.2.2 Phase I Field Pilot Testing

Phase I field pilot tests were conducted in June 1998 (TtEMI 1998b). Tests conducted included free-product recovery using pumps and belt skimmers, in addition to vacuum-enhanced free-product recovery.

Results of this testing indicated that belt skimmers were more effective in recovering free product than were the pumps. Testing also indicated that the application of a vacuum to test wells did not result in significant recharge of bunker fuel, which represents the most viscous type of TPH fuel found as free product in groundwater at Site 3. However, tests of vacuum-enhanced product recovery indicated that moderate to high levels of hydrocarbons were recovered in the vapor phase, particularly at test well MW11-27, which contains a mix of bunker fuel and diesel. A maximum total hydrocarbon concentration of 21,500 parts per million by volume (ppmv) was detected in the vapor discharge from this well. High levels also were detected at test well MW11-37 (which contains primarily bunker fuel), where a maximum of 2,200 ppmv total hydrocarbons was detected.

These test results indicated that standard techniques for recovery of free product (especially bunker fuel) would result in only limited success at Site 3. The test results also suggested that significant removal of hydrocarbon mass in the vapor phase would be possible given the relatively high concentrations of vapor-phase TPH detected, particularly in the diesel plume areas.

### 2.2.3 Bench-Scale Treatability Study Using Soil Heating

A bench-scale treatability study using soil heating to mobilize TPH compounds was conducted as part of Phase II field pilot testing (XDD 1999). These bench-scale tests were conducted to evaluate the effectiveness of soil heating technologies for remediation of soil at Site 3 and removal of free product. Results of the tests indicated that heating the soil to temperatures of 150 degrees Celsius (degrees C) was required to achieve significant (more than 87 percent) reductions in the levels of residual bunker fuel within a brief (24-hour heating) testing period.

### 2.2.4 Ex Situ Bioremediation Study

A bioremediation study for ex situ treatment of soil laden with bunker fuel was conducted at the site (Heath and others 2000). The study involved amendment of the excavated soil with a proprietary mixture of facultative microbes and nutrients. The soils were periodically turned using a front loader or backhoe throughout the 8-month study to supply oxygen for aerobic biodegradation of hydrocarbons. Preliminary results indicate significant reductions of bunker fuel levels in the test soil pile. A final report on this study has not yet been released.

### 2.2.5 Bioslurper System Testing

A bioslurping test was conducted at Site 3 wells in July 2000 (Batelle 2000). A bioslurping system is the same as an MPE system, except that a bioslurping system is designed primarily to enhance conditions for biodegradation. As such, airflow requirements for a bioslurping system typically are lower than for an MPE system.

The bioslurping test was conducted at three wells: well MW11-27R, located within a mixed diesel and bunker fuel plume; well P86-13/14, located within a diesel plume; and well MW11-36, located within a bunker fuel plume. Results of the testing indicated a limited ability to recover hydrocarbons as free product. During testing, approximately 3 gallons of free product were recovered from the test wells. The reason for the relatively low product recovery volume was likely the limited availability of product in the vicinity of the test wells at the time of testing, particularly at wells MW11-27R and P86-13/14. The limited product recovery at well MW11-36 probably occurred because ambient conditions would not permit effective movement of the bunker fuel. The measured radius of vacuum influence during testing at well MW11-27R was 37.5 feet. Concentrations of TPH in the vapor phase discharge from the test system ranged from 46 ppmv while testing at well MW11-36, to 180 ppmv while testing at well P86-13/14.

## 3.0 INVESTIGATION DESIGN AND DATA QUALITY OBJECTIVES

The design of this investigation was developed with the objective of filling data gaps as necessary to provide adequate data for the EE/CA at Site 3. As such, this study builds on previous investigations conducted at Site 3. Previous investigations of soil and groundwater involved selection of sampling locations based on a judgmental approach. This approach was based on the primary objective of further delineating the extent of free product, as well as identifying the chemical constituents in soil and groundwater at the site.

The investigation covered by this work plan will also be based on a judgmental sampling approach. Locations for soil and groundwater sampling and exploratory trenching have been selected to fill data gaps before TtEMI begins the EE/CA for Site 3. The locations recommended for soil and groundwater sampling are intended to provide further coverage of contaminant concentrations at the site. Additionally, groundwater will be sampled from existing monitoring wells to evaluate attenuation of dissolved contaminants over time. Data from these samples will also be used to assess operation of the groundwater containment system. Analytical results for soil and groundwater samples will be compared

with the action levels to identify areas of soil and groundwater that may require remediation. Exploratory trenching is intended to provide a better volume estimate of waste disposed at the FRF.

As demonstrated during Phase I testing, free-product recovery using belt skimmers, product pumps, and vacuum-enhanced extraction met with limited success. Based on the bench-scale study of soil heating, it appears that heating the soil in excess of 100 to 150 degrees C will result in significant increases in hydrocarbon removal from site soil if combined with vapor and product recovery methods. Although pilot testing radio frequency (RF) heating was considered to evaluate enhanced product recovery, this technology is energy intensive and may not be significantly less expensive than excavation; therefore, this technology will not be tested in the field, but may still be evaluated in the EE/CA. Sparging and SVE in the area contaminated by diesel are recommended for testing because these technologies will promote physical removal via in situ stripping and volatilization of the lighter-end components of diesel and aerobic biodegradation of the moderate and heavier components of diesel fuel.

MPE in the diesel plume in the vicinity of well MW11-54 has not been tested. Based on the periodic detection of relatively thick accumulations of diesel free product at well MW11-54, it is possible that MPE would be an effective means of addressing free product at this location.

The seven-step DQO process developed by EPA (EPA 2000) was used as a basis for creating the sampling design and establishing objectives for soil and groundwater sampling and field pilot testing for this investigation at Site 3. The DQO process and each of the steps are presented in detail in Section A1.2 in the accompanying QAPP (attached as Appendix B to this work plan).

## 4.0 SITE INVESTIGATION TASKS

Specific tasks for this site investigation will include collection and analysis of soil and groundwater samples, exploratory trenching, and further delineation of the extent of free product. The following areas are targeted specifically for additional soil and groundwater sampling:

- The former FRF
- The Treatment Ponds Area
- The areas in the vicinity of tanks E, F, and G

For this work plan, the Treatment Ponds Area includes the area between Building 6, the former FRF, the shoreline, and Diesel Road (see Plate 2-1).

A brief description of the work associated with these tasks is provided below. Detailed descriptions of the methods for soil and groundwater sampling and free-product monitoring are presented in the FSP, Appendix A of this document.

## 4.1 SOIL SAMPLING AND ANALYSIS

Soil samples will be collected and analyzed to achieve the following objectives:

- Evaluate for the presence of TPH-saturated soil that may indicate the presence of free product.
- Compare concentrations of TPH, BTEX compounds, VOCs, and PAHs to risk-based action levels.
- Develop site-specific TPH soil-water partitioning coefficients.
- Compare concentrations of metals in samples from the FRF to risk-based action levels.
- Evaluate the vertical extent of VOCs at the former sump pond.

Locations for soil sampling and analyses are presented on Plate 2-4 of this field work plan and are also summarized Table 4-1 of the FSP (Appendix A). The sampling strategy for soils is based on findings from previous investigations, site history, and anticipated site closure activities. Previous investigations indicate that the distribution of contaminants in shallow soil is limited. There are also limited data for soil at depths less than 10 feet bgs; therefore, additional shallow soil sampling is planned. Additional sample locations are primarily where samples have not been previously collected or in areas where contaminants were previously detected at levels of concern. Knowledge of the site history has aided in identifying a number of contaminant sources to target for sampling. These sources include tanks, pipelines, the FRF and other fuel reclamation operations, and the former sump pond. Limited sampling is planned in areas where pipelines were removed, including the Diesel Road area; these areas were characterized during the basewide pipeline removal. Only a limited number of soil samples are planned in the immediate vicinity of the existing treatment ponds. This sampling is limited under this field work plan because the ponds will be closed under a separate action. Closure will include excavation of pond sludges and contaminated material in contact with the ponds, backfilling, and regrading the site, as well s additional soil sampling.

Soil will be evaluated for TPH saturation using visual inspection of split-spoon samples, combined with screening of samples for total hydrocarbon levels using a handheld total organic vapor analyzer. Comparison of analytical data for soil with boring log notes (TtEMI 2000a) indicates that the presence of residual saturation has been effectively identified in the past based on visual observation and field screening methods. Soil samples will be collected from soil borings advanced using standard hollow-stem auger (HSA) drilling techniques. Sampling locations have been recommended to fill data gaps that remain from previous site investigations and focus on areas where existing data do not allow full delineation of the extent of residual contamination in soil.

Composite soil samples will be collected at two depths at each boring location to allow comparison of the results with multiple risk-based action levels. Composite samples are recommended for the comparison to action levels because discrete samples are less capable of fully representing the risk associated with specific action levels. Two zones are targeted for composite sampling: surface soil at 0 to 3 feet bgs, and deeper soil at 5 to 10 feet bgs.

Analytical results for shallow composite soil samples are to be compared with terrestrial ecological risk-based action levels. These shallow soil samples will also be used to evaluate the conceptual site model, which indicates that the majority of contamination is at depth. Analytical results for shallow and deep composite soil samples are to be compared with risk-based action levels for human exposure. Action levels will be summarized in the NFD Point Molate FPALDR. The final FPALDR is scheduled to be submitted by August 2001. Concentrations of VOCs and metals will be compared with risk-based action levels, such as preliminary remediation goals (PRGs). The proposed locations for soil borings are presented in Plate 2-4 of this work plan and are also summarized in Table 4-1 of the FSP (Appendix A).

Soil samples will be analyzed for TPH as residual bunker fuel, diesel, and gasoline. Samples will also be analyzed for BTEX and PAH compounds. Select soil sample locations will be analyzed for VOCs (in addition to BTEX compounds) based on historical data and areas that have not been previously sampled. Analytical results will be compared with the action levels and will be used as input to establish the areas that may require soil remediation at Site 3.

Soil samples collected at depths below 10 feet bgs will be used to evaluate soil contamination as a potential source of groundwater contamination. Data for soil samples collected within the saturated zone will be compared with groundwater data to calculate empirical, site-specific soil-water partitioning coefficients. These data will be used to evaluate the actual site impact of TPH concentrations in soil on dissolved TPH concentrations in groundwater. The data on equilibrium partitioning will be used to evaluate contaminant behavior at Site 3 and as an alternative means for estimating the mass of hydrocarbons within the site soil.

Composited soil samples from the FRF will be analyzed for metals (in addition to TPH, BTEX, PAH, and VOCs). These sample locations were selected for analysis of metals to evaluate potential contamination from disposal of industrial waste. Analytical results for metals will be compared with risk-based action levels (such as PRGs) to evaluate areas that may require remediation at Site 3.

Soil samples within the saturated zone will be analyzed for VOCs to evaluate the vertical extent of VOCs beneath the former sump pond. Relatively high concentrations of VOCs were detected at boring SB11-44 (Plate 2-4). Soil samples at a depth immediately above and within the Bay Mud will be collected at boring SB11-120 adjacent to SB11-44. Samples will be collected immediately above the contact with Bay Mud at three other locations within the former sump pond.

## 4.2 GROUNDWATER SAMPLING AND ANALYSIS

The extent of groundwater contamination will be further delineated by collection and analysis of groundwater samples from existing monitoring wells at Site 3, combined with collection and analysis of groundwater samples from newly installed monitoring wells. Locations of existing monitoring wells recommended for sampling as part of this work plan are based on the following information:

- Historical data indicating dissolved concentrations of hydrocarbons that exceed action levels for groundwater (see Plate 2-2)
- Historical data indicating dissolved concentrations of hydrocarbons that do not exceed groundwater action levels (see Plate 2-2)
- Historical data indicating concentrations of VOCs greater than 100 μg/L (see Plate 2-2)
- New groundwater data from wells located on the inland and shoreline sides of the groundwater extraction and containment wall
- Groundwater data collected along specific hydraulic lines of flow for the evaluation of natural attenuation

Locations of new monitoring wells have been recommended to eliminate data gaps that remain from previous site investigations, to focus on areas where existing data do not allow full delineation of the extent of groundwater contamination at Site 3, and to support the evaluation of natural attenuation by positioning wells within specific hydraulic pathways. The proposed locations for new monitoring wells and recommended locations for groundwater sampling are presented on Plate 2-2. A summary of the sampling locations and analytical methods for groundwater samples is presented in Table 4-2 of the FSP (Appendix A of this work plan). Wells MW11-20 and MW11-88 are not included for sampling in this Site 3 work plan because they will be sampled as part of the work plan for Site 4 (TtEMI 2001).

The selection of target analytes for groundwater samples was based on the need to obtain data on constituents that have been detected in past groundwater sampling events at Site 3. As such, groundwater samples will be analyzed for TPH as residual bunker fuel, diesel, and gasoline. Samples will also be analyzed for BTEX compounds. Selected samples will also be analyzed for VOCs, heterotrophic plate counts (HPC), nitrate, orthophosphate, sulfate, total Kjeldahl nitrogen (TKN), metals, and dissolved ferrous iron. All groundwater samples will be analyzed for TPH and BTEX compounds because these constituents have been detected in numerous past groundwater samples from Site 3. Samples collected from wells in the vicinity of wells MW11-13 and MW11-44 will be analyzed for VOCs because past sampling events have indicated that these are the only locations at Site 3 where significant concentrations (greater than 100 μg/L) of non-BTEX VOCs (TtEMI 2000a) were detected. Additional collection and analysis of samples from the vicinity of wells MW11-13 and MW11-44 is recommended to evaluate changes of VOC levels over time and the extent of VOCs. Because samples have not been previously collected at the FRF, samples from the new wells installed in the FRF also will be analyzed for VOCs (in addition to TPH and BTEX). In addition, samples from the new wells installed in the FRF will be analyzed for metals to evaluate the affect of industrial waste disposal. As shown on Table 2-1, the highest detection of SVOCs was of N-nitrosodiphenylamine. The detections of N-nitrosodiphenylamine were from only one groundwater sampling event, and because N-nitrosodiphenylamine was not detected during additional groundwater sampling events, it is suspected to be a false positive. The highest concentration of N-nitrosodiphenylamine (580 μg/L) was in a sample from well MW11-93 collected in 1992; this well was sampled six additional times between 1994 and 1998 and N-nitrosodiphenylamine was not detected in any of these additional sampling events.

Analytical results for groundwater samples will be compared with the action levels (from the FPALDR, as well as other available action levels) to identify areas that may require groundwater remediation at Site 3.

Groundwater data will be compared with soil data to estimate empirical, site-specific soil-water partitioning coefficients. These data will be used to support recommendations for soil remediation areas.

## 4.3 EXPLORATORY TRENCHING

To enable collection of samples from all of the recommended locations in the former FRF, structures and piping within this area were removed in March 2001. The structures include tanks, concrete sumps, valves, and piping. Discarded industrial waste was discovered during these activities, as described in Section 2.2 of this FWP.

Exploratory trenching will be used to evaluate the contents and extent of the area of industrial waste in the FRF. The approximate locations of exploratory trenches are shown on Plate 2-4. Trenches will be dug along the approximated boundary of the disposal area about every 50 feet. Trenches will also be excavated within the center of the disposal area. A description of the boundaries of the waste, depth and thickness of waste, the type of waste, the depth to groundwater, and any other observations by field personnel will be logged for each trench. These data will be used to estimate the extent and volume of waste that will be evaluated in the EE/CA.

### 4.4 DELINEATION OF FREE PRODUCT

Free product will be delineated by measuring the thickness of free product in existing and new monitoring wells at Site 3. The following locations are specific areas where additional information on the thickness of free product is warranted:

- The former FRF
- The Treatment Ponds Area
- The areas around tanks E, F, and G

The results of monitoring for free product at the new and existing monitoring wells will be combined with historical monitoring data for distribution of free product to develop a site conceptual model with respect to the extent of free product across Site 3. Historical trends in the thickness of free product will be evaluated, including the effect of changes in groundwater elevation and operation of the containment wall and extraction system on the thickness of free product measured at Site 3.

## 5.0 FIELD PILOT TESTING AND TECHNOLOGY EVALUATION

Field pilot testing is recommended to evaluate several technologies, including sparging and SVE, and MPE. The ongoing occurrence of natural attenuation, specifically with respect to biodegradation, will be evaluated as part of this work plan. A summary that describes each recommended technology, the basis for testing each technology at Site 3, and the manner in which the data will be used is presented in Sections 5.1 through 5.4. Detailed descriptions of field pilot testing and associated sampling methods are presented as Appendix C to this work plan.

## 5.1 AIR SPARGING AND SOIL VAPOR EXTRACTION TESTING

Air sparging involves injection of air into the saturated soil via air sparge wells to remove contaminants from groundwater and saturated soil by physical stripping (volatilization) and biodegradation. The physical stripping of contaminants from the saturated zone will occur if Henry's Law constant (partitioning constant for vapor-aqueous equilibrium condition) of the target contaminant favors partitioning from the aqueous phase into the vapor phase. Henry's Law constants, for a portion of the components of diesel fuel, are within the range considered feasible for stripping (greater than $4.15 \times 10^{-4}$, dimensionless [API 1995]). Many of the components of diesel will not be amenable to stripping; however, most of these compounds are considered amenable to in situ aerobic biodegradation. Sparging systems may be operated in a biosparging configuration such that the primary objective is to supply oxygen to the saturated soil to support aerobic biodegradation. Therefore, soil in the area contaminated with TPH as diesel is considered amenable to sparging technologies. Air sparge testing is recommended for soil in the vicinity of well MW11-54, as presented in Plate 2-7. Typically, an SVE system is used in conjunction with an air sparging system to capture contaminants transported from the saturated soil into the overlying vadose zone. Thus, a limited amount of SVE testing in the sparging test area is also recommended.

The primary objectives of the sparging tests are as follows:

- Evaluate the effective zone of influence at the sparge test wells (based on pressure and helium tracer testing).
- Confirm vertical transport of injected air (and thus volatilized contaminants) from the sparge well up into the vadose zone (based on monitoring vadose zone for changes in TPH levels in soil vapor and helium during tracer tests).
- Evaluate the potential for lateral air flow within the targeted soil that results from air sparging by monitoring of pressure during all air sparging tests and monitoring helium during tracer tests.
- Obtain sparging air flow and pressure data.

The objectives associated with SVE testing are as follows:

- Evaluate the effective vacuum zone of influence associated with the test SVE well.
- Obtain data on concentrations of TPH and BTEX in the extracted soil vapor.
- Obtain data on vacuum and soil vapor flow.

Data collected from the sparging and SVE testing will be used to evaluate the technical feasibility of these technologies to address contamination by TPH as diesel at Site 3. If the technologies are considered technically feasible for Site 3, the data will also be used to estimate the cost of implementing them in a full-scale scenario. The field pilot test approach for air sparging and SVE is presented in Appendix C.

## 5.2 MULTIPHASE EXTRACTION TESTING

MPE involves the simultaneous extraction of vapors, TPH as free product, and groundwater from a single well point. As such, MPE systems are capable of removing hydrocarbons as a separate phase (free product) and in the vapor phase. Contaminants are also destroyed by enhancing conditions for aerobic biodegradation because of the supply of oxygen that results from flow of vapor into the MPE well. For Site 3, testing of MPE is recommended for the diesel plume in the vicinity of well MW11-54.

The primary objectives of the MPE tests are as follows:

- Evaluate free-product recovery rates using MPE.
- Obtain data for vapor-phase hydrocarbon recovery rates.
- Evaluate the effective zone of influence at the test MPE wells (based on vacuum propagation).
- Obtain data for vapor and aqueous flow rates.

Data collected from MPE testing will be used to evaluate the technical feasibility of this technology to address contamination by TPH as diesel at Site 3. If the technology is considered technically feasible for Site 3, the data will also be used to estimate the cost of implementing it in a full-scale scenario. The approach for the field pilot test of multiphase extraction is presented in Appendix C.

## 5.3 EVALUATION OF NATURAL ATTENUATION

Natural attenuation involves a reduction in contaminant mass caused by physical, biological, and chemical reactions that occur naturally in the subsurface. For TPH, the primary mechanism of natural attenuation is most likely biological degradation. Biological degradation will occur by both aerobic and anaerobic bacteria indigenous to the soil at the site. Oxygen levels are typically limiting (less than 1

milligram per liter [mg/L]) in the heart of the contaminant plume; thus, anaerobic biodegradation occurs within and immediately hydraulically downgradient of the plume.

This work plan recommends collection of data that will support a preliminary evaluation of natural attenuation at Site 3. This evaluation is recommended because MNA is a reasonable component of several integrated remediation strategies that may be applied at this site. Based on the heterogeneous soil conditions at the site, it is highly unlikely that any one remedial technology will successfully meet 100 percent of the remediation action levels. As such, MNA should be considered as a potential complementary technology to be implemented after a contaminant source-reduction phase of remediation.

For this study, monitoring for natural attenuation will be based primarily on evaluation of biological attenuation parameters in groundwater at several locations (see Plate 2-7 and FSP Table 4-2). The locations for monitoring natural attenuation and collecting groundwater samples for laboratory analysis were selected to provide data from across the site. Sampling locations will cover areas hydraulically upgradient of the plume (well MW11-49), mid-plume (well MW11-44), and downgradient within the plume (wells MW11-27R and MW11-106). Additional groundwater samples will be collected and analyzed to provide data from the former FRF (well MW11-102) and the plume that is predominantly composed of diesel (well MW11-107). A limited analysis of natural attenuation will be conducted on specified soil samples, as presented in Plate 4-1 and FSP Table 4-1.

Samples for analysis of natural attenuation parameters will be collected at the same time as the other soil and groundwater samples, as described in Sections 4.1 and 4.2. For soil samples, total HPC is the parameter to be analyzed to evaluate MNA. MNA-specific parameters to be monitored in groundwater include selected anions (nitrate, sulfate, and orthophosphate), dissolved ferrous iron, total HPC, dissolved oxygen, pH, and TKN.

## 6.0 DATA MANAGEMENT

Data generated as part of this work plan will be tracked by the project chemist. After review and validation of the data reports for field and laboratory analysis of soil and groundwater samples, the data will be entered into the NFD Point Molate database. A more detailed description of data management and data handling is presented in the QAPP (attached as Appendix B).

# 7.0 HEALTH AND SAFETY PROJECT PLAN

This section supplements the NFD Point Molate base-wide health and safety plan (HASP) (TtEMI 2000b) by providing a project-specific overview of health and safety requirements and procedures to be used in conjunction with the base-wide HASP. Requirements and procedures that do not deviate from the base-wide HASP are noted as such.

## 7.1 INTRODUCTION

General health and safety requirements for all field activities are provided in the revised base-wide HASP for NFD Point Molate (TtEMI 2000b). This base-wide HASP has been designed as a comprehensive document that governs the health and safety aspects of all field activities under the CLEAN contract at NFD Point Molate. This section supplements and is to be used in conjunction with the base-wide HASP. An on-site health and safety officer (OHSO) will be present during field activities to implement the HASP. Dave West is the designated OHSO and can be reached at (303) 312-8879. Jon Polonsky (303) 312-8787 and Doug Sterling (415)-222-8270 are the alternate OHSOs. TtEMI employees, team subcontractors, and other subcontractors are expected to follow the health and safety requirements set forth in this plan and supporting documents, at a minimum, or the more stringent requirements of their employers. Each subcontractor shall submit a company health and safety program and job hazard analysis for its tasks, subject to acceptance by TtEMI before field work begins.

## 7.2 SITE BACKGROUND

This section does not deviate from the corresponding section in the revised base-wide HASP. Site background is also summarized in Section 2.0 of this field work plan.

## 7.3 ORGANIZATION, RESPONSIBILITIES, AND REQUIREMENTS

This section does not deviate from the corresponding section in the revised base-wide HASP.

## 7.4 HAZARD IDENTIFICATION AND ANALYSIS

With the exception of air sparging and SVE or MPE equipment, project-specific hazards are consistent with the corresponding section in the revised base-wide HASP. Physical hazards that may be

encountered during field activities include noise, heat stress, and working around remediation systems and heavy equipment. Personnel will be familiar with, and abide by, the manufacturer's operation and maintenance (O&M) procedures when working at or near the RF heating, air sparging and SVE, or MPE equipment.

Chemical hazards include several petroleum hydrocarbon fuels, primarily bunker fuel and diesel in soil and groundwater at Site 3, as discussed in Section 2.2 of this work plan. Several plumes of free product have been identified at Site 3 as well. Helium will be used as a tracer during the air sparging and SVE pilot test. Even though this gas is nontoxic, it is a simple asphyxiant at high concentrations and will not be used in enclosed areas.

Industrial hazards include underground utilities and overhead electrical hazards. Before drilling or trenching, underground plans will be reviewed, and utility locations will be checked. In addition, a utility search using specialized cable-detection equipment will be conducted and documented. When working in the area of overhead utilities, the subcontractor shall prepare a detailed hazard analysis in accordance with CLEAN Standard Operating Procedure (SOP) H-008, "Job Hazard Analysis" (PRC 1996c), before heavy equipment (for example, an excavator) is operated underneath or within 20 feet of the maximum reach of the equipment.

Biological hazards include bees, wasps, yellow jackets, ticks, black widow spiders, brown recluse spiders, wild (feral) dogs, and poison oak. In all cases, a person suspected of being bitten by a black widow spider, brown recluse spider, or wild dog will receive medical attention.

## 7.5 FIELD SAFETY RULES

This section does not deviate from the corresponding section in the revised base-wide HASP. Regular health and safety inspections will be conducted and documented by the OHSO and project managers at each work site.

## 7.6 SITE CONTROL AND DECONTAMINATION

This section does not deviate from the corresponding section in the revised base-wide HASP. The OHSO will implement a single-zone, controlled area during groundwater sampling that includes a barrier to delineate the clean, uncontrolled areas from the exclusion zone. The standard three-zone system of

site control will be used during drilling and trenching. The OHSO will establish area entry and exit protocol. Personnel will sign in and out daily. Delineation of an exclusion zone is required. The contamination reduction zone will be delineated as a separate area at the exit of the exclusion zone. The site will be posted to indicate the activity, standard requirements, and restrictions. Open trenches will be posted on all sides. Site personnel and the OHSO will maintain site security. Unrecognized personnel shall be required to provide proper identification. The OHSO will maintain a list of authorized personnel for site entry. The work zone will be barricaded with cones, barricade stands, or caution tape. The OHSO will prepare a hazardous work permit. A standard decontamination facility will be maintained during drilling, trenching, and groundwater sampling to include three wash decontamination stations, running tepid water, deluge water, towels, soap, disposal containers, and a respirator wash facility. In addition, there will be a pressurized eyewash station at the decontamination facility.

## 7.7 HAZARD MONITORING PROGRAM

The OHSO will initiate a monitoring program for heat stress whenever personnel are wearing semipermeable or impermeable protective clothing and the outside temperature exceeds 75 °F. For personnel in normal work clothing (that is, modified Level D), a monitoring program for heat stress will be initiated when the outside temperature exceeds 85 °F.

TtEMI will carry out all necessary air surveillance. This section does not deviate from the corresponding section in the revised base-wide HASP except for the following activities: the OHSO shall perform or oversee initial and periodic air monitoring, as described in Table 7-1, at the designated field locations for health and safety. Since direct measurements of PAHs in the field are not possible, real-time monitoring of respirable dust will be conducted. Total concentrations of dust will be measured with a Miniram7 instrument. All persons at Site 3 will don an air-purifying respirator if total concentrations of dust exceed the action level of 0.5-milligram per cubic meter. In addition to photoionization detector and flame ionization detector (PID/FID) measurements, Dräger tubes will be used to monitor airborne concentrations of benzene and vinyl chloride in areas where these compounds have been detected historically. Table 7-1 is a summary of the air monitoring plan for Site 3.

## 7.8 PROTECTION AND HAZARD COMMUNICATION PROGRAMS

All on-site personnel conducting field work will don a minimum of modified Level D personal protective equipment (PPE), which includes safety glasses, leather work boots with steel toe and shank, long pants,

short- or long-sleeved shirt, ear plugs (as required), rubber over-the-sock boot with steel toe and shank (optional in lieu of work boot), and hard hat. Where equipment-guarding techniques (engineering controls) and administrative procedures (such as lockout/ tagout procedures) are not adequate, PPE is to be used to reduce exposure hazards to acceptable limits (for example, donning leather gloves while working with air sparging and SVE equipment that is hot).

During drilling, trenching, and groundwater sampling at Site 3, all on-site personnel will don Tyvek (for dry environments) or polyethylene-coated Tyvek (for wet environments) coveralls taped at the cuffs and ankles and chemical protective gloves in addition to the modified Level D PPE described previously.

On-site personnel will have ready for use a sufficient number of full-face respirators with P-100 rated filters and organic vapor filters for all field personnel working in the area if an action level for total organic vapor is exceeded. Before field work begins, a respirator hazard assessment form will be completed; action levels will be established at that time.

Field personnel will have been respirator fit tested within the previous 6 months and will be participating in a medical surveillance program. Hazard communications training will be provided as required by regulations.

## 7.9 EMERGENCY RESPONSE PLAN

This section does not deviate from the corresponding section in the revised base-wide HASP. TtEMI and each subcontractor shall conduct and document safety meetings on a regular basis, including daily morning tailgate briefings. The OHSO will ensure that first aid personnel, first aid supplies, and emergency deluge water are available on site. The OHSO will also ensure that there is a pressurized eyewash station on all sites where there is a potential to encounter free product.

Field personnel will be certified in 40-hour Occupational Safety and Health Administration (OSHA) training for hazardous-waste site operations, and be trained in first aid and cardiopulmonary resuscitation.

All evacuation routes will be in the direction upwind of or at right angles to the hazard that causes the emergency. During an emergency, all personnel shall meet in front of Building 6 (Figure 2-2), unless otherwise directed by emergency response team personnel.

A project-specific map to the emergency medical facility is provided as Figure 7-1. Information on and directions to the medical facility are provided on Table 7-2.

## 8.0 SAMPLING AND ANALYSIS

Environmental media will be sampled and analyzed in accordance with federal, state, and local regulations and guidance. Site-specific sampling and analysis, as described in the FSP and QAPP for this investigation, will be conducted in accordance with CLEAN guidance. Analysis will follow state and federal standard methods, where applicable.

Samples of surface and subsurface soil and groundwater collected during the investigation at Site 3 will be analyzed for TPH and BTEX compounds. Selected subsurface soil and groundwater samples will also be analyzed for PAHs, VOCs, anions (nitrate, sulfate, and orthophosphate), TKN, dissolved ferrous iron, and total HPC. In addition, groundwater samples will be analyzed in the field during sampling for dissolved oxygen, pH, and total dissolved solids (TDS). Details of all analyses are provided in the accompanying QAPP (Appendix B). Proposed locations for groundwater and soil sampling are presented in Plates 2-7 and 4-1.

IDW soil will be sampled and characterized to identify the appropriate disposal method. IDW groundwater will be transferred to and treated using the GWTP that is already in operation at Site 3. Free product generated during this work will be placed in 55-gallon drums and disposed of by the Navy's on-site operations and maintenance contractor. A summary of characterization samples for groundwater, soil, and IDW to be collected and analyzed is provided in the QAPP that accompanies this work plan.

Details of the sampling methods are described in the accompanying FSP and QAPP. These two documents address the following:

- Sampling and analysis to be conducted, along with specific QA/QC requirements.
- All data collection activities presented in Section 4.0 of this work plan, with reference to appropriate SOPs.

## 9.0 QUALITY ASSURANCE

Work for this CTO will be conducted in accordance with TtEMI's CLEAN II Quality Management Plan (QMP) (PRC 1996d) and Quality Improvement Plan (QIP) (TtEMI 1999). Activities defined in this work plan may be subject to a systems audit by QA staff to document that work is conducted in accordance with the quality management plan. Audit results will be included in a summary report, as necessary.

The accompanying QAPP details QA/QC procedures for sampling and analytical work under the investigation of Site 3. For the sampling activities, 10 percent duplicate samples will be collected for groundwater samples. Matrix spike and matrix spike duplicate (MS/MSD) analyses for each chemical analysis in each medium will be performed for 5 percent of the samples collected. Data validation will include 90 percent cursory (Level III) and 10 percent full (Level IV) validation for all analytical results. A summary of the QC samples to be collected and a detailed description of the function of QC samples are provided in the accompanying QAPP (Appendix B).

The QAPP also describes procedures that will be followed during field audits and correction of any nonconformances. QC summary reports will also be prepared; the content of these reports is described in the QAPP.

## 10.0 REPORTING

The technical deliverables that will be completed as part of this Site 3 investigation are as follows:

- Draft work plan, FSP, and QAPP
- Response to comments (RTC) on the draft work plan, FSP, and QAPP
- Final RTC to state and Restoration Advisory Board (RAB) comments
- Final work plan, FSP, and QAPP investigation at Site 3 and results

Other documentation that will be produced during the Site 3 investigation includes the following:

- IDW management and disposal records
- Field forms
- Health and safety records and reports
- Field log books (bound)
- QC summary reports

The letter report will incorporate a summary of the sampling and pilot test results. Extensive evaluation and discussion of the sampling and test results will be presented in the EE/CA. Data tables will be included as attachments to the letter report. The summary report will be included as an appendix to the EE/CA, and will not be reviewed separately by the Base Realignment and Closure (BRAC) Cleanup Team (BCT) and RAB until the EE/CA is submitted.

## 11.0 COMMUNITY RELATIONS

No community relations plan is required for this investigation. It is anticipated that the TtEMI project manager or installation coordinator will attend several monthly RAB and BCT meetings to present progress reports on the investigation of Site 3 during the 3-month duration of the project. TtEMI will also assist Navy staff in preparing for and facilitating RAB meetings where project issues are to be discussed.

During the December 6, 2000, RAB meeting, TtEMI and the Navy provided a briefing on future work planned at Site 3.

## 12.0 PROJECT MANAGEMENT

Project management tasks include planning and technical and administrative activities necessary for properly monitoring and promoting consistency throughout all facets of the project. The proposed project schedule is shown in Figure 12-1. QC is also a part of project management. Specific activities for project management include the following:

- Coordinate project startup and closeout.
- Coordinate project tasks and scheduling involving TtEMI, the Navy, and project subcontractors.
- Attend planning and comment-resolution meetings involving TtEMI, the Navy, regulatory agencies, and the public.
- Coordinate this project with other Navy CLEAN projects at NFD Point Molate.
- Ensure that proper document control and project records are maintained as required.
- Maintain and update project schedules.

The investigation at Site 3 will be staffed with a multidisciplinary team composed of technically qualified professionals. The project team members who will coordinate activities completed during the Site 3 investigation are as follows:

| | | |
|---|---|---|
| Navy Remedial Project Manager (RPM) | Michelle Gallice-Sondrup | (619) 532-0971 |
| Navy QA Officer | Narciso A. Ancog | (619) 532-2540 |
| TtEMI Program Manager | Daniel Chow | (415) 222-8222 |
| NFD Point Molate Navy Site Contact | Gregg Harden | (510) 231-7902 |
| TtEMI Program QA Manager | Greg Swanson | (619) 718-9676 |
| TtEMI Lead Geologist | David West | (303) 312-8879 |
| TtEMI Installation Coordinator (IC) | Brian Schuller | (303) 441-7912 |
| TtEMI Project Manager | Jon Polonsky | (303) 382-8787 |
| TtEMI Project QA Manager | Ron Ohta | (916) 853-4506 |
| TtEMI Health and Safety Manager | Conrad Sherman | (415) 222-8377 |
| TtEMI Community Relations Coordinator | Brian Schuller | (303) 441-7912 |
| TtEMI Analytical Coordinator | Karin Kaiser | (303) 312-8846 |

The TtEMI offices in Denver, Colorado; Sacramento, California; and San Francisco, California; will staff the project. If required, additional technical resources will be provided by other TtEMI offices. The TtEMI IC, Brian Schuller, has primary responsibility for the quality and completion of all work according to schedule and will oversee all activities (from initiation to completion) for the investigation at Site 3. He will coordinate technical resources and report directly to Ms. Michelle Gallice-Sondrup, the Navy RPM, regarding overall program guidance and key technical and policy issues. Descriptions of the responsibilities and lines of authority and communication for project team members are presented in Section A2.2 and Figure A-1 of the QAPP (Appendix B of this work plan).

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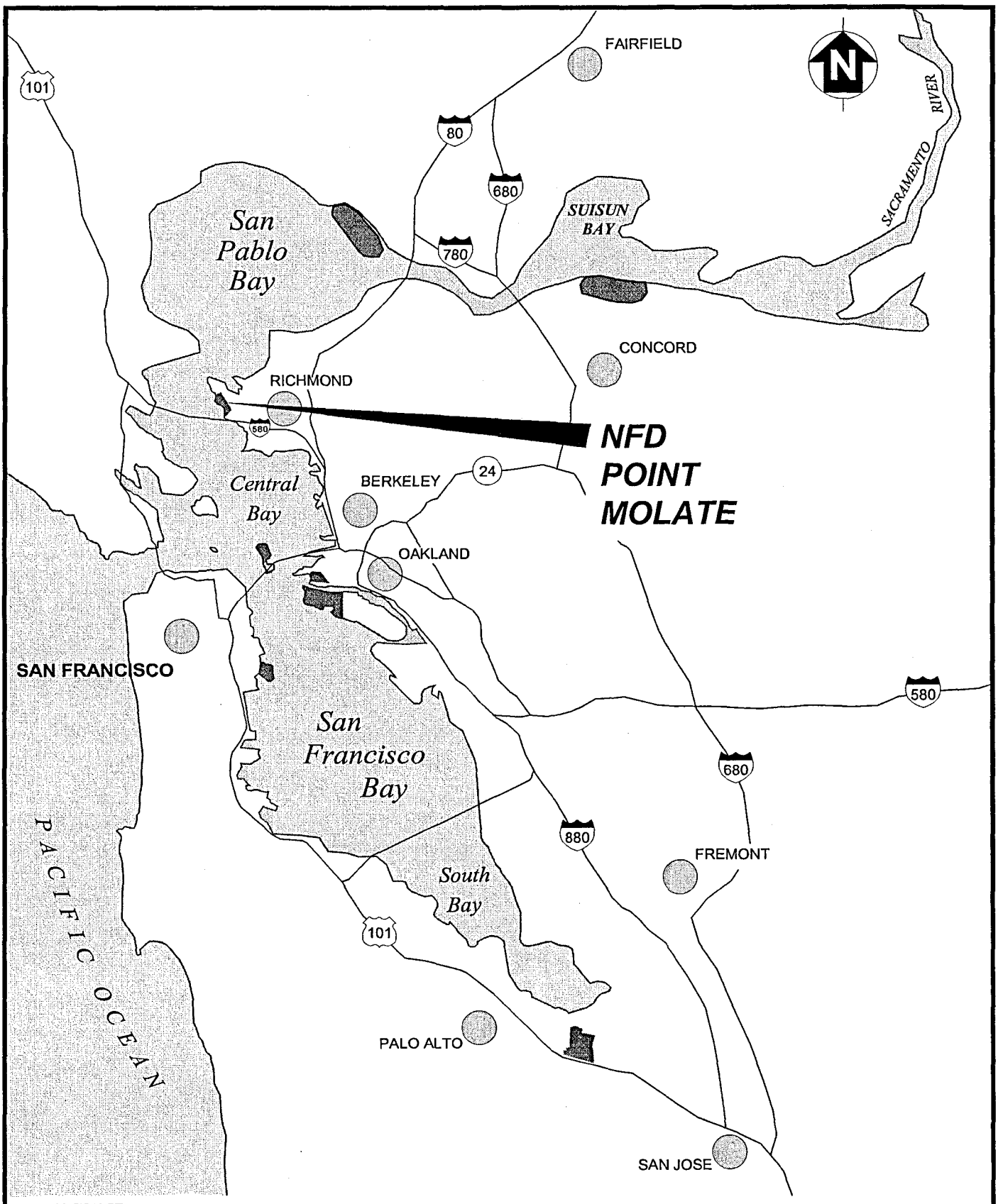
# FIGURES




LEGEND

BAY AREA NAVAL INSTALLATIONS

*NOT TO SCALE*

FIGURE 2-1
NAVAL FUEL DEPOT POINT MOLATE
SITE LOCATION MAP

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DS.0379.15002

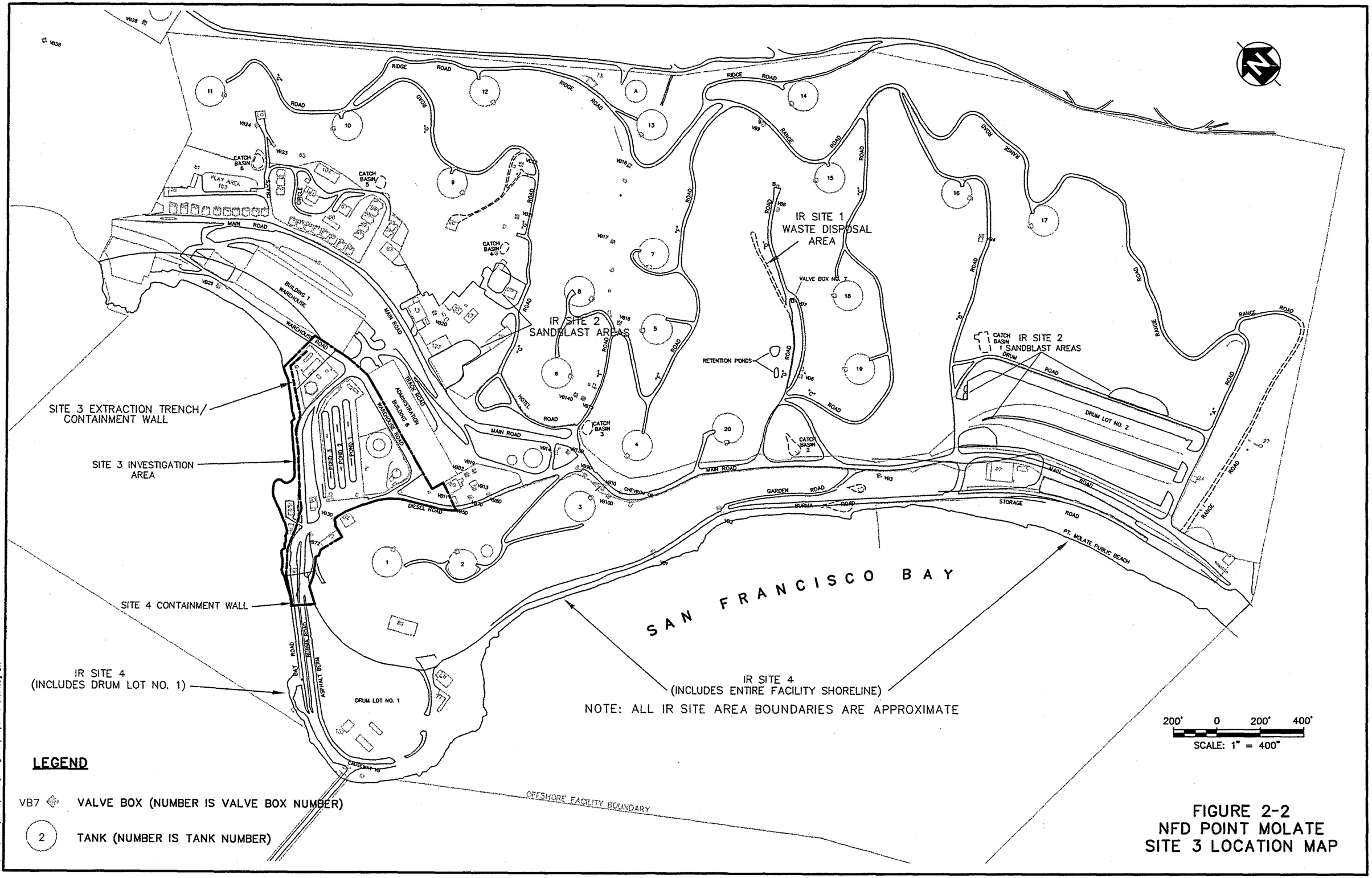


FIGURE 2-2
NFD POINT MOLATE
SITE 3 LOCATION MAP

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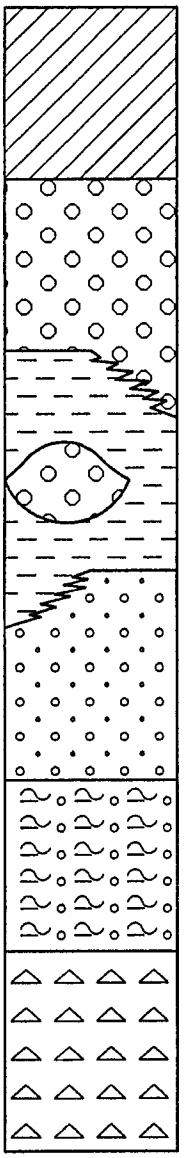

| | |
|---|---|
| ARTIFICIAL FILL | HETEROGENEOUS MIXTURE OF POORLY-SORTED GRAVEL, SILT, SANDY SILT, SANDY CLAY, AND BEDROCK FRAGMENTS; SOME ORGANIC-RICH HORIZONS WITH ABUNDANT PLANT STEMS; OCCASIONAL PEAT HORIZONS. |
| ALLUVIUM | SAND OR SANDY GRAVEL AND COBBLES. INTERFINGERS WITH BAY MUD. |
| BAY MUD | SANDY CLAY, SILTY SAND, AND SANDY SILT WITH MODERATE TO ABUNDANT SHELL FRAGMENTS; UNIFORM AND VERY DARK GRAY. INTERFINGERS WITH ALLUVIAL SANDS. |
| REWORKED INTERTIDAL SEDIMENTS | SANDY SILT AND SILTY SAND WITH ABUNDANT SUBROUNDED LITHIC/BEDROCK FRAGMENTS AND NUMEROUS SHELL FRAGMENTS. |
| COLLUVIUM | CLAYEY AND SILTY SAND WITH WEATHERED BEDROCK FRAGMENTS. SAPROLITE NEAR BEDROCK CONTACT; DENSE, DISTINCT YELLOWISH BROWN COLOR. |
| BEDROCK | INTERBEDDED SANDSTONE, MUDSTONE AND QUARTZITE OF FRANCISCAN FORMATION. SOFT SEDIMENT DEFORMATION (FLAME STRUCTURES) EVIDENT. |

FIGURE 2-3
NFD POINT MOLATE
GENERALIZED DEPOSITIONAL SEQUENCE
OF SOIL AND SEDIMENTS AT SITE 3

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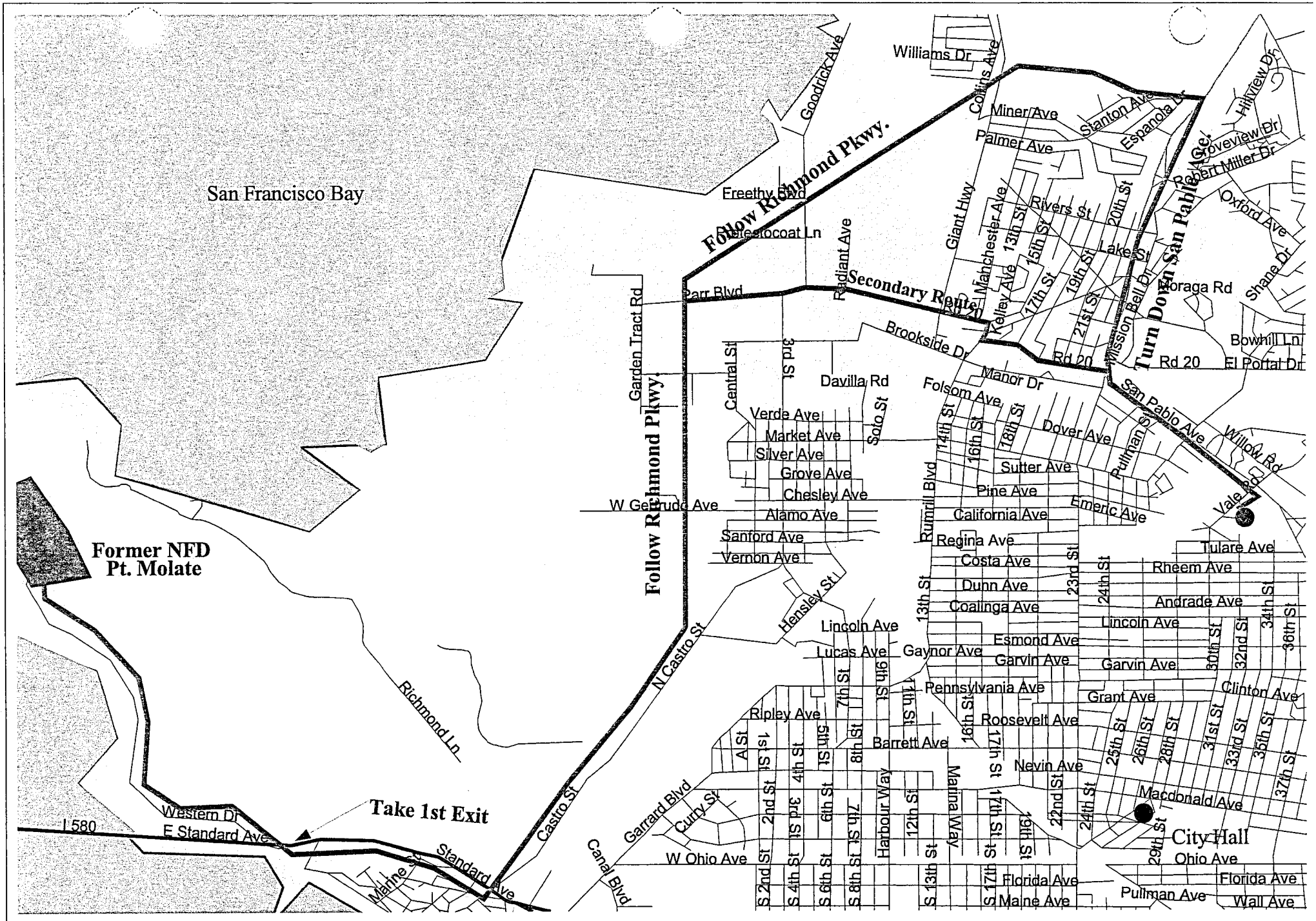


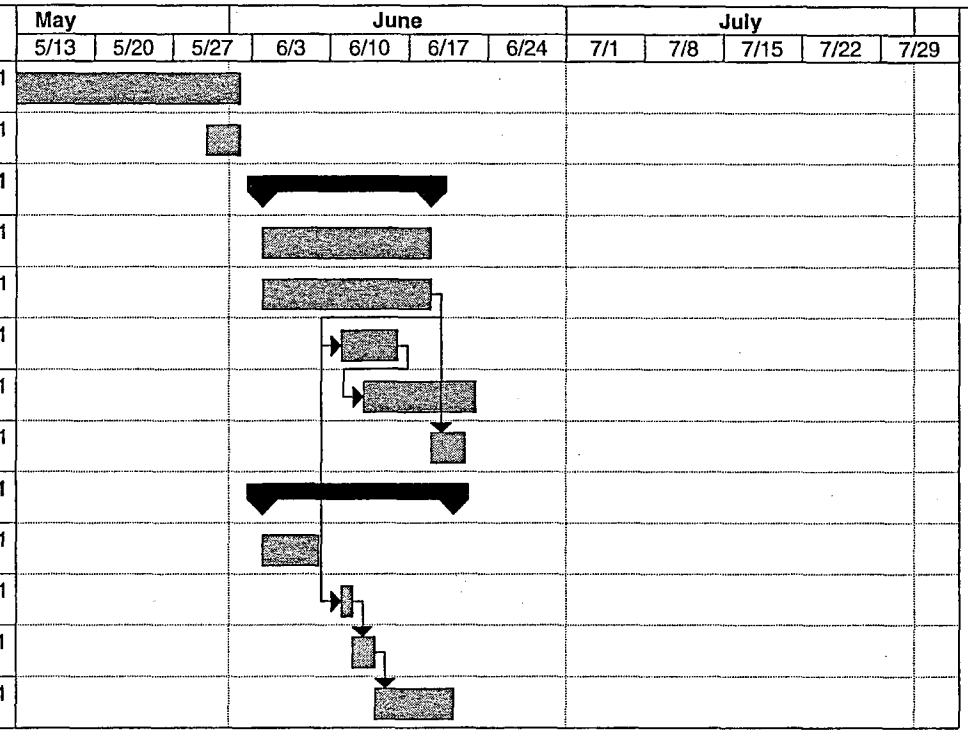

FIGURE 7-1
Health and Safety
Emergency Hospital Route Map
Former Navy Fuel Depot
Pt. Molate, CA.

**Doctor's Medical Center**
**2000 Vale Road**
**San Pablo, CA 94806**
**(510) 970-5140**
**CALL 911 IN EMERGENCY**

# FIGURE 12-1

## SCHEDULE FOR SAMPLING AND FIELD PILOT TESTING AT SITE 3
## NFD POINT MOLATE - RICHMOND, CALIFORNIA

| ID | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | MOBILIZATION | 24 days | Tue 5/1/01 | Fri 6/1/01 |
| 2 | UTILITY LOCATION | 3 days | Wed 5/30/01 | Fri 6/1/01 |
| 3 | **SOIL SAMPLING & WELLS** | **11 days** | **Mon 6/4/01** | **Mon 6/18/01** |
| 4 | SOIL SAMPLING | 11 days | Mon 6/4/01 | Mon 6/18/01 |
| 5 | WELL INSTALLATION | 11 days | Mon 6/4/01 | Mon 6/18/01 |
| 6 | WELL DEVELOPMENT | 5 days | Mon 6/11/01 | Fri 6/15/01 |
| 7 | GROUNDWATER SAMPLING | 8 days | Wed 6/13/01 | Fri 6/22/01 |
| 8 | LAND SURVEYING | 3 days | Tue 6/19/01 | Thu 6/21/01 |
| 9 | **FIELD PILOT TESTING** | **13 days** | **Mon 6/4/01** | **Wed 6/20/01** |
| 10 | PILOT TEST MOBE | 5 days | Mon 6/4/01 | Fri 6/8/01 |
| 11 | SVE PILOT TEST | 1 day | Mon 6/11/01 | Mon 6/11/01 |
| 12 | AIR SPARGE PILOT TEST | 2 days | Tue 6/12/01 | Wed 6/13/01 |
| 13 | MPE PILOT TEST | 5 days | Thu 6/14/01 | Wed 6/20/01 |



# TABLES

TABLE 2-1

NFD POINT MOLATE
WORK PLAN FOR SAMPLING AND FIELD PILOT TESTING
SITE 3 - TREATMENT PONDS AREA
SUMMARY OF GROUNDWATER DATA

| Analyte[1] | FREQUENCY | | Percent Frequency Detection[2] | Maximum Detection (µg/L) | Mean[2] (µg/L) | Standard Deviation (µg/L) | Preliminary FPALDR Values (µg/L)[3,4] | |
|---|---|---|---|---|---|---|---|---|
| | Total Samples | Detected | | | | | greater than 150 ft | less than 150 ft |
| **TOTAL PETROLEUM HYDROCARBONS** | | | | | | | | |
| DIESEL RANGE ORGANICS | 56 | 18 | 32 | 4,100 | 471 | 845 | 15,000 | 2,200 |
| GASOLINE RANGE ORGANICS | 84 | 41 | 49 | 2,220 | 297 | 490 | 13,000 | 1,200 |
| JP-5 RANGE ORGANICS | 77 | 4 | 5 | 41,000 | 690 | 4,690 | None | None |
| MOTOR OIL RANGE ORGANICS | 56 | 7 | 13 | 200 | 229 | 333 | 21,000 | 2,200 |
| OTHER HEAVY TPH COMPONENTS | 58 | 13 | 22 | 6,400 | 635 | 1,536 | None | None |
| OTHER LIGHT TPH COMPONENTS | 58 | 58 | 100 | 3,300 | 613 | 914 | None | None |
| TPH - BUNKER FUEL (C10-C28) | 77 | 53 | 69 | 60,000 | 5,370 | 9,253 | 21,000 | 2,200 |
| TPH - DIESEL F-76 (C8-C28) | 45 | 3 | 7 | 18,000 | 772 | 3,181 | 15,000 | 2,200 |
| **VOLATILE ORGANIC COMPOUNDS** | | | | | | | | |
| 1,1-DICHLOROETHENE | 75 | 1 | 1 | 1 | 9.1 | 57.5 | None | None |
| 1,2-DICHLOROETHANE | 75 | 1 | 1 | 0.4 | 8.8 | 57.6 | None | None |
| 1,2-DICHLOROETHENE (TOTAL) | 75 | 5 | 7 | 710 | 18.7 | 99.3 | None | None |
| 1,3-DICHLOROBENZENE | 58 | 2 | 3 | 1 | 14.9 | 65.3 | None | None |
| 1,4-DICHLOROBENZENE | 58 | 6 | 10 | 5 | 15.0 | 65.3 | None | None |
| 2-BUTANONE | 75 | 11 | 15 | 41 | 11.8 | 58.0 | None | None |
| 2-HEXANONE | 75 | 2 | 3 | 29 | 10.3 | 57.8 | None | None |
| 4-METHYL-2-PENTANONE | 75 | 1 | 1 | 19 | 10.2 | 57.8 | None | None |
| ACETONE | 75 | 10 | 13 | 32 | 11.5 | 57.8 | None | None |
| BENZENE | 84 | 43 | 51 | 62 | 4.8 | 9.4 | 650 | 510 |
| BROMODICHLOROMETHANE | 75 | 1 | 1 | 2 | 9.1 | 57.5 | None | None |
| CARBON DISULFIDE | 75 | 2 | 3 | 0.6 | 9.1 | 57.5 | None | None |
| CHLOROBENZENE | 75 | 14 | 19 | 180 | 17.0 | 64.0 | None | None |
| CHLOROFORM | 75 | 15 | 20 | 19 | 9.6 | 57.5 | None | None |
| CHLOROMETHANE | 75 | 1 | 1 | 3 | 9.1 | 57.5 | None | None |
| ETHYLBENZENE | 84 | 27 | 32 | 29 | 1.6 | 4.4 | 1,000 | 43 |

TABLE 2-1

NFD POINT MOLATE
WORK PLAN FOR SAMPLING AND FIELD PILOT TESTING
SITE 3 - TREATMENT PONDS AREA
SUMMARY OF GROUNDWATER DATA

| Analyte[1] | FREQUENCY | | Percent Frequency Detection[2] | Maximum Detection (µg/L) | Mean[2] (µg/L) | Standard Deviation (µg/L) | Preliminary FPALDR Values (µg/L)[3,4] | |
|---|---|---|---|---|---|---|---|---|
| | Total Samples | Detected | | | | | greater than 150 ft | less than 150 ft |
| **VOLATILE ORGANIC COMPOUNDS (continued)** | | | | | | | | |
| m, p-XYLENE | 2 | 2 | 100 | 49 | 25.0 | 33.9 | None | None |
| METHYLENE CHLORIDE | 75 | 1 | 1 | 1 | 9.3 | 57.6 | None | None |
| METHYL-T-BUTYL ETHER | 11 | 7 | 64 | 84 | 16.0 | 24.3 | None | None |
| o-XYLENE | 5 | 1 | 20 | 10.3 | 4.9 | 6.0 | None | None |
| TETRACHLOROETHENE | 75 | 1 | 1 | 13 | 9.3 | 57.5 | None | None |
| TOLUENE | 84 | 35 | 42 | 38.5 | 3.8 | 7.7 | 2,100 | 1,000 |
| TRICHLOROETHENE | 75 | 7 | 9 | 52 | 9.8 | 57.8 | None | None |
| VINYL CHLORIDE | 75 | 2 | 3 | 260 | 12.3 | 64.5 | None | None |
| XYLENE (TOTAL) | 84 | 45 | 54 | 83 | 7.7 | 14.8 | 232,000 | 130 |
| **SEMIVOLATILE ORGANIC COMPOUNDS** | | | | | | | | |
| 1-METHYLNAPHTHALENE | 5 | 2 | 40 | 8.7 | 2.5 | 3.6 | None | None |
| 2,4-DIMETHYLPHENOL | 56 | 2 | 4 | 0.5 | 15.4 | 66.5 | None | None |
| 2-METHYLNAPHTHALENE | 61 | 35 | 57 | 210 | 15.3 | 30.7 | None | None |
| 4,6-DINITRO-2-METHYLPHENOL | 55 | 3 | 5 | 3 | 38.4 | 167.6 | None | None |
| 4-BROMOPHENYL-PHENYLETHER | 58 | 1 | 2 | 1 | 15.4 | 65.3 | None | None |
| 4-METHYLPHENOL | 56 | 7 | 13 | 6 | 14.8 | 66.5 | None | None |
| 4-NITROPHENOL | 56 | 6 | 11 | 3 | 38.9 | 166.1 | None | None |
| ACENAPHTHENE | 61 | 22 | 36 | 7 | 13.4 | 63.7 | None | None |
| ANTHRACENE | 61 | 2 | 3 | 1 | 14.6 | 63.8 | 2,800 | - |
| BENZO(A)ANTHRACENE | 61 | 2 | 3 | 0.4 | 14.6 | 63.8 | 8.2 | - |
| BENZO(A)PYRENE | 59 | 1 | 2 | 0.3 | 15.0 | 64.8 | 0.6 | - |
| BIS(2-ETHYLHEXYL)PHTHALATE | 58 | 7 | 12 | 140 | 10.2 | 20.7 | None | None |
| BUTYLBENZYLPHTHALATE | 58 | 6 | 10 | 0.7 | 15.2 | 65.4 | None | None |
| CHRYSENE | 61 | 2 | 3 | 1 | 14.3 | 63.8 | 82 | - |
| DIBENZOFURAN | 58 | 15 | 26 | 3 | 27.8 | 163.5 | None | None |

TABLE 2-1

NFD POINT MOLATE
WORK PLAN FOR SAMPLING AND FIELD PILOT TESTING
SITE 3 - TREATMENT PONDS AREA
SUMMARY OF GROUNDWATER DATA

| Analyte[1] | FREQUENCY | | Percent Frequency Detection[2] | Maximum Detection (µg/L) | Mean[2] (µg/L) | Standard Deviation (µg/L) | Preliminary FPALDR Values (µg/L)[3,4] | |
|---|---|---|---|---|---|---|---|---|
| | Total Samples | Detected | | | | | greater than 150 ft | less than 150 ft |
| **SEMIVOLATILE ORGANIC COMPOUNDS (continued)** | | | | | | | | |
| DIETHYLPHTHALATE | 58 | 2 | 3 | 12 | 15.6 | 65.3 | None | None |
| DI-N-BUTYLPHTHALATE | 58 | 7 | 12 | 1 | 15.3 | 65.3 | None | None |
| FLUORANTHENE | 61 | 4 | 7 | 0.9 | 14.2 | 63.8 | 1,100 | - |
| FLUORENE | 61 | 26 | 43 | 13 | 13.9 | 63.8 | 1,100 | - |
| HEXACHLOROCYCLOPENTADENE | 58 | 6 | 10 | 1 | 15.5 | 65.3 | None | None |
| NAPHTHALENE | 60 | 3 | 5 | 4 | 14.5 | 64.3 | 5,200 | - |
| N-NITROSODIPHENYLAMINE (1)[5] | 58 | 5 | 9 | 580 | 16.7 | 75.7 | None | None |
| PENTACHLOROPHENOL | 55 | 2 | 4 | 3 | 38.4 | 167.6 | None | None |
| PHENANTHRENE | 61 | 13 | 21 | 24 | 15.0 | 63.8 | 1,100 | None |
| PHENOL | 55 | 1 | 2 | 0.4 | 15.3 | 67.1 | None | None |
| PYRENE | 61 | 17 | 28 | 6 | 13.3 | 63.9 | 870 | None |
| **GENERAL CHEMISTRY** | | | | | | | | |
| BIOLOGICAL OXYGEN DEMAND | 5 | 5 | 100 | 85,000 | 35,400 | 28,325 | None | None |
| CHLORIDE | 29 | 29 | 100 | 5,000,000 | 523,231 | 1,010,113 | None | None |
| FLUORIDE | 29 | 29 | 100 | 1,200 | 709 | 193 | None | None |
| NITRATE | 29 | 3 | 10 | 5,700 | 405 | 1,215 | None | None |
| ORTHOPHOSPHATE | 29 | 9 | 31 | 2,500 | 262 | 458 | None | None |
| SULFATE | 29 | 15 | 52 | 14,000,000 | 511,624 | 2,595,472 | None | None |
| TOTAL DISSOLVED SOLIDS | 16 | 16 | 100 | 12,500,000 | 1,772,438 | 3,153,354 | None | None |
| TOTAL ORGANIC CARBON | 11 | 11 | 100 | 25,000 | 18,418 | 6,252 | None | None |

**Notes:**

– Not Applicable

BTEX Benzene, toluene, ethylbenzene, and xylene

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# TABLE 2-1

## NFD POINT MOLATE
## WORK PLAN FOR SAMPLING AND FIELD PILOT TESTING
## SITE 3 - TREATMENT PONDS AREA
## SUMMARY OF GROUNDWATER DATA

| Analyte[1] | FREQUENCY | | Percent Frequency Detection[2] | Maximum Detection (µg/L) | Mean[2] (µg/L) | Standard Deviation (µg/L) | Preliminary FPALDR Values (µg/L)[3,4] | |
|---|---|---|---|---|---|---|---|---|
| | Total Samples | Detected | | | | | greater than 150 ft | less than 150 ft |

**Notes (continued):**

mg/kg Milligrams per kilogram

PAH Polynuclear aromatic hydrocarbons

TPH Total petroleum hydrocarbons

[1] Analytes not detected in any laboratory analysis are not presented in this table, including benzo(a)pyrene.

[2] Field duplicate samples were not included in frequency of detection or summary statistical calculations.
Compounds analyzed by multiple methods (for example, BTEX and PAH compounds) are summarized together in the frequency of detection and summary statistics tables. Results for these multiple analyses have been grouped together for reporting purposes and to avoid double counting. If multiple results are non-detect, the lowest non-detect is used. If a detected value is available, the highest detect is used.

Extraction wells and soil boring water samples were not included in the frequency of detection or summary statistic calculations. These data are considered field screening level data because purging and sample collection protocols are not consistent with other monitoring well samples.

Non-detect values are incorporated into the calculation of the mean for each analyte using a value of one-half the detection limit.

[3] The FPALDR is currently in draft form (submitted in January 2001), thus the numbers presented in this table are considered preliminary. Residential and Park Maintenance are only two of the human risk exposure criteria, there are also criteria for Recreation, Terrestrial Ecological Receptors, and Soil for Soil/Groundwater human exposure.

[4] Groundwater FPALDR criteria are applied based on whether the sample location is greater than or less than 150 feet from the shoreline.

[5] N-nitrosodiphenylamine was detected during a single sampling event (May/June 1992); subsequent sampling events resulted in no detections of this compound.

TABLE 2-2

NFD POINT MOLATE
WORK PLAN FOR SAMPLING AND FIELD PILOT TESTING
IR SITE 3 - TREATMENT PONDS AREA
SUMMARY OF SOIL DATA

| Analyte[1] | FREQUENCY | | Percent Frequency Detection[2] | Maximum Detection (mg/kg) | Mean[2] (mg/kg) | Standard Deviation (mg/kg) | Preliminary FPALDR Values (mg/kg)[3] | |
|---|---|---|---|---|---|---|---|---|
| | Total Samples | Detected | | | | | Resi-dential | Park Maint. |
| **TOTAL PETROLEUM HYDROCARBONS** | | | | | | | | |
| DIESEL RANGE ORGANICS | 127 | 57 | 45 | 22,000 | 1,915 | 4,037 | 1,380 | 6,700 |
| GASOLINE RANGE ORGANICS | 128 | 32 | 25 | 17,000 | 504 | 2,271 | 1,030 | 5,900 |
| JP5 RANGE ORGANICS | 90 | 8 | 9 | 15,000 | 343 | 1,726 | 1,380 | 6,700 |
| MOTOR OIL RANGE ORGANICS | 73 | 46 | 63 | 19,000 | 1,439 | 3,332 | 1,900 | 9,400 |
| OTHER HEAVY TPH COMPONENTS | 83 | 36 | 43 | 25,000 | 916 | 3,087 | 1,900 | 9,400 |
| OTHER LIGHT TPH COMPONENTS | 80 | 57 | 71 | 5,400 | 407 | 987 | 1,030 | 5,900 |
| TPH - BUNKER FUEL (C10-C28) | 89 | 48 | 54 | 83,000 | 7,327 | 15,372 | 1,900 | 9,400 |
| TPH - DIESEL F-76 (C8-C28) | 10 | 1 | 10 | 66 | 151 | 145 | 1,380 | 6,700 |
| **VOLATILE ORGANIC COMPOUNDS** | | | | | | | | |
| 1,2-DICHLOROETHENE (TOTAL) | 23 | 1 | 4 | 29 | 2.1 | 6.1 | None | None |
| 2-BUTANONE | 23 | 1 | 4 | 0.01 | 1.1 | 2.2 | None | None |
| ACETONE | 23 | 4 | 17 | 0.9 | 1.2 | 2.1 | None | None |
| BENZENE | 129 | 11 | 9 | 0.7 | 0.1 | 0.8 | 0.6 | 5 |
| ETHYLBENZENE | 129 | 28 | 22 | 8.6 | 0.3 | 1.3 | 840 | 6,600 |
| METHYL-T-BUTYL ETHER | 46 | 3 | 7 | 0.016 | 1.9 | 7.3 | None | None |
| METHYLENE CHLORIDE | 23 | 1 | 4 | 0.023 | 1.2 | 2.2 | None | None |
| TETRACHLOROETHENE | 23 | 2 | 9 | 200 | 9.5 | 41.6 | None | None |
| TOLUENE | 129 | 30 | 23 | 9.9 | 0.4 | 1.4 | 530 | 12,800 |
| XYLENE (TOTAL) | 129 | 58 | 45 | 34 | 1.3 | 4.4 | 1,080 | 109,000 |
| **SEMIVOLATILE ORGANIC COMPOUNDS** | | | | | | | | |
| 1-METHYLNAPHTHALENE | 7 | 6 | 86 | 34 | 14.3 | 14.4 | None | None |
| 2,4-DIMETHYLPHENOL | 13 | 0 | 0 | - | 8.9 | 8.4 | None | None |
| 2-METHYLNAPHTHALENE | 20 | 12 | 60 | 52 | 14.4 | 18.7 | None | None |
| 4,6-DINITRO-2-METHYLPHENOL | 13 | 0 | 0 | - | 22.0 | 21.0 | None | None |
| 4-BROMOPHENYL-PHENYLETHER | 13 | 0 | 0 | - | 8.9 | 8.4 | None | None |
| 4-METHYLPHENOL | 13 | 0 | 0 | - | 8.9 | 8.4 | None | None |
| 4-NITROPHENOL | 13 | 0 | 0 | - | 18.6 | 14.1 | None | None |

TABLE 2-2

NFD POINT MOLATE
WORK PLAN FOR SAMPLING AND FIELD PILOT TESTING
IR SITE 3 - TREATMENT PONDS AREA
SUMMARY OF SOIL DATA

| Analyte[1] | FREQUENCY | | Percent Frequency Detection[2] | Maximum Detection (mg/kg) | Mean[2] (mg/kg) | Standard Deviation (mg/kg) | Preliminary FPALDR Values (mg/kg)[3] | |
|---|---|---|---|---|---|---|---|---|
| | Total Samples | Detected | | | | | Resi-dential | Park Maint. |
| **SEMIVOLATILE ORGANIC COMPOUNDS (CONTINUED)** | | | | | | | | |
| ACENAPHTHENE | 20 | 1 | 5 | 0.3 | 6.0 | 7.8 | None | None |
| ACENAPHTHYLENE | 20 | 1 | 5 | 1.7 | 5.9 | 7.9 | None | None |
| ANTHRACENE | 20 | 5 | 25 | 1.0 | 5.9 | 7.9 | 5,900 | 17,800 |
| BENZO(A)ANTHRACENE | 20 | 7 | 35 | 9.2 | 6.9 | 7.5 | 0.43 | 1.5 |
| BENZO(A)PYRENE | 20 | 0 | 0 | - | 5.8 | 8.0 | 0.04 | 0.15 |
| BENZO(B)FLUORANTHENE | 20 | 1 | 5 | 2.2 | 5.9 | 7.9 | 0.43 | 1.5 |
| BENZO(G,H,I)PERYLENE | 20 | 0 | 0 | - | 5.8 | 8.0 | 620 | 1,700 |
| BENZO(K)FLUORANTHENE | 20 | 0 | 0 | - | 5.8 | 8.0 | 0.43 | 1.5 |
| BIS(2-ETHYLHEXYL)PHTHALATE | 13 | 0 | 0 | - | 8.9 | 8.4 | None | None |
| BUTYLBENZYLPHTHALATE | 13 | 0 | 0 | - | 8.9 | 8.4 | None | None |
| CHRYSENE | 20 | 9 | 45 | 1.7 | 3.7 | 6.7 | 4.3 | 15 |
| DI-N-BUTYLPHTHALATE | 13 | 0 | 0 | - | 8.9 | 8.4 | None | None |
| DIBENZOFURAN | 13 | 0 | 0 | - | 8.9 | 8.4 | None | None |
| DIETHYLPHTHALATE | 13 | 0 | 0 | - | 8.9 | 8.4 | None | None |
| FLUORANTHENE | 20 | 2 | 10 | 1.9 | 5.6 | 8.0 | 820 | 2,300 |
| FLUORENE | 20 | 4 | 20 | 6.8 | 3.3 | 2.9 | 770 | 2,300 |
| HEXACHLOROCYCLOPENTADIENE | 13 | 0 | 0 | - | 8.9 | 8.4 | None | None |
| N-NITROSODIPHENYLAMINE (1) | 13 | 0 | 0 | - | 8.9 | 8.4 | None | None |
| NAPHTHALENE | 20 | 0 | 0 | - | 6.1 | 7.8 | 480 | 2,300 |
| PENTACHLOROPHENOL | 13 | 0 | 0 | - | 22.0 | 21.0 | None | None |
| PHENANTHRENE | 20 | 17 | 85 | 25.0 | 6.8 | 6.8 | 600 | 1,700 |
| PHENOL | 13 | 0 | 0 | - | 8.9 | 8.4 | None | None |
| PYRENE | 20 | 12 | 60 | 9.2 | 3.0 | 6.8 | 620 | 1,700 |
| **METALS** | | | | | | | | |
| ALUMINUM | 15 | 15 | 100 | 20,800 | 14,663 | 3,289 | None | None |
| ARSENIC | 15 | 15 | 100 | 15 | 4 | 4 | None | None |
| BARIUM | 15 | 15 | 100 | 235 | 114 | 58 | None | None |

TABLE 2-2

NFD POINT MOLATE
WORK PLAN FOR SAMPLING AND FIELD PILOT TESTING
IR SITE 3 - TREATMENT PONDS AREA
SUMMARY OF SOIL DATA

| Analyte[1] | FREQUENCY | | Percent Frequency Detection[2] | Maximum Detection (mg/kg) | Mean[2] (mg/kg) | Standard Deviation (mg/kg) | Preliminary FPALDR Values (mg/kg)[3] | |
|---|---|---|---|---|---|---|---|---|
| | Total Samples | Detected | | | | | Resi-dential | Park Maint. |
| **METALS (continued)** | | | | | | | | |
| BERYLLIUM | 15 | 9 | 60 | 1.1 | 0.7 | 0 | None | None |
| CADMIUM | 15 | 3 | 20 | 1.9 | 0.6 | 0 | None | None |
| CALCIUM | 15 | 15 | 100 | 18,500 | 8,664 | 4,095 | None | None |
| CHROMIUM | 15 | 15 | 100 | 71 | 22 | 16 | None | None |
| COBALT | 15 | 14 | 93 | 17 | 9 | 4 | None | None |
| COPPER | 15 | 9 | 60 | 155 | 26 | 37 | None | None |
| IRON | 15 | 15 | 100 | 31,000 | 18,467 | 5,438 | None | None |
| LEAD | 20 | 19 | 95 | 38 | 12 | 8 | None | None |
| LEAD, ORGANIC | 16 | 3 | 19 | 5 | 1 | 1 | None | None |
| MAGNESIUM | 15 | 15 | 100 | 10,700 | 4,857 | 1,913 | None | None |
| MANGANESE | 15 | 15 | 100 | 510 | 284 | 89 | None | None |
| MERCURY | 13 | 4 | 31 | 0 | 0 | 0 | None | None |
| NICKEL | 15 | 15 | 100 | 81 | 28 | 16 | None | None |
| POTASSIUM | 15 | 12 | 80 | 3,870 | 2,746 | 804 | None | None |
| SELENIUM | 15 | 2 | 13 | 1 | 0 | 0 | None | None |
| SILVER | 13 | 1 | 8 | 1 | 0 | 0 | None | None |
| SODIUM | 15 | 4 | 27 | 2,590 | 694 | 908 | None | None |
| VANADIUM | 15 | 15 | 100 | 69 | 32 | 13 | None | None |
| ZINC | 15 | 15 | 100 | 191 | 66 | 41 | None | None |
| **GENERAL CHEMISTRY** | | | | | | | | |
| BIOCHEMICAL OXYGEN DEMAND | 2 | 2 | 100 | 850 | 715 | 191 | None | None |
| TOTAL ORGANIC CARBON | 4 | 4 | 100 | 24,000 | 12,075 | 9,216 | None | None |

**Notes:**

– Not Applicable
BTEX Benzene, toluene, ethylbenzene, and xylene
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mg/kg Milligrams per kilogram

# TABLE 2-2

## NFD POINT MOLATE
## WORK PLAN FOR SAMPLING AND FIELD PILOT TESTING
## IR SITE 3 - TREATMENT PONDS AREA
## SUMMARY OF SOIL DATA

| Analyte[1] | FREQUENCY | | Percent Frequency Detection[2] | Maximum Detection (mg/kg) | Mean[2] (mg/kg) | Standard Deviation (mg/kg) | Preliminary FPALDR Values (mg/kg)[3] | |
|---|---|---|---|---|---|---|---|---|
| | Total Samples | Detected | | | | | Resi-dential | Park Maint. |

PAH Polynuclear aromatic hydrocarbons
TPH Total petroleum hydrocarbons

[1] Analytes not detected in any laboratory analysis are not presented in this table, including benzo(a)pyrene.

[2] Field duplicate samples were not included in frequency of detection or summary statistical calculations.

Compounds analyzed by multiple methods (for example, BTEX and PAH compounds) are summarized together in the frequency of detection and summary statistics tables. Results for these multiple analyses have been grouped together for reporting purposes and to avoid double counting. If multiple results are non-detect, the lowest non-detect is used. If a detected value is available, the highest detect is used.

Non-detect values are incorporated into the calculation of the mean for each analyte using a value of one-half the detection limit.

Extraction wells and soil boring water samples were not included in the frequency of detection or summary statistic calculations. These data are considered field screening level data because purging and sample collection protocols are not consistent with other monitoring well samples.

[3] The Draft FPALDR is currently scheduled for submittal in January 2001, thus the numbers presented in this table are considered preliminary. Residential and Park Maintenance are only two of the human risk exposure criteria, there are also criteria for Recreation, Terrestrial Ecological Receptors, and Soil for Soil/Groundwater human exposure.

TABLE 2-3

# NFD POINT MOLATE
# WORK PLAN FOR SAMPLING AND FIELD PILOT TESTING
# IR SITE 3-TREATMENT PONDS AREA
# SUMMARY OF SHALLOW SOIL DATA

| Analyte | FREQUENCY[1,2,3] | | | | Percent Frequency Detection | Maximum Detection (mg/kg) | Mean (mg/kg) | Standard Deviation (mg/kg) | Preliminary FPALDR Action Levels (mg/kg)[4] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total Samples 0-3 ft | Total Samples 3-10 ft | Total Samples | Detected | | | | | Residential | Park Maint. |
| **TOTAL PETROLEUM HYDROCARBONS** | | | | | | | | | | |
| DIESEL RANGE ORGANICS | 15 | 38 | 53 | 32 | 60 | 14,000 | 1,566 | 3,207 | 1,380 | 6,700 |
| GASOLINE RANGE ORGANICS | 15 | 38 | 53 | 24 | 45 | 10,000 | 482 | 1,644 | 1,030 | 5,900 |
| JP5 RANGE ORGANICS | 0 | 15 | 15 | 0 | 0 | - | 57 | 94 | 1,380 | 6,700 |
| MOTOR OIL RANGE ORGANICS | 15 | 33 | 48 | 33 | 69 | 9,200 | 964 | 1,914 | 1,900 | 9,400 |
| OTHER HEAVY TPH COMPONENTS | 0 | 13 | 13 | 2 | 15 | 1,800 | 164 | 492 | 1,900 | 9,400 |
| OTHER LIGHT TPH COMPONENTS | 0 | 13 | 13 | 12 | 92 | 5,400 | 1,168 | 2,021 | 1,030 | 5,900 |
| TPH - BUNKER FUEL (C10-C28) | 0 | 15 | 15 | 13 | 87 | 74,000 | 11,963 | 17,845 | 1,900 | 9,400 |
| TPH - DIESEL F-76 (C8-C28) | 0 | 2 | 2 | 0 | 0 | - | 278 | 4 | 1,380 | 6,700 |
| **VOLATILE ORGANIC COMPOUNDS** | | | | | | | | | | |
| BENZENE | 15 | 38 | 53 | 7 | 13 | 0.015 | 0 | 0 | 0.6 | 5 |
| ETHYLBENZENE | 15 | 38 | 53 | 13 | 25 | 8.6 | 0.24 | 1.2 | 840 | 6,600 |
| METHYL-T-BUTYL ETHER | 14 | 25 | 39 | 3 | 8 | 0.016 | 0 | 0.02 | None | None |
| TOLUENE | 15 | 38 | 53 | 12 | 23 | 4.1 | 0.18 | 0.72 | 530 | 12,800 |
| XYLENE (TOTAL) | 15 | 38 | 53 | 21 | 40 | 34 | 1.1 | 4.8 | 1,080 | 109,000 |
| **SEMIVOLATILE ORGANIC COMPOUNDS** | | | | | | | | | | |
| 1-METHYLNAPHTHALENE | 0 | 2 | 2 | 2 | 100 | 12.1 | 8.0 | 5.9 | None | None |
| 2,4-DIMETHYLPHENOL | 0 | 2 | 2 | 0 | 0 | - | 6 | - | None | None |
| 2-METHYLNAPHTHALENE | 0 | 4 | 4 | 3 | 75 | 45 | 22.2 | 24.1 | None | None |
| 4,6-DINITRO-2-METHYLPHENOL | 0 | 2 | 2 | 0 | 0 | - | 14.8 | - | None | None |
| 4-BROMOPHENYL-PHENYLETHER | 0 | 2 | 2 | 0 | 0 | - | 6 | - | None | None |
| 4-METHYLPHENOL | 0 | 2 | 2 | 0 | 0 | - | 6 | - | None | None |
| 4-NITROPHENOL | 0 | 2 | 2 | 0 | 0 | - | 14.8 | - | None | None |
| ACENAPHTHENE | 0 | 4 | 4 | 0 | 0 | - | 3.4 | - | None | None |
| ANTHRACENE | 0 | 4 | 4 | 1 | 25 | 0.39 | 3.1 | 3.3 | 5,900 | 17,800 |
| BENZO(A)ANTHRACENE | 0 | 4 | 4 | 3 | 75 | 5.1 | 3.6 | 2.4 | 0.43 | 1.5 |
| BENZO(A)PYRENE | 0 | 4 | 4 | 0 | 0 | - | 3.0 | - | 0.04 | 0.15 |
| BENZO(B)FLUORANTHENE | 0 | 4 | 4 | 0 | 0 | - | 3.02 | - | 0.43 | 1.5 |

# TABLE 2-3

## NFD POINT MOLATE
## WORK PLAN FOR SAMPLING AND FIELD PILOT TESTING
## IR SITE 3-TREATMENT PONDS AREA
## SUMMARY OF SHALLOW SOIL DATA

| Analyte | FREQUENCY[1,2,3] | | | | Percent Frequency Detection | Maximum Detection (mg/kg) | Mean (mg/kg) | Standard Deviation (mg/kg) | Preliminary FPALDR Action Levels (mg/kg)[4] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total Samples 0-3 ft | Total Samples 3-10 ft | Total Samples | Detected | | | | | Residential | Park Maint. |
| BENZO(G,H,I)PERYLENE | 0 | 4 | 4 | 0 | 0 | - | 3.02 | - | 620 | 1700 |
| BENZO(K)FLUORANTHENE | 0 | 4 | 4 | 0 | 0 | - | 3.02 | - | 0.43 | 1.5 |
| BIS(2-ETHYLHEXYL)PHTHALATE | 0 | 2 | 2 | 0 | 0 | - | 6 | - | None | None |
| BUTYLBENZYLPHTHALATE | 0 | 2 | 2 | 0 | 0 | - | 6 | - | None | None |
| CHRYSENE | 0 | 4 | 4 | 2 | 50 | 1.7 | 2.2 | 2.6 | 4.3 | 15 |
| DI-N-BUTYLPHTHALATE | 0 | 2 | 2 | 0 | 0 | - | 6 | - | None | None |
| DIBENZOFURAN | 0 | 2 | 2 | 0 | 0 | - | 6 | - | None | None |
| DIETHYLPHTHALATE | 0 | 2 | 2 | 0 | 0 | - | 6 | - | None | None |
| FLUORANTHENE | 0 | 4 | 4 | 1 | 25 | 1.9 | 2.0 | 2.8 | 820 | 2,300 |
| FLUORENE | 0 | 4 | 4 | 1 | 25 | 0.8 | 3.2 | 3.2 | 770 | 2,300 |
| HEXACHLOROCYCLOPENTADIENE | 0 | 2 | 2 | 0 | 0 | - | 6 | - | None | None |
| N-NITROSODIPHENYLAMINE (1) | 0 | 2 | 2 | 0 | 0 | - | 6 | - | None | None |
| NAPHTHALENE | 0 | 4 | 4 | 0 | 0 | - | 3.4 | - | 480 | 2,300 |
| PENTACHLOROPHENOL | 0 | 2 | 2 | 0 | 0 | - | 14.8 | - | None | None |
| PHENANTHRENE | 0 | 4 | 4 | 4 | 100 | 19 | 10.3 | 9.5 | 600 | 1,700 |
| PHENOL | 0 | 2 | 2 | 0 | 0 | - | 6 | - | None | None |
| PYRENE | 0 | 4 | 4 | 3 | 75 | 5.2 | 2.9 | 2.5 | 620 | 1,700 |
| **METALS** | | | | | | | | | | |
| ALUMINUM | 0 | 2 | 2 | 2 | 100 | 13,400 | 13,050 | 495 | None | None |
| ARSENIC | 0 | 2 | 2 | 2 | 100 | 2.9 | 1.9 | 1.4 | None | None |
| BARIUM | 0 | 2 | 2 | 2 | 100 | 138 | 135 | 4.2 | None | None |
| BERYLLIUM | 0 | 2 | 2 | 1 | 50 | 0.79 | 0.58 | 0.3 | None | None |
| CADMIUM | 0 | 2 | 2 | 0 | 0 | - | 0.34 | - | None | None |
| CALCIUM | 0 | 2 | 2 | 2 | 100 | 13,700 | 8,970 | 6,689 | None | None |
| CHROMIUM | 0 | 2 | 2 | 2 | 100 | 16.2 | 15.5 | 0.99 | None | None |
| COBALT | 0 | 2 | 2 | 2 | 100 | 10.3 | 8.6 | 2.5 | None | None |
| COPPER | 0 | 2 | 2 | 1 | 50 | 14.7 | 10.3 | 6.3 | None | None |
| IRON | 0 | 2 | 2 | 2 | 100 | 15,400 | 14,800 | 849 | None | None |
| LEAD | 0 | 4 | 4 | 3 | 75 | 14 | 9.2 | 6.1 | None | None |

# TABLE 2-3

## NFD POINT MOLATE
## WORK PLAN FOR SAMPLING AND FIELD PILOT TESTING
## IR SITE 3-TREATMENT PONDS AREA
## SUMMARY OF SHALLOW SOIL DATA

| Analyte | FREQUENCY[1,2,3] | | | | Percent Frequency Detection | Maximum Detection (mg/kg) | Mean (mg/kg) | Standard Deviation (mg/kg) | Preliminary FPALDR Action Levels (mg/kg)[4] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total Samples 0-3 ft | Total Samples 3-10 ft | Total Samples | Detected | | | | | Residential | Park Maint. |
| LEAD, ORGANIC | 0 | 3 | 3 | 0 | 0 | - | 0.3 | - | None | None |
| MAGNESIUM | 0 | 2 | 2 | 2 | 100 | 4,110 | 3,625 | 686 | None | None |
| MANGANESE | 0 | 2 | 2 | 2 | 100 | 282 | 254 | 40.3 | None | None |
| NICKEL | 0 | 2 | 2 | 2 | 100 | 23.2 | 22.1 | 1.6 | None | None |
| POTASSIUM | 0 | 2 | 2 | 2 | 100 | 3,520 | 2,935 | 827 | None | None |
| SILVER | 0 | 2 | 2 | 1 | 50 | 1.1 | 0.72 | 0.54 | None | None |
| VANADIUM | 0 | 2 | 2 | 2 | 100 | 33.5 | 30.7 | 4.0 | None | None |
| ZINC | 0 | 2 | 2 | 2 | 100 | 56 | 50.9 | 7.3 | None | None |

Notes

[1] Statistical calculations are based on combination of all samples from 0 to 10 feet below grade surface.

[2] With the exception of JP5 and semivolatile organics, and metals, analytes not detected in any laboratory analyses are not presented in this table.

[3] Field duplicate samples were not included in frequency of detection or summary statistical calculations.
Compounds analyzed by multiple methods (for example, BTEX and PAH compounds) are summarized together in the frequency of detection and summary statistics tables. Results for these multiple analyses have been grouped together for reporting purposes and to avoid double counting. If multiple results are non-detect, the lowest non-detect is used. If a detected value is available, the highest detect is used.

Non-detect values are incorporated into the calculation of the mean for each analyte using a value of one-half the detection limit.

Extraction wells and soil boring water samples were not included in the frequency of detection or summary statistic calculations.

[4] The Draft FPALDR is currently scheduled for submittal in January 2001, thus the numbers presented in this table are considered preliminary. Residential and Park Maintenance are only two of the human risk exposure criteria, there are also criteria for Recreation, Terrestrial Ecological Receptors, and Soil for Soil/Groundwater human exposure.

## TABLE 7-1

## AIR MONITORING PLAN
## NFD POINT MOLATE

| Activity | Chemical Hazard | Instrument | Responsible Party | Frequency |
|---|---|---|---|---|
| Drilling | Hydrocarbons | PID and FID | OHSO | Start of task, hourly |
| | Benzene, vinyl chloride[a] | Dräger tubes | OHSO | Start of task, every 4 hours |
| | PAH | Miniram7 | OHSO | Start of task, every 4 hours, during dusty conditions |
| Trenching | Hydrocarbons | PID and FID | OHSO | Start of task, every 4 hours |
| Groundwater sampling | Hydrocarbons | PID and FID | OHSO | Start of task at each well |
| | Benzene, vinyl chloride[a] | Dräger tubes | OHSO | Start of task at each well |

Notes:

FID Flameionization detector
O&M Operation and maintenance
OHSO On-site health and safety officer
PAH Polynuclear aromatic hydrocarbons
PID Photo-ionization detector

a Vinyl chloride will be monitored only at locations near monitoring well MW11-44.

## TABLE 7-2

## MEDICAL FACILITIES AND DIRECTIONS PULLOUT
## NFD POINT MOLATE

**Emergency Room (see Figure 7-1):**

- Site 3 is located at the Treatment Ponds Area. From the Treatment Ponds Area, take any one of the many roads that connect the Treatment Ponds Area to the main road (Western Drive is the main road through NFD Point Molate)
- Leave NFD Point Molate on Western Drive
- Go straight to enter Highway 580 East
- From Highway 580 take first exit – Point Richmond and Richmond Parkway
- LEFT under highway heading north on Castro Street, which becomes Richmond Parkway; continue about 3 miles
- RIGHT on Parr Boulevard. Stay on Parr Boulevard as it turns into Rd 20 (after Giant Highway); Rd 20 jogs right at Rumrill Boulevard, but take quick LEFT to stay on Rd. 20, travel about 2 miles from Richmond Parkway
- RIGHT onto San Pablo Avenue. Stay on San Pablo Avenue through downtown San Pablo for about 2 miles, stay to left when San Pablo Avenue curves left.
- RIGHT on Vale Road (watch for Vale Road and hospital signs)
- First LEFT to hospital emergency room

**Doctor's Medical Center**
**2000 Vale Road**
**San Pablo, California 94806**
**(510) 970-5140**
**Emergency – 911**

Note: Depending on traffic, trip to hospital may take more than 30 minutes.

# APPENDIX A

## FIELD SAMPLING PLAN
## FOR
## SAMPLING AND PILOT TESTING AT SITE 3

## NAVAL FUEL DEPOT POINT MOLATE,
## RICHMOND, CALIFORNIA

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN II)
Northern and Central California, Nevada, and Utah
Contract No. N62474-94-D-7609
Contract Task Order 379

Prepared for

DEPARTMENT OF THE NAVY
Naval Facilities Engineering Command
Southwest Division
San Diego, California

# FINAL
# FIELD SAMPLING PLAN
# FOR
# SAMPLING AND FIELD PILOT TESTING
# AT SITE 3

NAVAL FUEL DEPOT POINT MOLATE
RICHMOND, CALIFORNIA

DS.0379.15002

May 14, 2001

Prepared by

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San Francisco, California 94105
(415) 543-4880

Brian Schuller, Project Manager

**SITE 3**
**SAMPLING AND FIELD PILOT TESTING**

**FINAL FIELD SAMPLING PLAN**

**NAVAL FUEL DEPOT POINT MOLATE**
**RICHMOND, CALIFORNIA**

**Prepared for:**
**DEPARTMENT OF THE NAVY**

REGISTERED GEOLOGIST
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DS.0379.15002

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## ATTACHMENTS


**Attachment**

A-1 DESCRIPTION OF EPA METHOD 5035

## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| APR | Air-purifying respirator |
| ASTM | American Society for Testing and Materials |
| bgs | Below ground surface |
| BRAC | Base realignment and closure |
| BTEX | Benzene, toluene, ethyl benzene, xylenes |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CLEAN | Comprehensive Long-term Environmental Action Navy |
| CME | Central Mine Equipment |
| CTO | Contract task order |
| DQO | Data quality objective |
| EB | Equipment blank |
| EE/CA | Engineering evaluation and cost analysis |
| ep | Equilibrium partitioning |
| EPA | U.S. Environmental Protection Agency |
| FID | Flame ionization detector |
| FPALDR | Fuel Product Action Level Development Report |
| FRF | Fuel reclamation facility |
| FSP | Field sampling plan |
| GSA | Geological Society of America |
| GWTP | Groundwater treatment plant |
| HASP | Health and safety plan |
| HDPE | High density polyethylene |
| $HNO_3$ | Nitric acid |
| HPC | Heterotrophic plate counts. |
| HSA | Hollow-stem auger |
| ID | Inside diameter |
| µg/L | Micrograms per liter |
| µm | Micron |
| µm | Micromole per liter |
| mL | Milliliter |
| MPE | Multiphase extraction |
| MS/MSD | Matrix spike and matrix spike duplicate |
| NFD | Naval Fuel Depot |
| NIOSH | National Institute for Occupational Safety and Health |
| OD | Outside diameter |
| OVA | Organic vapor analyzer |
| PAH | Polynuclear aromatic hydrocarbons |
| PID | Photoionization detector |
| PPE | Personal protective equipment |
| PRC | PRC Environmental Management, Inc. |
| PVC | Polyvinyl chloride |

## ACRONYMS AND ABBREVIATIONS (Continued)

| | |
|---|---|
| QA | Quality assurance |
| QAPP | Quality assurance project plan |
| QC | Quality control |
| SAP | Sampling and analysis plan |
| SVE | Soil vapor extraction |
| SVOA | Semivolatile organic analysis |
| SVOC | Semivolatile organic compound |
| SWB | Source water blanks |
| SWDIV | Department of the Navy, Naval Facilities Engineering Command, Southwest Division |
| TKN | Total Kjeldahl Nitrogen |
| TPH | Total petroleum hydrocarbon |
| TtEMI | Tetra Tech EM Inc. |
| USCS | Unified Soil Classification System |
| UST | Underground storage tank |
| VOA | Volatile organic analysis |
| VOC | Volatile organic compound |

# 1.0 INTRODUCTION

Tetra Tech EM Inc. (TtEMI) received Contract Task Order (CTO) 379 under Comprehensive Long-term Environmental Action Navy (CLEAN) Contract Number N62474-94-D-7609 (CLEAN II) from the Department of the Navy, Naval Facilities Engineering Command, Southwest Division (SWDIV). This CTO includes, in part, soil and groundwater sampling and field pilot testing at Site 3 at Naval Fuel Depot (NFD) Point Molate. This sampling and testing is meant to support a removal action being conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) at Site 3. NFD Point Molate was used as a fuel storage and transfer facility from 1943 through 1995. Site 3 at NFD Point Molate includes the Treatment Ponds Area, the former fuel reclamation facility (FRF), a groundwater treatment plant (GWTP), a former sewage treatment plant, and a former waste oil sump pond. As a result of past operations at the facility, soil and groundwater contain elevated levels of petroleum hydrocarbons, and free product (bunker fuel, diesel, and jet fuel) has been measured in monitoring wells at several locations across the site. The site location is presented on Figure 2-1 of the work plan to which this field sampling plan (FSP) is attached.

This FSP provides specific details about the methods to be used for sample collection, the number of samples to be collected, field quality control (QC) procedures, sampling and handling procedures, and shipping procedures. A quality assurance project plan (QAPP) (Appendix B of the work plan) has also been developed to supplement this document. The QAPP fully describes the project data quality objectives (DQO), which have been developed through the seven-step DQO process (U.S. Environmental Protection Agency [EPA] 2000), in accordance with EPA guidance for preparation of QAPPs (EPA 1998). This FSP, along with the accompanying QAPP, form the sampling and analysis plan (SAP). A detailed discussion of the site background, the results of previous investigations, the rationale for the current investigation, and the locations of samples proposed are provided in the work plan to which this FSP is attached.

The base-wide health and safety plan (HASP) and Section 7.0 (Health and Safety Project Plan) of the field work plan cover activities associated with this FSP. The base-wide HASP has been revised in accordance with the periodic HASP review and update schedule (TtEMI 2000). The revised HASP and the Health and Safety Project Plan discuss health and safety concerns involved in all activities presented in this FSP.

In this FSP, Section 2.0 discusses the purpose and objectives of this investigation. Section 3.0 contains summary information about the site location and background. Section 4.0 contains specific details about the proposed field activities and field procedures. Section 5.0 refers to procedures to be used for field quality assurance and quality control (QA/QC) samples. Section 6.0 provides procedures for sample designation, handling, shipment, and chain of custody. Section 7.0 summarizes health and safety requirements for this investigation and provides references to the base-wide HASP and the field work plan. Section 8.0 presents the schedule for sampling and field pilot testing at Site 3. Finally, Section 9.0 lists all references cited in this document. Tables and figures are presented after the text and references.

## 2.0 PURPOSE AND OBJECTIVES

The purpose and objectives of this FSP are to present the methods for sample collection, designation, handling, and shipping. The objectives of sampling and field pilot testing are described in Section 1.1 of the accompanying work plan. These sampling activities and field pilot testing are being conducted to support a removal action under CERCLA at Site 3.

## 3.0 SITE LOCATION AND BACKGROUND

The following sections provide a brief description of the site location and background. A full discussion of the environmental setting is provided in Section 2.0 of the work plan to which this FSP is attached.

### 3.1 SITE LOCATION

NFD Point Molate covers approximately 413 acres in the Potrero Hills along the northeastern shore of San Francisco Bay on the San Pablo Peninsula. The facility is located in Richmond, California, about 1.5 miles north of the Richmond-San Rafael Bridge, as presented in Figure 2-1 of the work plan. NFD Point Molate is bordered to the north, south, and east by the Chevron Corporation, and to the west by the San Francisco Bay. San Pablo Peninsula divides San Francisco and San Pablo Bays. Chevron uses most of the land near NFD Point Molate for oil refining and storage; the land east of NFD Point Molate is used for storage, shipping, and pipeline distribution of petroleum products, and the land immediately north and south is unused open space.

## 3.2 SITE BACKGROUND

NFD Point Molate was a fuel storage facility for jet turbine fuels (JP-5 and JP-8) and marine diesel fuel (F-76) and had a storage capacity of more than 40 million gallons. Other fuels have historically been stored at the facility, including bunker fuel, gasoline, and aviation gasoline. Fuel storage and supply ceased in May 1995, and NFD Point Molate became a closing base under the Base Realignment and Closure (BRAC) IV Program on September 30, 1995.

Site 3 covers 10 acres of land located between the shoreline and the hills at NFD Point Molate. The primary contaminants detected in soil and groundwater at the site include total petroleum hydrocarbons (TPH) as bunker fuel and diesel. Low to moderate levels of benzene, toluene, ethylbenzene, and xylenes (BTEX) have also been detected in soil and groundwater samples collected from Site 3.

The average depth to groundwater at Site 3 is approximately 11 feet. The depth varies across the site and is typically deeper along the shoreline, where a groundwater extraction trench/containment wall system is currently operating. Soil consists of fill (silt, clay, sand, and cobbles) overlying sand (reworked intertidal alluvium). Bay Mud typically is found below the fill or sand lens at a depth of 15 to 29 feet below ground surface (bgs). The Bay Mud, consisting primarily of clay, acts as a lower confining layer at Site 3. Refer to Section 2.1 of the work plan for a more extensive description of the geology and hydrogeology at NFD Point Molate.

# 4.0 FIELD METHODS AND PROCEDURES

The following sections provide details about the procedures and methods to be used in the field. Sampling locations have been identified on the basis of eliminating existing data gaps, as is further described in Section 3.0 of the work plan. Section 4.1 describes the process for clearing subsurface utilities. Sections 4.2 and 4.3 of this FSP provide details on sampling surface and subsurface soil. Section 4.3 also describes methods to be used for exploratory trenching in the former FRF. Section 4.4 provides details on installation and development of groundwater monitoring wells. Section 4.5 provides details on groundwater sampling and analysis. Section 4.6 provides details about collection and analysis of soil vapor samples. The accompanying QAPP provides details about collection and analysis of QC samples.

## 4.1 CLEARANCES

Subsurface utilities will be cleared at all drilling locations before intrusive work begins. Each drilling site will be marked in the field with a wooden stake or spray paint (if on the road) and, if different than the planned location as presented in the work plan, will also be marked on a site plan. Utilities will be located and marked by a utility location subcontractor that will be procured by TtEMI before drilling begins at Site 3. If a subsurface utility is located at a sampling or drilling site, a new location will be selected that is nearby. The deviation will be noted in the field logbook and will be presented in the summary letter that will describe this work.

## 4.2 SURFACE SOIL SAMPLING

Twenty-three surface soil samples (0 to 3 feet bgs) will be collected at Site 3. The sampling locations were selected to obtain surface soil data from across the site so that analytical data for soil can be compared with action levels for soil (human-risk and terrestrial ecological-based action levels). Surface soil samples will not be collected from locations with obvious hydrocarbon staining. These areas will be removed as part of Site 3 closure activities, which will include closure of the Treatment Pond Area and aboveground storage tanks.

The following sections describe the proposed sampling locations, procedures to be used for sample collection, and the laboratory analyses planned. A more complete discussion of the analytical methods and QA/QC procedures is provided in the accompanying QAPP.

### 4.2.1 Sampling Locations

The 23 locations proposed for surface soil sampling are presented in Plate 2-4 of the work plan (all plates are located at the end of the field work plan, after Appendix C). Surface soil samples are recommended for the following locations:

- The former FRF – no soil data exist for this area
- The Treatment Ponds Area (excluding areas to be addressed by closure of the treatment ponds) – limited surface soil data exist for this area

For this FSP, the Treatment Ponds Area includes locations between Building 6, the former FRF area (former Tank E), the shoreline, and Diesel Road (see Plate 2-1 of the work plan).

### 4.2.2 Sampling Methods

Surface samples will be collected using a hollow-stem auger (HSA) drill rig and split-spoon sampling core barrels, as described in Section 4.3.2. An HSA drill rig is being used for collection of surface soil samples because each surface soil sampling location is at a soil boring location, which already requires use of an HSA rig to collect deeper soil samples.

Soil will be collected from grade to 3 feet bgs for each surface soil sample. The collected soil will be homogenized in a stainless-steel mixing bowl and sampled, excluding gravel and pieces of caliche from the sample. Organic material (grass, roots, and twigs) will be removed, and clods of soil and pieces of caliche will be crushed and homogenized for sampling. Samples collected for analysis of TPH-purgeable, BTEX, and volatile organic compounds (VOCs) will be collected from the midpoint of the sampling interval using EPA method 5035 (EnCore samplers) before the sample is composited to avoid loss of the target compounds caused by volatilization during mixing. A description of EPA method 5035 is presented in Attachment A-1 to this FSP. All sampling tools, including spoons, hand augers, and mixing bowls, will be decontaminated between sample locations. Equipment will be decontaminated in accordance with the procedures outlined in Section 4.7 of this FSP.

Each sampling location will be marked in the field after samples have been collected. All sampling locations will be surveyed using standard land survey methods as soon as possible after sampling, as described in Section 4.7 of this FSP.

### 4.2.3 Sample Analysis

All surface soil samples will be analyzed for TPH (bunker fuel, diesel, and gasoline), BTEX, and polynuclear aromatic hydrocarbons (PAHs). A limited number of samples will also be analyzed for VOCs and metals. Table 4-1 of this FSP presents the anticipated number of samples and chemical analyses for each soil boring location. Table 2-1 in Appendix 2 of the accompanying QAPP presents the sample methods, containers, preservation, and holding times for all chemicals to be analyzed during this investigation. Additional sampling locations to be selected in the field are not listed in this table.

## 4.3 SUBSURFACE SOIL SAMPLING

Twenty-three soil borings will be drilled to collect additional soil samples and, in many cases, to install monitoring wells across Site 3 as part of this investigation. Four soil borings will be advanced for field

pilot testing in the area of the diesel plume (see Figure C-1 in Appendix C of the work plan). Soil borings will be advanced using an HSA drill rig; the purpose of soil sampling will be as follows:

(1) Assess the vertical extent of hydrocarbon contamination.

(2) Evaluate the presence of free product.

(3) Obtain lithologic data for soil.

(4) Obtain data for evaluating remedial technologies at locations that show evidence of free product or residual hydrocarbon contamination.

Analytical results for soil samples will be compared with action levels based on potential human exposure and also will be used to evaluate soil-water partitioning of target compounds.

### 4.3.1 Sampling Locations

The 23 locations proposed for soil borings to be advanced for soil sampling are presented on Plate 2-4 of the accompanying work plan (plates are at the end of the work plan, after Appendix C). Continuous samples will be collected for the entire depth of each soil boring. Samples will be screened with a handheld total hydrocarbon analyzer (photoionization detector [PID] or flame ionization detector [FID]), and soil lithologies will be logged. Composite soil samples will be collected from surface soils (described in Section 4.2 of this FSP) and subsurface soils (Section 4.3.2) for laboratory analysis.

Subsurface soil samples are recommended for the following locations:

- The former FRF – no soil data exist for this area
- Small pad adjacent to Tank F – surface staining at this pad and its proximity to former Tank F warrant further investigation
- Treatment Ponds Area – additional soil sampling is recommended for further delineation of soil downgradient (toward the shoreline) from the treatment ponds and in the immediate vicinity of the treatment ponds

The proposed work includes 19 borings within and downgradient of the Treatment Ponds Area (including former Tank F) and four borings within the former FRF.

### 4.3.2 Drilling and Sampling Methods

Soil borings will be advanced using standard HSA drilling equipment. Proposed locations for soil borings will be marked using wooden stakes or spray paint (for paved areas) before drilling begins. If necessary, based on site-specific access or utility locations, the exact locations for drilling may be modified slightly from the areas proposed in the work plan. Any changes in drilling locations will be recorded for future reporting. The depth of each boring will depend on the extent of soil contamination, the specific objectives for the boring location, and the depth to the undisturbed Bay Mud; however, all borings will be advanced to a minimum of 15 feet bgs, as long as refusal or the Bay Mud is not encountered at a shallower depth. If contamination is observed, borings will extend to below the observable extent of contamination, to the Bay Mud, or until refusal (if it occurs above the Bay Mud). No soil borings will extend below the Bay Mud. Bay Mud has been contacted at depths ranging from approximately 15 feet bgs to 29 feet bgs at Site 3.

Soil borings will be advanced using 4-1/4-inch inside diameter (ID) by 7-7/8-inch outside diameter (OD) HSAs and continuous sampling methods. Where monitor wells are to be installed and significant free product is expected (that is, where there is immediate recharge of free product when purging the well during groundwater sampling), 6-1/4-inch ID HSAs may be used to allow installation of 4-inch ID monitoring wells. Soil samples will be collected in a 3-inch ID by 5-foot long Central Mine Equipment (CME) split-spoon barrel, which will be advanced with the lead auger. The CME sampler will be locked into position ahead of the lead auger to allow collection of representative (undisturbed) soil samples. A TtEMI geologist will log each boring. Soil types will be categorized according to the Unified Soil Classification System (USCS). An example of the field borelog form appears on Figure 4-1. A Munsell or Geological Society of America (GSA) soil color chart will be used to describe soil color.

Field screening methods for soil obtained from continuous sampling with a CME or split-spoon barrel will use the following procedures. When the split spoon is opened or after the sample is extruded from a core barrel, soil will be immediately screened with a PID or FID. Obvious odors, such as product or solvent, will be noted first in lieu of using the PID, which becomes unreliable in the presence of high humidity (during heavy rain). Soil from the CME sampler that is described in field borelogs will be selectively chosen to avoid slough or other nonrepresentative materials. Material that exhibits obvious (visible) fuel, fuel staining, or a fuel sheen will be collected in sample jars for potential laboratory analysis. Table 4-1 presents a summary of the number of soil samples to be collected at each boring location and the intended use of data.

Subsurface soil samples will be collected for laboratory analysis for the following reasons:

(1) To characterize soil between grade and 10 feet below surface grade for comparison with preliminary action levels (TtEMI, Internal Draft Fuel Product Action Level Report [FPALDR], submitted in January 2001)

(2) To identify the type of hydrocarbon (bunker fuel, diesel, jet fuel, or gasoline) for soil that contains free product or are residually saturated.

(3) To obtain data on soil for use in calculating empirical site-specific equilibrium partitioning coefficients

In general, data for subsurface samples collected from a depth of 5 to 10 feet bgs will be compared with action levels based on the potential for human exposure (in addition to surface soil samples described in Section 4.2). If soil is noted to contain residual TPH based on an observed separate phase, staining, or PID screening results on samples collected from above 5 feet bgs, the interval for the composite sample may extend from above 5 feet bgs. The soil collected will be homogenized in a stainless-steel mixing bowl and sampled, excluding gravel, pieces of caliche, and large pieces of organic matter. However, clods of soil will be crushed and homogenized for sampling. Samples collected for analysis of TPH-purgeable, BTEX, and VOCs will be collected from the midpoint of the sampling interval using EPA method 5035 (EnCore samplers) before the sample is composited to avoid loss of the target compounds caused by volatilization during mixing. A description of EPA method 5035 is presented in Attachment A-1 to this FSP. All sampling tools, including spoons, hand augers, and mixing bowls, will be decontaminated between sample locations. Equipment will be decontaminated in accordance with the procedures outlined in Section 4.7 of this FSP.

For specified locations (see Table 4-1), soil samples will be collected from below the water table to calculate site-specific equilibrium partitioning coefficients. These soil samples will be collected from a depth that is within the screened interval of the monitoring well to be installed at the soil boring. Approximate depths of the samples to be collected for calculation of partition coefficients are also presented in Table 4-1. The basis for the sampling depths of soil for evaluation of equilibrium partitioning is to collect samples from the top third and bottom third of the anticipated saturated segment of the screened interval in the monitoring well. Actual sampling depths for samples to be collected for calculation of equilibrium partitioning will be based on field observations (extent of contaminated soil in the saturated zone), and will likely vary from the depths presented in Table 4-1.

In addition to selectively choosing specific intervals within soil borings to collect samples for laboratory analysis, a descriptive classification system will be used in the field. The site geologist will apply a classification (ranking) system based on physical observations of fuel contamination at each soil boring. The ranks to be used in the field classification are presented as follows:

| | |
|---|---|
| Rank 1: | Product staining or odors is not observed during inspection or from PID readings. |
| Rank 2: | Relict (aged) product staining is observed. |
| Rank 3: | Recent product staining or product odor is observed. |
| Rank 4: | Residual product or product saturation is observed through intervals or within discrete patches. |
| Rank 5: | Free product is observed. |

This classification system, which has been used throughout the field work for characterization of underground storage tanks (UST) at NFD Point Molate, will be used to establish consistency in visual description and characterization of subsurface conditions.

If needed, alternative sampling methods may be used. These methods include use of brass sleeves within 2-foot split-spoon samplers. Smaller-diameter (2- or 2-1/2-inch) split spoon samplers are sometimes used when the larger diameter CME barrel results in poor sample recovery or encounters obstructions. Six-inch brass sleeves can be used as liners within split-spoon samplers for collection of undisturbed samples.

Methods for sample collection will depend on the consolidation and texture of the sample and will be selected to minimize the loss of volatile components. Selected soil samples will be designated and prepared for laboratory analysis as described in Section 6.0. Selected boreholes will be completed as monitoring wells (see Section 4.4) after soil sampling is complete.

If a monitoring well is not to be installed in the boring, the borehole will be backfilled (grouted with cement) after samples have been collected. Soil cuttings with no obvious signs of contamination will be segregated during drilling and will be returned to the borehole or spread on the ground surface at the site at the conclusion of drilling. Soil cuttings with obvious contamination will be isolated and stockpiled for off-site disposal.

### 4.3.3 Sample Analysis

All subsurface soil samples will be analyzed for TPH (residual, diesel, and gasoline), BTEX compounds, and PAHs. Selected samples will also be analyzed for VOCs and heterotrophic plate counts (HPC). The analyses to be conducted on samples from each boring location are presented in Table 4-1. A description of the basis for selection of analyses is presented in Section 4.1 of the attached work plan. Table 2-1 in Appendix 2 of the accompanying QAPP presents the sample methods, containers, preservation, and holding times for all chemicals of interest during this investigation.

### 4.3.4 Methods for Investigative Trenching

Exploratory trenching will be used to evaluate the contents and extent of the area of industrial waste in the former FRF. The approximate locations of the assumed boundary of the waste and planned exploratory trenches are shown on Plate 2-4 of the work plan (located after Appendix C). Trenches will be excavated along the approximated boundary of the waste about every 50 feet. Trenches will also be dug in the center of the disposal area. A description of the boundary of the waste, the depth and thickness of waste, the type of waste, the depth to groundwater, and any other observations by field personnel will be logged for each trench. Excavations will extend vertically and horizontally until materials free of industrial waste are identified. These data will be used to estimate the extent and volume of waste that will be evaluated in the engineering evaluation and cost analysis (EE/CA).

Trenches will be excavated with a 4-wheel-drive, rubber-tired backhoe. The backhoe will be capable of excavating to depths of 13 to 15 feet bgs. The backhoe bucket will be 18 to 24 inches wide and will be equipped with teeth capable of excavating waste materials. Excavated wastes will be backfilled into the trench. Surface materials will be compacted to prevent future settlement. The trenches will be excavated in isolated areas that are not used as roadways or otherwise accessed; therefore, some settlement is inconsequential.

## 4.4 MONITORING WELL INSTALLATION AND DEVELOPMENT

The 14 new monitoring wells proposed for installation at Site 3 include 12 wells within the Treatment Ponds Area and two wells inside the former FRF. For wells in the Treatment Ponds Area, one is adjacent to former Tank F, one is within the footprint of former Tank G, six are within 150 feet of the shoreline, and four are more than 150 feet from the shoreline (see Plate 2-2 of the work plan, located after

Appendix C). A summary of the wells to be installed is presented in Table 4-2. Samples from the 14 new monitoring wells will be used to aid in delineating contaminants in groundwater across Site 3.

### 4.4.1 Monitoring Well Installation

Monitoring wells will be installed in borings advanced using HSA equipment, as described in Section 4.3. Wells will be constructed using 2-inch or 4-inch diameter Schedule 40 polyvinyl chloride (PVC) flush-thread well screen (0.020-inch slot) and riser. The depth of the screened intervals will be based on the observed thickness of TPH contamination, along with historical measurements of depth to water.

In general, the well screen will be extended to a depth that approximates the lower extent of observed TPH contamination, where applicable. If TPH contamination is not visually observed or detected by PID screening of soil core samples, then the well screen will be extended to a depth of approximately 5 to 7 feet below the current water table. The top of the screened interval will be set at an elevation that is at least 2 feet above the current observed water table, and within 1 foot of the maximum historical water table within the general vicinity of the well (based on data available from existing wells). Thus, for wells located close to the shoreline and the operating groundwater extraction trench, the top of the well screen may extend as much as 5 to 7 feet above the current water table because operation of the groundwater extraction trench has lowered the water table. This approach to selecting the depth and length of the screened interval will allow for current and future monitoring of depth to water and product thickness, regardless of whether the groundwater extraction trench is in operation. A summary of the estimated well screen intervals is presented in Table 4-2.

A filter pack (sand pack) will extend from the base of the boring to approximately 1 foot above the top of the screened interval. The filter pack will be sized based on the observed soil type(s) during drilling and sampling A seal of bentonite pellets, 1.5 to 2 feet thick, will be placed above the filter pack and hydrated. The remaining annular space will be filled with a cement grout that contains 5 percent powdered bentonite or a Volclay slurry. A tremie pipe will be used to pour the filter pack or grout where formation materials cave or slough. The depths below ground to the top of the filter pack and the top of the bentonite seal will be verified with a weighted measuring tape.

The wells will be completed above ground, where possible. Traffic-rated, flush-mount completions will be used where vehicular traffic is anticipated. For aboveground completions, 8-inch-diameter surface

casing will be installed at least 24 inches below ground surface and anchored with aggregate concrete. The concrete will be finished so that it slopes away from the surface casing for a minimum distance of 2 feet. The surface casing will extend approximately 24 inches above the ground surface, will be painted, and will have weep holes (water drainage holes) near the base. Protective posts will be installed around the surface casing where necessary to protect the wellheads from vehicular damage.

Flush-mounted boxes will be anchored in aggregate concrete and will extend approximately 1 inch above the ground surface. The concrete will slope away from the top surface of the box lid. Grout will be added inside the box to ensure that the well annular space is sealed from surface contamination. Aboveground wells will be secured with locking caps. The wells installed in flush-mounted boxes will be secured with a water-tight (expanding) locking cap. All construction details for each monitoring well will be documented on a monitoring well installation form (see Figure 4-2).

Flowing sands, caving formations, or unconsolidated fill may be encountered during well construction, and their presence may require alternative construction methods. A method previously used at NFD Point Molate when flowing sands were encountered involves installation of a temporary sacrificial wooden plug inserted in the lead auger. After flowing sands are encountered, the auger flights will be removed and a tapered wooden plug will be inserted in the lead auger, in place of a drill bit. The borehole will again be reamed to total depth and the auger flights will be flooded with water, creating a hydrostatic head to counter the force of flowing sands. The plug will be knocked free and the well screen and casing will be installed within the auger. The desired sand pack will then be added. Forced placement of sand pack may be required, in which case tremie pipe and possibly water injection will be used. Water used during the well installation process will be tap water supplied by NFD Point Molate. As the augers are retrieved above the flowing sands, the well will be completed with simultaneous addition of the sand pack.

In addition, unconsolidated material tends to slough into the borehole, creating an unsuitable filter pack or causing bridging within the filter pack, bentonite seal, or cement grout. Should bridging occur, the driller will use a tremie pipe to place the completion materials at the correct location in the annular space, as discussed above. The borehole will be redrilled or relocated if bridging or excessive sloughing cannot be avoided.

### 4.4.2 Monitoring Well Development

All monitoring wells installed under this investigation will be developed to maximize the flow of formation water into the well casing, remove any fluids introduced during drilling, allow the groundwater and potential contaminants to equilibrate after they are disturbed during drilling, and represent aquifer conditions near the monitoring well prior to sampling. Various established well development techniques will be used, including swabbing, bailing, surging, and pumping. Water generated during development will be temporarily placed in containers (in drums or a Baker tank), and then emptied into the facility's wastewater treatment system.

After the grout has hardened (a minimum of 24 hours after placement), each monitoring well will be developed according to American Society for Testing and Materials (ASTM) standards (including surging and pumping). At a minimum, a volume equal to the amount of any water used during drilling and monitoring well installation, plus three times the casing volume and pore volume in the filter pack, will be removed during development.

The pH, specific conductance, turbidity, and temperature will be regularly monitored during well development. Development will continue until these parameters are stable over three readings and the required volume has been extracted. Readings will be taken at a minimum frequency of once for every casing and filter pack volume removed. The readings will be considered stable when they do not change by more than 10 percent over three readings. Development data will be recorded on well development forms. An example well development form is provided as Figure 4-3. Each monitoring well will be developed sufficiently to obtain clear water; however, development will be halted if, after a reasonable effort, water from the monitoring well does not become clear, as long as the other parameters are stable. Development water will be placed in containers and stored in drums at the site for future treatment using the facility's wastewater treatment system.

## 4.5 GROUNDWATER SAMPLING

The following sections provide details about sampling locations, sampling methods, and sample analysis. Additional details about chemical analysis of groundwater and QC samples are provided in the QAPP (attached as Appendix B of the work plan).

### 4.5.1 Sampling Locations

Groundwater will be sampled from 36 wells, including 14 new wells and 22 existing wells, to characterize groundwater. Proposed locations for groundwater sampling are shown on Plate 2-2 of the work plan (plates are attached to this document after Appendix C). Any deviations from these locations will be discussed in the summary letter report.

### 4.5.2 Sampling Methods

After it is developed, each newly installed monitoring well will be allowed to recover for a minimum of 48 hours before sampling begins. Wells will be purged before groundwater samples are collected, and groundwater quality parameters will be measured to monitor the stability and representativeness of the groundwater. A minimum of three casing volumes will be purged prior to sampling, depending on the rate of groundwater recharge. Information including water levels, PID readings at the well head, purge volumes, groundwater quality, and well construction details will be recorded on the groundwater sampling form shown on Figure 4-4. The following procedure describes collection of groundwater samples:

(1) The breathing zone will be monitored with a PID when the well cap is removed.

(2) The water level and total depth within the well casing will be measured and the casing volume will be calculated. If floating product is present, its thickness will be measured with an interface probe (see Step 3).

(3) The presence of light or dense (floating or sinking) immiscible phases in all wells will be monitored with an interface probe. If an immiscible phase is present, the thickness of the product will be measured using the interface probe. If a sample of the product is required, a clear Teflon or polypropylene bailer will then be carefully lowered into the product or water column until it starts to fill. The bailer will be allowed to fill slowly to capture as much of the immiscible phase as possible. A sample of the immiscible phase will then be decanted into a sample container for analysis.

(4) If an immiscible phase is not present, the well will be purged to obtain a representative water sample. The casing volume of the well will be calculated using the water level and total depth measurements (cross-sectional area times h, where h equals the total depth of the well minus the depth to water). All wells will be purged with a bailer or submersible pump. Before the sample is collected, no less than three, and normally five or more, casing volumes of water will be purged from the well. Where adequate recharge is available, a submersible pump will be used to purge the well; however, groundwater samples will be collected with a prepackaged disposable bailer or with a decontaminated Teflon or stainless steel bailer. In all wells where floating hydrocarbons are not present, the water sample will be collected from the top of the water column. The water in the bailer will be visually inspected for any oily sheen or oil globules. The pH, conductivity,

temperature, and turbidity of the purged water will be measured and recorded regularly throughout the purging process. If, after three casing volumes have been removed, these parameters have not stabilized, purging will continue until they have stabilized. The pH, conductivity, salinity, temperature, and turbidity of the water will be measured just before the sample is collected.

(5) To sample the groundwater in a well that has a layer of floating product, the product layer will first be evacuated using a bailer or oil-absorbent pads. An interface probe will be used to detect recharge of the hydrocarbon layer. If recharge of the hydrocarbon layer is not detected, groundwater will be purged and sampled as described above. If the hydrocarbons recharge to the well faster than they can be removed, an alternative method of obtaining a groundwater sample will be employed. This alternative method will involve inserting sections of 2-inch ID flush-joint PVC pipe inside the existing (4-inch) well, through the hydrocarbon layer, and into the groundwater below. However, the leading end of the 2-inch drop pipe will be shielded with a temporary plug (or plastic with a taped seal) before it is lowered through the product. The plug must be capable of being removed from the drop pipe and from the monitoring well. After the 2-inch drop pipe is inserted, a weighted measuring tape or probe will be lowered through the drop pipe, passing out the temporary plug (or plastic). The temporary plug must also be removed from the monitoring well (for example, by attaching heavy nylon fishing line to the plug before it is installed in the drop pipe). Residual product must be swabbed from inside the drop pipe with oil-absorbent pads. The groundwater will then be purged through the drop pipe with a 2-inch submersible pump (Grundfos Redi-Flo 2 pump), peristaltic pump, bladder pump, hand-operated pump, or a bailer. A sample of the groundwater beneath the hydrocarbon layer will then be withdrawn through the drop pipe.

(6) Bottles used to hold samples for analysis of VOCs and semivolatile organic compounds (SVOC) (or PAHs) will be filled first. The sample bottles will be maintained in a cool environment before the samples are collected to minimize loss of volatile components when they are filled. After the bottle is sealed with a Teflon-lined cap, the bottle will be inverted, tapped lightly, and visually inspected for the presence of air bubbles. If any headspace is present, the bottles will be topped off or refilled accordingly. Containers for analysis of TPH will then be filled. A small amount of air-filled head space will be allowed for samples for analysis of TPH extractable, but not for analysis of TPH purgeables. The sample bottles for other analytes and general water quality parameters will be filled last. Samples for analysis of dissolved metals, if needed, will require filtering through a 0.45 micron (μm) high-capacity filter into a sample container containing nitric acid ($HNO_3$). All sample containers are typically sent with preservative already placed in the container.

The following equipment is required to complete sample collection:

- Water level indicator
- Adjustable flow rate pump (bladder, piston, peristaltic, impeller)
- Discharge flow controller
- pH probe

- Dissolved oxygen probe
- Turbidity probe
- Oxidation and reduction (redox) probe
- Specific conductance probe
- Temperature probe
- Calibration solutions for pH, specific conductance, turbidity, and dissolved oxygen probes
- Container of known volume for flow measurement or calibrated flow meter
- Data recording and management system
- Disposable Teflon bailers with Teflon leader wire

### 4.5.3 Sample Analysis

All groundwater samples will be sent to the laboratory for analysis of TPH (residual, diesel, and gasoline) and BTEX, with the exception of 13 samples (as presented in Table 4-2) that will be analyzed for VOCs (EPA Method 8260B) instead of BTEX (EPA Method 8021). Selected samples will also be analyzed for PAHs, HPC, total Kjeldahl nitrogen (TKN), ferrous iron, anions (nitrate, sulfate, and orthophosphate), and metals. Samples from the vicinity of wells MW11-13 and MW11-44 will be analyzed for VOCs because previous groundwater samples from these wells contained the highest concentrations of VOCs detected (the only wells with detections greater than 100 micrograms per liter [μg/L]). The analyses for HPC, TKN, ferrous iron, and anions are intended to provide data for evaluation of ongoing bioattenuation in saturated soil and groundwater at Site 3. The analysis for metals for samples collected from within the former FRF are intended to evaluate potential impacts from industrial wastes recently identified in this area. A summary of the anticipated laboratory analyses associated with each groundwater sample location is presented in Table 4-2. Table 2-1 in Appendix 2 of the accompanying QAPP provides the sample methods, containers, preservation, and holding times for all target constituents in groundwater samples.

## 4.6 SOIL VAPOR SAMPLING

Soil vapor samples will be collected for laboratory and field analysis during field pilot testing at Site 3, including approximately three sets of samples for laboratory analysis, and numerous samples for field analysis. Soil vapor will be collected for the following purposes:

(1) Quantify concentrations of TPH and individual VOCs (including BTEX compounds) in extracted soil vapor during field pilot tests

(2) Obtain data for evaluating remedial technologies, specifically air controls equipment that may be required for a full-scale remediation system

(3) Obtain data to evaluate air flow pathways during air sparging

(4) Provide data to evaluate whether biodegradation is occurring

### 4.6.1 Sampling Locations

The proposed locations for soil vapor sampling include test well heads, soil gas monitoring points, selected monitoring wells, and at the discharge sample port on the pilot test skid (vacuum blower or pump). Samples will be collected for field and laboratory analysis. Laboratory analysis for TPH will be conducted primarily to confirm the results of field analysis for total organic vapor concentrations, identify TPH fingerprints, and quantify concentrations of individual BTEX constituents and other VOCs. Only samples collected from the discharge sample port on the test skid will be sent to the laboratory for analysis. A summary of sampling locations and associated laboratory analysis is presented in Table 4-3. The anticipated frequency of sampling is summarized in Appendix C of the work plan.

### 4.6.2 Sampling Methods

All soil vapor samples will be collected as grab samples. A minimum of one casing volume will be purged from monitoring wells before samples are collected using a soil gas sampling pump. Sampling methods for soil vapor will vary depending on the specific field pilot test being conducted and the location of the analysis (field or laboratory). During the air sparge, soil vapor extraction (SVE), and multiphase extraction (MPE) tests, soil vapor samples for field analysis will be collected from monitoring points and the discharge from the test system in 1-liter Tedlar bags. Samples of soil vapor for laboratory analysis will be collected on adsorbent tubes for analysis of TPH and VOCs (including BTEX compounds). Samples collected in adsorbent tubes will require one of the following two methods for measuring the volume of sample that is passed through the adsorbent tube:

(1) Use of a calibrated syringe to draw (under vacuum) a discrete volume of soil gas being sampled through the adsorbent tube during sampling.

(2) Use of a soil gas-sampling pump with airflow rate controls and a means of measuring the flow rate being drawn by the pump.

For all soil gas sampling, care must be taken to avoid cross contamination of samples. To minimize this possibility, the sampling syringe or soil gas-sampling pump will be on the "downstream" side of the sample tube for collection of soil vapor samples on tubes. Dedicated tubing is recommended for connection between the sample port and the sample tube at each sampling location. For samples collected in Tedlar bags for field analysis, dedicated sample bags will be used at locations with relatively high levels of TPH. For locations with moderate to low concentrations of TPH in soil gas, non-dedicated Tedlar bags may be used. However, it will be necessary to purge the sampling pump and non-dedicated Tedlar bags between each field sample collected for analysis.

The sampling methods are summarized in Table 4-3 for the various tests and sampling locations. Additional details (specifically, frequency of sampling) are presented in Appendix C.

### 4.6.3 Sample Analysis

Table 4-3 presents anticipated laboratory analytical methods for soil vapor samples to be used during the field pilot tests. For field analysis, soil vapor samples will be analyzed for total hydrocarbons, oxygen, carbon dioxide, and helium. Soil gas samples will be analyzed for concentrations of total hydrocarbons using a Foxboro organic vapor analyzer (OVA) Model 108 or TVA1000 equipped with an FID or equivalent. Samples will be analyzed for oxygen and carbon dioxide using a LandTec GA-90 or equivalent. Samples will be analyzed for helium using a Mark Model 9822 helium detector or equivalent.

In some cases, because of low oxygen levels in the soil gas, it will be necessary to dilute soil gas samples with ambient air to provide sufficient oxygen levels for analysis using a FID. The following sampling and analysis procedure should be used for diluted samples:

(1) Flush out a 1-liter Tedlar bag and a 500-milliliter (mL) syringe by repeatedly filling and emptying each with ambient air.

(2) After flushing, fill the syringe with 500 mL of ambient air.

(3) Attach the syringe to a 1-liter Tedlar bag and inject the air into the bag.

(4) Close the bag before detaching the syringe.

(5) Attach the syringe to the wellhead sample port with a section of high-density polyethylene (HDPE) tubing.

(6) Open the sample port and extract 500 mL of soil gas from the well.

(7) Close the sample port and the valve at the end of the syringe.

(8) Inject the soil gas into the Tedlar bag and close the Tedlar bag.

(9) Attach the FID to the Tedlar bag and immediately open the Tedlar bag.

(10) Measure soil gas and record the maximum reading. This diluted concentration must be multiplied by 2 to represent the actual concentration of total hydrocarbons in soil gas in the well. If additional dilution is required, this procedure should be repeated using the appropriate volumes of soil vapor and ambient air to achieve the desired dilution.

Soil vapor samples will be analyzed in the laboratory for total TPH and VOCs (including BTEX compounds). Samples will be analyzed for TPH using National Institute for Occupational Safety and Health (NIOSH) Method 1550. Samples will be analyzed for VOCs using EPA Method TO-17. Table 2-1 in Appendix 2 of the accompanying QAPP presents the sample methods, containers, preservation, and holding times for all chemicals of interest during this investigation.

## 4.7 LAND SURVEYING

After soil sampling and well installation are complete, all locations for soil borings, surface soil samples, and new monitoring wells will be surveyed for horizontal and vertical position. A State of California-licensed professional land surveyor will survey the site. All surveying will be referenced to the state plane coordinate system and will be recorded in feet along the y-axis (northing) and the x-axis (easting). To maintain consistency, all surveying will use established control points and benchmarks already at the base. Coordinates of surveyed locations will be recorded to an accuracy of 0.10 foot horizontally and 0.01 foot for elevations. For locations where a monitoring well has been installed, horizontal coordinates will be established to the center of the well casing, and an elevation will be established at the ground surface and to the top of the PVC well casing. Elevations established on the PVC well casing will be recorded to an accuracy of 0.01 foot. Vertical coordinates will be referenced to mean sea level.

## 4.8 EQUIPMENT DECONTAMINATION

This section describes decontamination procedures required for personnel and all drilling, sampling, and monitoring equipment used during field activities. Drilling equipment includes the back end of the drill rig, auger flights, drill rod, auger bits, well casing and screens (if not prepackaged), and development equipment, including bailers. Sampling equipment includes split spoons, stainless steel spoons, hand augers, brass sleeves, bailers, shovels, and hand trowels. Personnel will decontaminate before they leave the site. A steam cleaner will be used to decontaminate major drilling equipment such as augers or drill rods. Liquinox or Alconox cleaning solutions and deionized water rinses will be used for all

sampling equipment and accessory drilling equipment or tools. Because high-molecular weight fuel products are present, hexane will be used to decontaminate sampling equipment, followed by additional Alconox rinses and a final rinse with deionized water. Equipment blanks will be obtained to assess the adequacy of decontamination. Collection of equipment blanks is further discussed in Section 5.0. Decontamination procedures for specific equipment used in association with field activities are described in the remainder of this section.

### 4.8.1 Drilling Equipment

Drilling equipment will be decontaminated (steam-cleaned) before operations begin and between boring locations. Drilling equipment may be decontaminated at a designated centralized area at Site 3, or at a self-contained decontamination skid located near the drill rig (including steam cleaners and collection troughs that will collect rinse water and soil). The drilling subcontractor will provide steam cleaners for decontamination. The facility's high-pressure water system for fire hydrants will be used as source water. Drilling augers, bits, drill pipes, bailers, and other downhole equipment will be decontaminated before it is used at each soil boring.

Equipment will be decontaminated with a high-pressure steam spray. If equipment still contains soil after spraying, a wire or bristle brush will be used to loosen the residual soil and the equipment will again be rinsed with a steam spray. All rinse water will be contained temporarily on location and subsequently transported to the facility's operating wastewater treatment plant.

### 4.8.2 Sampling Equipment

All equipment that will come into direct contact with samples will be decontaminated before and after use. Sampling equipment includes Teflon bailers for groundwater samples, hand trowels, steel split spoons, brass sleeves, and buckets for soil samples. Laboratory-supplied sample containers are provided precleaned and will not require decontamination. Where oily or sludge samples are encountered, an initial steam cleaning may be necessary, followed by a rinse with hexane solvent, a thorough rinse in an Alconox solution, and final rinses with deionized water. The following procedures will be used to decontaminate sampling equipment:

(1) Scrub the sampling equipment in a bucket using a stiff brush and Liquinox or Alconox solution with potable water. Rinse with potable water, followed by a double rinse with distilled water.

(2) Rinse with hexane solvent, followed by rinse with deionized water, and allow to air dry.

Split spoons, utensils (spoons), or other sampling equipment will be stored inside clean plastic bags until further use. When they are not in use, sampling equipment is to be stored in a clean area, free of potential contamination. Wash and rinsate solutions will be containerized for proper disposal.

### 4.8.3 Personnel and Protective Equipment

Personnel working in the field are required to follow specific procedures for decontamination before they leave the site to ensure that contamination is not spread off site. Personnel decontamination procedures are listed below for Level-D or Level-C protective clothing and equipment only, and follow requirements described in the base-wide HASP (TtEMI 2000). Personnel decontamination procedures are as follows:

(1) Wash boots (or overboots) with Liquinox or Alconox solution and rinse with clean water. Remove overboots and retain for subsequent use. Disposable booties should be containerized in plastic bags for disposal.

(2) Wash outer gloves in Liquinox or Alconox solution and rinse in clean water. Remove outer gloves and place into plastic bag for disposal.

(3) Remove Tyvek suits and disposable booties. Containerize Tyvek and booties in plastic bag for disposal.

(4) Remove air-purifying respirator (APR), if used, and place the spent filters into a plastic bag for disposal. Filters should be changed daily, or sooner depending on use and application. Place respirator into a separate plastic bag after it has been cleaned and disinfected with towelettes or a nonphosphate cleaning solution.

(5) Remove disposable gloves and place them in a plastic bag for disposal.

(6) Thoroughly wash hands and face with clean water and soap.

## 4.9 WASTE MANAGEMENT

Water and soil waste will be generated as a result of the tasks included in this work plan. Clean soil generated as a result of drilling will be either spread out on the ground at Site 3 or backfilled into the soil borings. Contaminated soil generated as a result of drilling will be stored in drums or bins on site. Composite samples will be collected from each bin or from the drums and analyzed for TPH, BTEX, VOCs, SVOCs, and metals. Off-site disposal will depend on the analytical results for the samples. Soil will be disposed of at an off-site landfill as hazardous or nonhazardous, depending on the analytical results for samples.

Water generated during well development and equipment decontamination will be stored on site temporarily in drums or a Baker tank and subsequently transferred to the facility groundwater treatment

system. It is estimated that approximately 500 gallons of water will be generated as a result of monitoring well development and purging.

Personal protective equipment (PPE) and miscellaneous waste from sampling (paper towels, aluminum foil, and plastic sheeting) will be placed in large garbage bags; the bags will be sealed and placed in facility trash receptacles for disposal.

## 5.0 FIELD QUALITY ASSURANCE AND QUALITY CONTROL SAMPLES

QC samples consist of field duplicate samples, matrix spike and matrix spike duplicate (MS/MSD) samples, and field QC samples. Field duplicates, equipment rinsate samples, MS/MSD, field blanks, and source water blanks will be collected during this investigation according to the procedures presented in Section B6 in the accompanying QAPP.

## 6.0 SAMPLE DESIGNATION, HANDLING, SHIPMENT, AND CHAIN OF CUSTODY

This section describes sample designation, labeling, and handling procedures. Section 6.1 presents procedures for sample designation and labeling. Section B4 of the accompanying QAPP describes sample handling procedures, sample containers and preservation, and sample documentation. Documentation and records, including field forms and logbooks, are discussed in Section A4.4 of the accompanying QAPP, and blank field forms are presented in Appendix 1 of the QAPP.

### 6.1 SAMPLE DESIGNATION AND LABELING

The following sections present the sample designation and labeling approach for samples collected as part of this work plan.

#### 6.1.1 Sample Designation

A sample-numbering scheme has been developed that is compatible with a computerized database developed for NFD Point Molate. The numbering scheme allows each sample to be uniquely identified, and provides a means of tracking the sample from collection through analysis. The numbering scheme indicates the sampling activity, sample location, and sample depth (or interval depth) for soil samples, or water table depth for groundwater samples. The unique sample number will be entered on sample labels, field tracking sheets, chain-of-custody forms, and other records that document sampling activities. The template for the numbering scheme is shown and described below.

**Sample Numbering Template**

```
AABBBBBB – BBB-99
^      ^      ^  ^
|      |      |  |
|      |      |  |
|      |      |  |
1      2      3  4
```

A - Alphabetic character only
B - Either alphabetic or numeric character
9 - Numeric character only

**1** - Activity code. The following activity codes will be used for this investigation:

EB - Equipment blank (for QA/QC purposes)
MW - Groundwater sample from a monitoring well
SB - Soil sample from a soil boring or surface soil sample
SG - Soil gas sample
TB - Trip blank (for QA/QC purposes)

Additional activity codes that are not currently planned, but may be used if warranted, include:

AS - Air sample
CH - Bedrock or weathered bedrock sample from a corehole
GS - Miscellaneous grab sample (solid)
GL - Miscellaneous grab sample (liquid)
HP - Hydropunch groundwater sample
PT - Permeability test
SL - Sludge sample
SS - Sediment sample
SW - Surface water sample
TP - Solid or liquid material from an exploratory test pit
TR - Soil sample from an excavated trench
WB - Water sample from a soil boring
WT - Water sample from an excavated trench

**2** - Site code. The site codes for all samples collected at NFD Point Molate will correspond to the specific locations (valve box numbers or tank numbers) that are near or adjacent to the sample location. Specifically, a sample collected at a valve box or at a tank will use that valve box or tank number prefixed by "VB" (valve box) or "T" (tank), for example, VB23 or T19. For Site 3 samples, the site code is "11."

**3** - Specific location code. The specific location codes will correspond to the soil boring, monitoring well, excavated trench, or other specific location designations. Single-digit locations, for example test well 1 will be encoded "001." Similarly, for soil samples obtained from the 101st soil boring, samples will be designated "SB11-101."

4 - Specific sequential sample number. The specific sequential sample number is intended to differentiate between multiple samples collected from a specific sample location. For example, if 3 soil samples are collected from boring SB11-101 for laboratory analysis, the third sample collected for laboratory analysis will be designated "SB11-101-03."

Complete sample numbers will appear on labels, sample tracking forms, chain-of-custody forms, and any other sampling documents. All characters including dashes, parentheses, and decimal points must be included. Sample depths (for subsurface soil samples) will be recorded in sampling logbooks and on sample tracking forms.

QA/QC samples will be submitted for analysis as blind samples, or without indications designating these samples as duplicates or blanks. To designate blind duplicate samples, artificial boring numbers will be assigned to the original sample designation. These duplicate designations will be recorded for internal use in the field book or field tracking forms.

Additional QA/QC samples, such as equipment blanks (labeled as "EB") or trip blanks (labeled as "TB") will not be submitted blind. Site-specific designators may be used, based on the area from which the equipment blank was collected or the sample shipment the trip blank accompanies, and this information will be tracked in the field logbook or sample tracking form.

An MS/MSD will also be submitted for each sample matrix to be analyzed. This sample is not submitted to the laboratory as a blind sample. Moreover, groundwater samples require triplicate volumes for each analyte. The sample designation for the MS/MSD groundwater samples is identical to the normal sample; however, one suite of the triplicate volume will be labeled as "MS," and the other volume as "MSD" along with the sample number. Soil samples selected for MS/MSD analysis will be designated in a similar manner. The additional volume for MS/MSD analyses will be noted on the sample chain of custody.

### 6.1.2 Sample Labels

A sample label will be affixed to each sample container as samples are obtained and containerized. The label will indicate (in indelible ink) the following information:

- Project name and site number
- Sample designation

- Sample depth (it should be in the sample designation)
- Time and date of sample collection
- Analysis required (as shown below)
- Name or initials and company of the sampler
- Preservatives used
- Type of sample (grab or composite)

Clear plastic tape will be placed over the label once it is completed to protect it from damage and from sliding off after ice is packaged around the sample. PID readings or indications of gross contamination of the samples will be recorded on a separate field form and may also be included on the sample label if space permits. An abbreviated version of the analysis required will be written on the sample label, as follows:

Volatile organics analysis = VOA

Polynuclear aromatic hydrocarbons = PAH

Semivolatile organic analysis = SVOA
(base, neutral, and acid extractables)

Total petroleum hydrocarbons, purgeable and aromatic volatiles = TPHpurge+BTEX

Total petroleum hydrocarbons, extractable = TPHextract

## 6.2 SAMPLE CONTAINERIZATION, PRESERVATION, AND HOLDING TIME

Table 2-1 in Appendix 2 of the accompanying QAPP presents the sample containers, preservation, analytical method, and holding time for each chemical analysis.

## 6.3 DOCUMENTATION

Sample field tracking forms will be used to document the sample collection process and other pertinent information on sample location, sampling times, and conditions. The field tracking form will be completed as samples are obtained. The sample field tracking form will be used to document the sampling site; sample designations; analysis required; sample depths; date and time of sample collection; the name of the sampler; and comments, such as weather conditions, field equipment readings, and where (which monitoring well, soil boring location, or trench location) field equipment blanks were collected. An example of a sample field tracking form is shown as Figure 6-1. Additional documentation and

records, including field forms and bound logbooks, are discussed in Section A4.4 of the accompanying QAPP. Blank field forms are presented in Appendix 1 of the accompanying QAPP.

## 7.0 HEALTH AND SAFETY

The base-wide HASP (TtEMI 2000) has been revised to include all activities associated with tasks associated with this FSP. The base-wide HASP contains information about the physical, biological, and chemical hazards associated with the various field activities to be conducted during this investigation. A site-specific discussion of the HASP is included as Section 7.0 of the accompanying work plan.

## 8.0 SCHEDULE

The schedule for sampling and field pilot test tasks at Site 3 is provided as Figure 12-1 in the work plan to which this FSP is attached. The schedule relies on a number of assumptions that, when fully defined, may result in changes or updates. Critical assumptions include document review times and the execution time frame of other projects at NFD Point Molate.

## 9.0 REFERENCES

Tetra Tech EM Inc. (TtEMI) 2000. Base-wide Health and Safety Plan, Naval Fuel Depot Point Molate, California. October 13.

U.S. Environmental Protection Agency (EPA). 1998. EPA Guidance for Quality Assurance Project Plans. EPA QA/G-5. EPA/600/R-98/018.

EPA. 2000. Guidance for the Data Quality Objectives Process. EPA QA/G-4. Final. August.

**FIGURES**

FIGURE 4-1

**Tetra Tech EM Inc.**

BOREHOLE LOG
SHEET ____ OF ____

| LOCATION OF BOREHOLE | JOB NO.: | BOREHOLE ID: |
|---|---|---|
| | CLIENT: | DEPTH TO WATER: |
| | SITE: | LOGGED BY: |
| | SUBSITE: | DRILLING DATE(S): |
| | DRILLING CO.: | DRILLING METHOD: |
| | PERSONNEL: | SAMPLING METHOD: |

| SAMPLE INTERVAL | | | BLOWS/ 6 IN. SAMPLE | TIME | PID READING | LABORATORY ANALYSIS | DEPTH IN FEET | USCS SOIL TYPE | SOIL DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|
| TOP | BOTTOM | RECOVERED | | | | | | | |
| | | | | | | | 1 | | |
| | | | | | | | 2 | | |
| | | | | | | | 3 | | |
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| | | | | | | | 5 | | |
| | | | | | | | 6 | | |
| | | | | | | | 7 | | |
| | | | | | | | 8 | | |
| | | | | | | | 9 | | |
| | | | | | | | 0 | | |

S:\Geosciences Disciplines\Field Forms\CAD Files\ BOREHOLE LOG FORM.dwg 02/23/2000 FORDD DN

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FIGURE 4-2

TETRATECH EM INC

# MONITORING WELL COMPLETION RECORD

## MONITORING WELL

MONITORING WELL NO.: _____
PROJECT: _____
SITE: _____
BOREHOLE NO.: _____
WELL PERMIT NO.: _____
TOC TO BOTTOM OF WELL: _____

## DRILLING INFORMATION

DRILLING BEGAN:
DATE: _____ TIME: _____
WELL INSTALLATION BEGAN:
DATE: _____ TIME: _____
WELL INSTALLATION FINISHED:
DATE: _____ TIME: _____
DRILLING CO.: _____
DRILLER: _____
LICENSE: _____
DRILL RIG: _____
DRILLING METHOD:
- ☐ HOLLOW STEM AUGER
- ☐ AIR ROTARY
- ☐ OTHER: _____

DIAMETER OF AUGERS:
ID: _____ OD: _____

## WELL CASING

☐ SCHEDULE 40 PVC
☐ OTHER: _____
PRODUCT: _____
MFG. BY: _____
CASING DIAMETER:
ID: _____ OD: _____
LENGTH OF CASING: _____

## WELL SCREEN

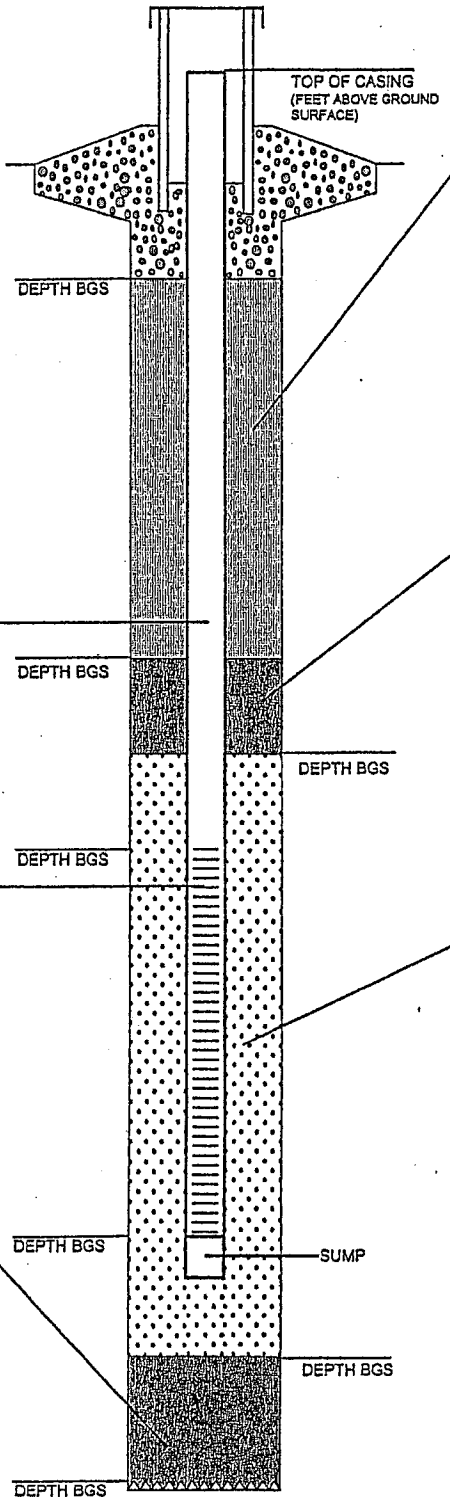
☐ SCHEDULE 40 PVC
☐ OTHER: _____
PRODUCT: _____
MFG. BY: _____
CASING DIAMETER:
ID: _____ OD: _____
SLOT SIZE: _____
LENGTH OF SCREEN: _____

## BOREHOLE BACKFILL

AMOUNT CALCULATED: _____
AMOUNT USED: _____
☐ BENTONITE CHIPS, SIZE: _____
☐ BENTONITE PELLETS, SIZE: _____
☐ SLURRY: _____
☐ FORMATION COLLAPSE: _____
☐ OTHER: _____
PRODUCT: _____
MFG. BY: _____
METHOD INSTALLED:
☐ POURED ☐ TREMIE
☐ OTHER: _____

## SURFACE COMPLETION

☐ FLUSH MOUNT
☐ ABOVE GROUND WITH BUMPER POST
☐ CONCRETE ☐ ASPHALT

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## SURVEY INFORMATION

TOC ELEVATION: _____
GROUND SURFACE ELEVATION: _____
NORTHING: _____
EASTING: _____
DATE SURVEYED: _____
SURVEY CO.: _____

## ANNULAR SEAL

VOLUME CALCULATED: _____
AMOUNT USED: _____
☐ GROUT FORMULA (PERCENTAGES)
PORTLAND CEMENT: _____
BENTONITE: _____
WATER: _____
☐ PREPARED MIX
PRODUCT: _____
MFG. BY: _____
METHOD INSTALLED:
☐ POURED ☐ TREMIE
☐ OTHER: _____

## BENTONITE SEAL

VOLUME CALCULATED: _____
AMOUNT USED: _____
☐ PELLETS, SIZE: _____
☐ CHIPS, SIZE: _____
☐ OTHER: _____
PRODUCT: _____
MFG. BY: _____
METHOD INSTALLED:
☐ POURED ☐ TREMIE
☐ OTHER: _____
AMOUNT OF WATER USED: _____

## FILTER PACK

☐ PREPACKED FILTER
VOLUME CALCULATED: _____
AMOUNT USED: _____
☐ SAND, SIZE: _____
PRODUCT: _____
MFG. BY: _____
METHOD INSTALLED:
☐ POURED ☐ TREMIE
☐ OTHER: _____
WATER LEVEL: _____
(BTOC AFTER WELL INSTALLATION)

## CENTRALIZERS USED?

☐ YES ☐ NO;
CENTRALIZER DEPTHS: _____ _____

### LEGEND

BGS = BELOW GROUND SURFACE
BTOC = BELOW TOP OF CASING
N/A = NOT APPLICABLE
NR = NOT RECORDED
TOC = TOP OF CASING

FIGURE 4-3

Tetra Tech EM Inc.

Sheet ___ of ___

# WELL DEVELOPMENT DATA SHEET

**BORING NO.** _____ **WELL NO.** _____

Project _____
Project No. _____
Date(s) of Installation _____
Date(s) of Development _____
Personnel/Company _____
_____
Type of Rig Used _____

Casing Diameter/Type _____
Borehole Diameter _____
Screened Interval(s) _____
Total Length of Well Casing _____
Measured Total Depth (TOC) Initial _____
Final _____
Initial Depth to Water
(TOC) _____ Date _____ Time _____
Stabilized Depth to Water
(TOC) _____ Date _____ Time _____

DEVELOPMENT

| TECHNIQUE(S) | EQUIPMENT TYPE/CAPACITY |
|---|---|
| ____ Jetting (Airlift) | _____ |
| ____ Surge Block | _____ |
| ____ Bailing | _____ |
| ____ Pumping | _____ |
| ____ Other | _____ |

FLUIDS ADDED

Lost Drilling Fluid: _____ Gallons
Lost Purge Water: _____ Gallons
Water During Installation: _____ Gallons
Total Fluids Added: _____ Gallons
Source of Added Water: _____
Ground Water Quality Parameters of
Added Water Measured: Y N
Sample Collected of Added Water: Y N
Sample Designation of Added Water: _____

PURGE VOLUME CALCULATION

Casing Volume: _____ Ft. of water
x _____ Gallons/Foot
= _____ Gallons per Single Casing Volume
Sand Pack Volume: _____ Ft. of Saturated Sand Pack
x _____ Gallons/Foot (borehole diameter)
= _____ Gallons (in borehole)
- _____ Gallons of Casing Volume
= _____ x 0.3 (Assuming porosity = 30%)
= _____ Gallons Within Sand Pack
Single Purge Volume: _____ Gallons (Casing Vol. + Sand Pack Vol. + Fluids Added)
Minimum Purge Volume: _____ Gallons
Actual Purge Volume: _____ Gallons
Volume Measured by: _____
Rate of Development _____ Gallons/Minute (Hour,Day)
Pumping Rate/Depth _____ @ _____ Ft. (Below Grd.)
Immiscible Phases Present: Y N Thickness _____

INSTRUMENT CALIBRATION

pH Meter: _____ Spec. Conductance Meter: _____
pH 4.0 = _____ @ _____ °C Standard _____ µmhos/cm@ 25°C
pH 7.0 = _____ @ _____ °C Reading _____ µmhos/cm @ _____ °C
pH 10.0 = _____ @ _____ °C Turbidity Meter: _____
Dissolved Oxygen Meter: _____ Other: _____

| Total Volume Discharged | Rate of Discharge | Time | Temp | pH | Specific* Conductance | Turbidity or D.O. | Clarity, Odor, PID Readings, Other: |
|---|---|---|---|---|---|---|---|
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Development Completed at _____ Gallons Discharged. Date: _____ Time: _____
Criteria: _____ Personnel: _____

* Specific Conductance readings temperature compensated to 25°C, if not, report temperatures at which reading obtained.

FIGURE 4-4

Tetra Tech EM Inc.

# GROUND WATER SAMPLING

PAGE ___ OF ___

WELL NAME _____

DATE _____

PROJECT _____ STATION ELEVATION _____ GND ___ TOC ___ IMMISCIBLE PHASES PRESENT YES ___ NO ___

PROJECT No. _____ STATIC WATER LEVEL(from TOC) _____ TYPE _____

WELL LOCATION _____ WELL STICK UP _____ MEASURED WITH _____

SAMPLE DATE _____ STATIC ELEVATION _____ PID READINGS (backgrnd) _____

SAMPLING PERSONNEL _____ WELL DEPTH _____ MEAS ___ RPTD ___ PID READINGS (TOC) _____

_____ FEET OF WATER _____ WELL INSTALLED BY _____

SAMPLE ID _____ GALLONS/FOOT _____ INSTALLATION DATE _____

DUPLICATE ID _____ CASING VOLUME _____ DEVELOPMENT DATE(S) _____

FIELD CHEMISTRY CALIBRATIONS

DATE/TIME _____ SPEC. CONDUCTANCE: STANDARD _____ UMHOS/CM AT 25C READING _____ UMHOS/CM AT ___ C

pH: pH 4.00 = _____ AT _____ C pH 7.00 = _____ AT _____ C pH 10.00 = _____ AT _____ C SLOPE _____

DISSOLVED OXYGEN: D.O. METER _____ MG/L AT ___ C PID: CALIBRATION GAS _____ PPM _____ SPAN _____ READING _____

| | TIME | DISCHARGE RATE (GPM) | DISSOLVED OXYGEN (MG/L) | pH | Eh/ORP | TEMP (C) | SPECIFIC CONDUCT. (UMHOS/CM AT C) | TURBID. (NTU) | CUMULATIVE VOL. OF WATER REMOVED (PURGED) GALLONS | CASING VOLS. | PID/OVA READING LOCATION | VALUE | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PUMP | | | | | | | | | | | | | |
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| BAILER | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

PUMPED PARAMETERS STABLE (Y/N) ___ PUMPED=BAILED PARAMETERS (Y/N) ___ CONDITION OF WELL: _____

REMARKS _____

FIELD EQUIPMENT

pH METER _____ SERIAL NUMBER _____

SPEC. COND. METER _____ SERIAL NUMBER _____

PUMP _____ SERIAL NUMBER _____

BAILER _____ SIZE _____

WATER LEVEL METER _____ SERIAL NUMBER _____

D. O. METER _____ SERIAL NUMBER _____

FILTER APPARATUS _____ FILTERS _____

TEMPERATURE MEASURE _____

INTERFACE PROBE _____ SERIAL NUMBER _____

PID/OVA _____ SERIAL NUMBER _____

FIELD CHEMISTRY CALIBRATIONS

FRACTIONS _____

NUMBER OF BOTTLES _____

SAMPLE DEPTH _____

FIELD NOTEBOOK _____

SAMPLE METHOD _____

DISCHARGE WATER CONTAINERIZED

YES _____ NO _____

I:\FORMS\GW SHEETS\GW SAMP2.FRP

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FIGURE 6-1
FIELD TRACKING FORM

PAGE ___ OF ___

INSTALLATION: NFD Point Molate

PROJECT NAME Site 3 Sampling and Field Pilot Testing

DATE _____

PROJECT NO: G0069-379 C0101

| Date/Time | Sampling Site | Sample ID (depth) | ANALYSES | | | | | | | | | | | Date Submitted | Lab Name | Comments (where EB collected, obvious fuel, etc.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TPH-P | TPH-E | VOC | PAHs | Fe(II) | $oPO_4$ | $NO_3$ | $SO_4$ | TKN | TOC | | | | |
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Notes: [1] For metals analyses, indicate Total or Dissolved with "T" or "D"

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s:\project\ptmolate\379\fwp\fsp\fieldtracking/10/9/00

**TABLES**

TABLE 4-1

NAVAL FUEL DEPOT POINT MOLATE, RICHMOND, CALIFORNIA
FIELD SAMPLING PLAN FOR SITE 3
SOIL SAMPLING SUMMARY

| Boring Location | Estimated Number of Laboratory Samples | Number of Samples Based on Objectives[1] | | | | | Approximate Sample Depth for ep Samples[2] (feet bgs) | Laboratory Analyses[3] | | | | | | Area for which data will be used to characterize contaminant distribution |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SS | 5-10 | ep | TD | QC | | TPH | BTEX | PAHs[4] | VOCs[6] | Metals | HPC | |
| SB11-99 | 2 | 1 | 1 | 0 | 0 | - | - | 2 | | 2 | 2 | 2 | | former FRF |
| SB11-100 | 2 | 1 | 1 | 0 | 0 | - | - | 2 | | 2 | 2 | 2 | | former FRF |
| SB11-101 | 2 | 1 | 1 | 0 | 0 | - | - | 2 | | 2 | 2 | 2 | | former FRF |
| SB11-102 | 2 | 1 | 1 | 0 | 0 | - | - | 2 | | 2 | 2 | 2 | | former FRF |
| SB11-103 | 4 | 1 | 1 | 2 | 0 | - | 16, 19 | 4 | 4 | 2 | | | 1 | Treatment Ponds Area/Shoreline |
| SB11-104 | 2 | 1 | 1 | 0 | 0 | - | - | 2 | | 2 | 2 | | | Treatment Ponds Area/Shoreline |
| SB11-105 | 4 | 1 | 1 | 2 | 0 | - | 17, 19 | 4 | 2 | 2 | 2 | | | Treatment Ponds Area/Shoreline |
| SB11-106 | 2 | 1 | 1 | 0 | 0 | - | - | 2 | 2 | 2 | | | | Treatment Ponds Area/Shoreline |
| SB11-107 | 4 | 1 | 1 | 2 | 0 | - | 13, 16 | 4 | 4 | 2 | | | 1 | Treatment Ponds Area/Shoreline |
| SB11-108 | 2 | 1 | 1 | 0 | 0 | - | - | 2 | 2 | 2 | | | | Treatment Ponds Area |
| SB11-109 | 2 | 1 | 1 | 0 | 0 | - | - | 2 | 2 | 2 | | | 1 | Treatment Ponds Area |
| SB11-110 | 2 | 1 | 1 | 0 | 0 | - | - | 2 | 2 | 2 | | | | Treatment Ponds Area |
| SB11-111 | 2 | 1 | 1 | 0 | 0 | - | - | 2 | 2 | 2 | | | | Treatment Ponds Area |
| SB11-112 | 2 | 1 | 1 | 0 | 0 | - | - | 2 | 2 | 2 | | | 1 | Treatment Ponds Area |
| SB11-113 | 3 | 1 | 1 | 0 | 1 | - | - | 3 | | 2 | 3 | | | Treatment Ponds Area/former Sump Pond |
| SB11-114 | 2 | 1 | 1 | 0 | 0 | - | - | 2 | | 2 | 2 | | 1 | Treatment Ponds Area |
| SB11-115 | 5 | 1 | 1 | 2 | 1 | - | 14, 16 | 4 | 2 | 2 | 3 | | | Treatment Ponds Area/former Sump Pond |
| SB11-116 | 2 | 1 | 1 | 0 | 0 | - | - | 2 | 2 | 2 | | | | Treatment Ponds Area/Bldg 6 |
| SB11-117 | 4 | 1 | 1 | 2 | 0 | - | 11, 13 | 4 | 4 | 2 | 2 | | | Treatment Ponds Area/Former Tank F |
| SB11-118 | 2 | 1 | 1 | 0 | 0 | - | - | 2 | 2 | 2 | | | | Treatment Ponds Area/Shoreline |
| SB11-119 | 2 | 1 | 1 | 0 | 0 | - | - | 2 | 2 | 2 | | | | Treatment Ponds Area/Diesel Rd |
| SB11-120 | 3 | 1 | 1 | 0 | 1 | - | - | 3 | | 2 | 3 | | | Treatment Ponds Area/former Sump Pond |
| SB11-121 | 3 | 1 | 1 | 0 | 1 | - | - | 3 | | 3 | 3 | | | Treatment Ponds Area/Former Tank G |
| **Field Pilot Test Wells[5]** | | | | | | | | | | | | | | |
| SW-01 | 0 | 0 | 0 | 0 | 0 | - | - | | | | | | | No lab samples collected |
| MP-01 | 0 | 0 | 0 | 0 | 0 | - | - | | | | | | | No lab samples collected |
| MP-02 | 0 | 0 | 0 | 0 | 0 | - | - | | | | | | | No lab samples collected |
| MP-03 | 0 | 0 | 0 | 0 | 0 | - | - | | | | | | | No lab samples collected |
| | | | | | | | | | | | | | | |
| **Quality Control/Quality Assurance Samples** | | | | | | | | | | | | | | |
| MS/MSD | - | - | - | - | - | 3 | - | 3 | 2 | 3 | 2 | 1 | - | Assumes 1 for every 20 samples |
| Equip. Rinsate | - | - | - | - | - | 3 | - | 3 | 2 | 3 | 2 | 1 | - | Assumes 1 for every 20 samples |
| Trip Blank | - | - | - | - | - | 4 | - | 4 | 4 | - | 4 | - | - | Assumes 1 for each cooler |
| Total | 60 | 23 | 23 | 10 | 4 | 10 | - | 69 | 42 | 53 | 36 | 10 | 5 | - |

## TABLE 4-1

## NAVAL FUEL DEPOT POINT MOLATE, RICHMOND, CALIFORNIA
## FIELD SAMPLING PLAN FOR SITE 3
## SOIL SAMPLING SUMMARY

Notes:

[1] Sampling Objectives:

| | |
|---|---|
| SS | Composite surface sample for comparison to terrestrial ecological action levels (composite from 0-3 feet bgs) |
| 5-10 | Composite sample collected between 5 to 10 feet bgs |
| ep | Two soil samples collected from within the planned screen interval of the monitoring well to be installed within the soil boring; results to be used to evaluate empirical equilibrium partitioning. |
| QC | Quality control/quality assurance samples |
| TD | Sample collected at total depth (bottom) of boring; specifically near or at the top of the Bay Mud |

[2] Actual sample depth will be depend on actual observed interval of hydrocarbon-saturated soils and the screened interval in the monitoring well.

[3] Laboratory analyses include:

| | |
|---|---|
| TPH | Total petroleum hydrocarbon as gasoline, diesel, residual (bunker fuel); analysis conducted on all SS, 5-10, and ep samples |
| BTEX | Benzene, toluene, ethylbenzene, and xylenes; analysis conducted on all SS, 5-10, and ep samples except where VOCs are being analyzed |
| PAHs | Polynuclear aromatic hydrocarbons; analysis conducted on all SS and 5-10 samples |
| HPC | Total heterotrophic plate counts; analysis conducted on selected 5-10 or ep samples |
| VOCs | Volatile ogranic compounds; analysis conducted on samples from selected borings - analysis of SS, 5-10, and TD samples |

[4] PAH analyses only to be conducted on samples collected from 0 to 10 feet bgs ("SS" and "5-10" samples).

[5] Borings are associated with AS/SVE/MPE testing in the vicinity of MW11-54; see Appendix C, Figure C-1.

[6] Samples collected for VOC analysis from the "SS" and "5-10" sample locations for selected borings; for the former sump pond area borings also collect VOC samples from "TD" sample locations

bgs Below ground surface

MS/MSD Matrix spike/matrix spike duplicate

FRF Fuel Reclamation Facility

TABLE 4-2

NAVAL FUEL DEPOT POINT MOLATE, RICHMOND, CALIFORNIA
WORKING DRAFT FIELD SAMPLING PLAN FOR SITE 3
GROUNDWATER SAMPLING SUMMARY

| Boring Location | Number of Laboratory Samples | Approximate Screen Interval[1] (feet bgs) | Laboratory Analyses[2] | | | | | | | | Area for which data will be used to characterize contaminant distribution |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TPH | BTEX | VOCs | Total HPC | TKN | Fe(II) | Anions | Metals | |
| NEW WELLS | | | | | | | | | | | |
| MW11-100 | 1 | 10 - 17 | 1 | | 1 | | | | | 1 | former FRF |
| MW11-102 | 1 | 10 - 20 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | former FRF |
| MW11-103 | 1 | 9 - 22 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |
| MW11-104 | 1 | 9 - 21 | 1 | | 1 | | | | | | Treatment Ponds Area/Shoreline |
| MW11-105 | 1 | 10 - 22 | 1 | | 1 | | | | | | Treatment Ponds Area/Shoreline |
| MW11-106 | 1 | TBD | 1 | | 1 | | | | | | Treatment Ponds Area/Shoreline |
| MW11-107 | 1 | 12 - 20 | 1 | 1 | | 1 | 1 | 1 | 1 | | Treatment Ponds Area/Shoreline |
| MW11-109 | 1 | 4 - 19 | 1 | 1 | | 1 | 1 | 1 | 1 | | Treatment Ponds Area/former GWTP |
| MW11-113 | 1 | TBD | 1 | | 1 | | | | | | Treatment Ponds Area |
| MW11-115 [D] | 1 | 7 - 17 | 1 | | 1 | 1 | 1 | 1 | 1 | | Treatment Ponds Area |
| MW11-117 | 1 | 3 - 16 | 1 | | 1 | | | | | | Treatment Ponds Area/Tank F |
| MW11-118 | 1 | 10-20 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |
| MW11-119 | 1 | 6-16 | 1 | 1 | | | | | | | Treatment Ponds Area/Diesel Rd |
| MW11-121 | 1 | 6-16 | 1 | | 1 | | | | | | Treatment Ponds Area/Former Tank G |
| EXISTING WELLS | | | | | | | | | | | |
| MW11-09 | 1 | 10 - 20.1 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |
| MW11-10 | 1 | 10.8 - 20.8 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |
| MW11-12 | 1 | 11.2-21.2 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |
| MW11-13 | 1 | 11.4 - 26.4 | 1 | | 1 | | | | | | Treatment Ponds Area/Shoreline |
| MW11-16 | 1 | 10.0-20.0 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |
| MW11-21 | 1 | 12.1-22.1 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |
| MW11-27R | 1 | 8.4-18.4 | 1 | 1 | | 1 | 1 | 1 | 1 | | Treatment Ponds Area |
| MW11-30 | 1 | 6-16 | 1 | | 1 | | | | | | Treatment Ponds Area |
| MW11-31 | 1 | 7.2 - 17.2 | 1 | | 1 | | | | | | Treatment Ponds Area/Shoreline |
| MW11-33 [D] | 1 | 5 - 15 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |
| MW11-41 | 1 | 4 - 14 | 1 | 1 | | 1 | 1 | 1 | 1 | | Treatment Ponds Area |
| MW11-44 | 1 | 3.8 - 18.8 | 1 | | 1 | 1 | 1 | 1 | 1 | | Treatment Ponds Area |
| MW11-49 | 1 | 1.8 - 6.8 | 1 | 1 | | 1 | 1 | 1 | 1 | | Treatment Ponds Area/Bldg 6 |
| MW11-51 | 1 | 6.8-16.8 | 1 | 1 | | | | | | | Treatment Ponds Area/Bldg 6 |
| MW11-53 | 1 | 7.7 - 17.7 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |

TABLE 4-2

NAVAL FUEL DEPOT POINT MOLATE, RICHMOND, CALIFORNIA
WORKING DRAFT FIELD SAMPLING PLAN FOR SITE 3
GROUNDWATER SAMPLING SUMMARY

| Boring Location | Number of Laboratory Samples | Approximate Screen Interval[1] (feet bgs) | Laboratory Analyses[2] | | | | | | | | Area for which data will be used to characterize contaminant distribution |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TPH | BTEX | VOCs | Total HPC | TKN | Fe(II) | Anions | Metals | |
| MW11-54 | 1 | 8.6-23.5 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |
| MW11-92 [D] | 1 | 8.6 - 18.6 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |
| MW11-94 | 1 | 5-15 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |
| MW13+27 | 1 | 10-20 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |
| MW16+25 | 1 | 9.8 - 20.1 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |
| MW-1 | 1 | 14.4-21.3 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |
| MW-3 | 1 | 1.1-23.4 | 1 | 1 | | | | | | | Treatment Ponds Area/Shoreline |
| **Quality Control/Quality Assurance Samples** | | | | | | | | | | | |
| Duplicates | - | - | 4 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | Assumes 1 for every 10 samples |
| MS/MSD | - | - | 2 | 2 | 1 | - | 1 | 1 | 1 | 1 | Assumes 1 for every 20 samples |
| Equipment Rinsates | - | - | 4 | 3 | 1 | - | 2 | 2 | 2 | 1 | Assumes 1 for every 20 samples |
| Trip Blanks | - | - | 2 | 2 | 1 | - | - | - | - | - | Assumes 1 for each cooler |
| Total | 36 | - | 48 | 33 | 17 | 9 | 12 | 12 | 12 | 5 | - |

Notes:

[1] Actual screen interval of "new wells" will be based on observed interval of hydrocarbon-contaminated soils and the depth to water.

[2] Laboratory analyses include:

| | |
|---|---|
| Anions | Nitrate, orthophosphate, and sulfate |
| BTEX | Benzene, toluene, ethylbenzene, and xylenes |
| Fe(II) | Dissolved ferrous iron |
| TKN | Total Kjeldahl nitrogen |
| HPC | Heterotrophic plate counts |
| TPH | Total petroleum hydrocarbon as gasoline, diesel, residual (bunker fuel) |
| VOCs | Volatile organic compounds |

[3] Samples to be collected from monitoring locations prior to and following field pilot testing in the Bunker Fuel Area.

[D] Collect additional sample from this location for duplicate analysis.

bgs below ground surface

TBD To be determined

FRF Fuel Reclamation Facility

GWTP Groundwater treatment plant

TABLE 4-3

NAVAL FUEL DEPOT POINT MOLATE, RICHMOND, CALIFORNIA
WORKING DRAFT FIELD SAMPLING PLAN FOR SITE 3
SOIL VAPOR SAMPLING SUMMARY

| Sampling Location | Number of Laboratory Samples | Laboratory Analyses[2] | |
|---|---|---|---|
| | | TPH | VOCs |
| **SVE TESTING IN DIESEL AREA** | | | |
| Vapor discharge[1] | 2 | 2 | 2 |
| **AIR SPARGE TESTING IN DIESEL AREA** | | | |
| Vapor discharge[1] | 1 | 1 | 1 |
| | | | |
| Total | 3 | 3 | 3 |

Notes:

[1] Samples to be collected from a vapor discharge sample port only if dilution air is not being used; if vapor stream is diluted sample will be collected from a sample port located in the test system process line prior to the dilution tee.

[2] Laboratory analyses include:

TPH Total petroleum hydrocarbons by NIOSH Method 1550
VOCs Volatile organic compounds by EPA Method TO-17

EPA U.S. Environmental Protection Agency
NIOSH National Institute of Occupational Safety and Health
SVE Soil vapor extraction

**ATTACHMENT A-1**

**DESCRIPTION OF EPA METHOD 5035**
**(SAMPLING USING ENCORE ™ SAMPLERS)**

# *Field Soil Sampling With EnCore™ Sampler for VOC Analysis*

## EnCore™ Sampler

The EnCore™ sampler system is a dedicated system designed to collect, store, and deliver approximately 5 or 35 gm of a soil sample in a zero headspace container. No chemicals for preservation are typically needed in the field. Extrusion and extraction of the whole sample in the core is done in the laboratory. No sub-sampling of the individual container is necessary. The EnCore™ sampling device was accepted in SW-846, 3rd update, and has been tested to deliver reliable data.

The Encore sampler is a single use device. It cannot be cleaned or re-used. It comes in two sizes for samples aliquots of 5 or 25 grams.

There are four components to the EnCore™ system:

1. Cartridge with moveable plunger
2. A cap with 2 locking arms
3. A T-handle to aid in sampling
4. An extrusion handle used in the laboratory

The soil collected by the sampler is stored in a sealed, headspace-free state. Three Viton o-rings achieve the seals; two located on the plunger and one on the cap of the sampler. At no time should these o-rings be removed or disturbed.

## Soil Sampling with EnCore™ Samplers

Before taking the sample:

1. Hold coring body and push plunger rod down until small rod rests against tabs. This will ensure that the plunger moves freely.
2. Depress locking lever on EnCore™ T-handle. Place coring body, plunger end first, into the open end of the T-handle, aligning the two slots on the coring body with the two locking pins in the T-handle. Twist coring body clockwise to lock pins in the slot. Check to ensure sampler is locked in place. Sampler is now ready for use.

Taking the sample:

Turn T-handle with the "T" up and the coring body down. This positions the plunger body flush with the bottom of the coring body. Using the T-handle, push and twist the sampler into the soil until the coring body is completely full. When the EnCore™ sampler is full, the small o-ring on the plunger rod will be centered in the T-handle viewing hole (the upper hole for the 25g sampler and the lower hole for the 5g sampler). Remove the sampler from the soil. Before capping the sampler, wipe excess soil from

the coring body exterior, ridge area, and any soil that may protrude beyond the opening end of the coring body to ensure proper sealing. Cap the coring body while it is still on the T-handle. Continue as above until three samples are collected from the location. If only VOCs are to be analyzed for a given location, another 2oz. Jar of sample is required to allow for moisture content analysis.

(Note: The EnCore™ sampling system cannot be reliably used as stated above to sample sand, loose soil, or sediment since a cohesive plug will not be formed with these materials. Pull the plunger all the way back and lock it. Turn the sampler upside down and scoop the material into the coring body and cap it. Make a note of this method deviation in the field notebook.)

Surface Soil

Apply EnCore™ sampler to a freshly exposed soil surface and collect samples immediately as described above.

Deep Soil

EnCore™ samples must be sub-sampled from one of the open ends of a sleeve core, taken at the desirable depth as soon as it is brought to the surface, using the procedures described above.

Samples should be shipped to the laboratory immediately.

## Sample shipment, preservation, and holding time:

Place the three co-located samples from each location into one zipper bag. Seal the bag and place in a pre-chilled cooler maintained at 4°C and shipped to the laboratory immediately for preservation and analysis.

The recommended holding time between sampling and preservation by the laboratory is 48 hours. The recommended holding time between preservation and analysis is 14 days.

The laboratory will preserve 2 aliquots of sample using sodium bisulfate and one aliquot of sample using methanol. This allows for both low-level and high-level analysis of the sample.

# APPENDIX B

# QUALITY ASSURANCE PROJECT PLAN
# FOR
# SAMPLING AND PILOT TESTING AT SITE 3

# NAVAL FUEL DEPOT POINT MOLATE
# RICHMOND, CALIFORNIA

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN II)
Northern and Central California, Nevada, and Utah
Contract No. N62474-94-D-7609
Contract Task Order No. 379

Prepared for

DEPARTMENT OF THE NAVY
Naval Facilities Engineering Command
Southwest Division
San Diego, California

# FINAL
# QUALITY ASSURANCE PROJECT PLAN
# FOR
# SAMPLING AND FIELD PILOT TESTING AT SITE 3

## NAVAL FUEL DEPOT POINT MOLATE
## RICHMOND, CALIFORNIA

DS.0379.15002

May 14, 2001

Prepared by

TETRA TECH EM INC.
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(415) 543-4880

Brian Schuller, Project Manager

**SITE 3**
**FIELD PILOT TEST WORK PLAN**

**FINAL QUALITY ASSURANCE PROJECT PLAN**

**NAVAL FUEL DEPOT, POINT MOLATE**
**RICHMOND, CALIFORNIA**

**Prepared for:**

**DEPARTMENT OF THE NAVY**

**REVIEW AND APPROVALS**

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DS.0379.15002

N30519_000286
NFD POINT MOLATE
SSIC NO. 5090.3

# FINAL
# ADDENDUM 01 TO THE FINAL QUALITY ASSURANCE PROJECT PLAN INSTALLATION RESTORATION SITE 3

DATED 11 JULY 2007

THIS RECORD IS ENTERED IN THE DATABASE AND FILED AS

RECORD NO. N30519_000494

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3 PRECISION AND ACCURACY GOALS
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## FIGURES

**Figure**

A-1 PROJECT ORGANIZATION CHART
C-1 QA AUDIT FLOW CHART

## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AA | Atomic absorption |
| bgs | Below ground surface |
| BRAC | Base Realignment and Closure |
| BTEX | Benzene, toluene, ethylbenzene, and xylenes |
| °C | Degrees Celsius |
| CFR | Code of Federal Regulations |
| CLEAN II | Comprehensive Long-term Environmental Action Navy |
| CLP | Contract Laboratory Program |
| COC | Chemicals of concern |
| CPR | Cardiopulmonary resuscitation |
| CTO | Contract task order |
| DO | Dissolved oxygen |
| DQO | Data quality objective |
| EDD | Electronic data deliverable |
| EE/CA | Engineering evaluation and cost analysis |
| EPA | U.S. Environmental Protection Agency |
| Fe II | Ferrous iron |
| FID | Flame ionization detector |
| FPT | Field pilot testing |
| FPALDR | Fuel Product Action Level Development Report |
| FRF | Fuel Reclamation Facility |
| FSP | Field sampling plan |
| GC | Gas chromatograph |
| GFAA | Graphite furnace atomic absorption |
| GWTP | Groundwater treatment plant |
| HPC | Heterotrophic plate count |
| HPLC | High pressure liquid chromatography |
| HASP | Health and safety plan |
| HASPM | Health and safety program manager |
| IC | Installation coordinator |
| ICP | Inductively coupled plasma emission spectroscopy |
| ID | Identification |
| IDL | Instrument detection limit |
| IRDQM | Installation Restoration Chemical Data Quality Manual |
| LCS | Laboratory control sample |
| LCSD | Laboratory control sample duplicate |
| LIMS | Laboratory information management system |
| LUFT | California leaking underground fuel tank |

## ACRONYMS AND ABBREVIATIONS (Continued)

| | |
|---|---|
| MCAWW | Methods for Chemical Analysis of Water and Waste |
| MDL | Method detection limit |
| MNA | Monitored natural attenuation |
| MPE | Multiphase extraction |
| MS | Matrix spike |
| MSD | Matrix spike duplicate |
| MSR | Monthly status report |
| NA | Not applicable |
| NEDTS | Navy Environmental Data Transfer Standard |
| NFD | Naval Fuel Depot |
| NFESC | Naval Facilities Engineering Service Center |
| NIOSH | National Institute for Occupational Safety and Health |
| NORGB | Nitrogen (organic) Macro-Kjeldahl Method |
| OLM | Organic laboratory method |
| ORP | Oxidation reduction potential |
| OSHA | Occupational Safety and Health Administration |
| O-$PO_4$ | Orthophosphate |
| %R | Percent recovery |
| %RSD | Percent relative standard deviation |
| PAH | Polynuclear aromatic hydrocarbon |
| PARCC | Precision, accuracy, representativeness, completeness, and comparability |
| PHSC | Project health and safety coordinator |
| PID | Photoionization detector |
| PM | Program manager |
| PPE | Personal protective equipment |
| PRC | PRC Environmental Management, Inc. |
| PRRL | Project-required reporting limit |
| QA | Quality assurance |
| QAO | Quality assurance officer |
| QAPP | Quality Assurance Project Plan |
| QC | Quality control |
| QCSR | Quality Control Summary Report |
| RF | Radio frequency |
| RI | Remedial investigation |
| RPD | Relative percent difference |
| RPM | Remedial project manager |
| SDG | Sample delivery group |
| SM | Standard method |
| SMEWW | Standard methods for the examination of water and wastewater |
| SOP | Standard operating procedure |
| SOW | Statement of work |
| SQL | Sample quantitation limit |
| SVE | Soil vapor extraction |
| SWDIV | Department of the Navy, Naval Facilities Engineering Command, Southwest Division |

## ACRONYMS AND ABBREVIATIONS (Continued)

| | |
|---|---|
| TAL | Target analyte list |
| TDS | Total dissolved solids |
| TIC | Tentatively identified compound |
| TKN | Total Kjeldahl Nitrogen |
| TCL | Target compound list |
| TPH-e | Total petroleum hydrocarbons-extractable |
| TPH-p | Total petroleum hydrocarbons-purgeable |
| TSS | Total suspended solids |
| TtEMI | Tetra Tech EM Inc. |
| VOC | Volatile organic compound |
| WP | Work plan |

# A1 INTRODUCTION

Tetra Tech EM Inc. (TtEMI) prepared this Quality Assurance Project Plan (QAPP) for the Department of the Navy under Comprehensive Long-term Environmental Action Navy (CLEAN) II, Contract No. N62474-94-D-7609, Contract Task Order (CTO) No. 379. TtEMI prepared this QAPP in support of the work plan for sampling and field pilot testing for Site 3 at Naval Fuel Depot (NFD) Point Molate in Richmond, California. This QAPP documents data quality objectives (DQOs), project organization, and quality assurance and quality control (QA/QC) to be implemented for field activities at NFD Point Molate Site 3. This document was prepared according to U.S. Environmental Protection Agency (EPA) guidelines (EPA 1998a), as well as guidance from Department of the Navy, Naval Facilities Engineering Command, Southwest Division (SWDIV).

Section A1.1 references the EPA guidelines used to develop this QAPP. Section A1.2 describes the seven-step process used to define DQOs for this project. Section A1.3 provides the proposed use of this QAPP, and Section A1.4 reviews the history and setting of NFD Point Molate. Documents prepared in conjunction with this QAPP include the:

- Work plan
- Field sampling plan (FSP)

## A1.1 DOCUMENT REQUIREMENTS AND FORMAT

The requirements for this QAPP, including format, have been adapted from EPA's Requirements for Quality Assurance Project Plans, EPA QA/R-5 (EPA 1999a). EPA QA/R-5 states that the requirements for QAPPs include (1) evaluating the DQOs for the project, (2) ensuring that intended measurements and data acquisitions are appropriate for achieving project objectives, (3) ensuring that QA/QC procedures are adequate for obtaining quality data, and (4) identifying limitations on the use of the data. Table A-1 provides a summary of the elements contained in this QAPP.

## A1.2 DATA QUALITY OBJECTIVES

DQOs are qualitative and quantitative statements developed through the seven-step DQO process (EPA 2000). DQOs clarify the study objective, define the most appropriate data to collect and the conditions from which to collect the data, and specify tolerable limits on decision errors that will be used as the basis for establishing the quantity and quality of data needed to support decision-making. The general format of the seven-step DQO process is described in Sections A1.2.1 through A1.2.7, below. Project-specific descriptions of the seven steps are provided in Table A-2 and throughout this QAPP, as referenced in the following discussions.

## TABLE A-1

## NAVY FUEL DEPOT POINT MOLATE, CALIFORNIA
## WORKING DRAFT FIELD WORK PLAN FOR SITE 3
## ELEMENTS OF THE QUALITY ASSURANCE PROJECT PLAN

| **A. Project Management** | |
|---|---|
| **Element Content** | **Report Section** |
| A1 Title and approval sheet | Not applicable |
| A2 Contents | Not applicable |
| A3 Distribution List | Cover letter |
| A4 Project and Task Organization | A2 |
| A5 Problem Definition/Background | A3 |
| A6 Project and Task description | A4 |
| A7 Quality Objectives and Criteria for Measuring Data | A5 |
| A8 Special Training Requirements and Certification | A2.3 |
| A9 Documentation and Records | A6 |
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| **Element/Content** | **Report Section** |
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| B4 Sample Handling, Custody, and Shipping Procedures | B4 |
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| **Element/Content** | **Report Section** |
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| C2 Reports to Management | C1.3 |
| **D. Data Validation and Usability** | |
| **Element/Content** | **Report Section** |
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| D2 Validation and Verification Methods | D1.2 |
| D3 Reconciliation with Data Quality Objectives | D2 |

## TABLE A-2

## NAVY FUEL DEPOT POINT MOLATE, CALIFORNIA
## QUALITY ASSURANCE PROJECT PLAN
## FIELD WORK PLAN FOR SITE 3
## SUMMARY OF DATA QUALITY OBJECTIVES

**STEP 1: State the Problem**

- Soils and groundwater in Site 3 are contaminated with TPH-p, TPH-e, BTEX, VOCs, and PAH compounds; however, the extent of contaminated soils and groundwater has not been delineated sufficiently to recommend a specific area for remediation.
- Data are required to evaluate whether metals have been released to soil or groundwater within the former FRF as a result of disposal of batteries.
- The volume and extent of industrial waste at the FRF are unknown; a reliable estimate is necessary to evaluate alternatives for addressing this waste in the EE/CA
- Site-specific data are needed to assess the effectiveness of various remediation technologies (air-sparging/ SVE, MPE, and MNA) and provide a basis for evaluation as part of the upcoming EE/CA.
- Site-specific, empirical partitioning coefficients are needed to accurately estimate the impact of contaminants in soil on groundwater.

**STEP 2: Identify the Decisions**

1. Are soils saturated with TPH-p or TPH-e such that free product is present at each sampling location?
2. Are concentrations of TPH-p or TPH-e in soil high enough to cause equilibrated groundwater to exceed action levels for TPH-p or TPH-e in groundwater?
3. Do concentrations of TPH-p, TPH-e, BTEX, or VOC compounds in groundwater samples at Site 3 exceed action levels?
4. Do concentrations of TPH-p, TPH-e, BTEX, PAH, or VOC compounds in soil samples at Site 3 exceed action levels?
5. Does VOC contamination exist near the contact with Bay Mud below the former sump pond?
6. Is there a large amount of industrial waste remaining within the former FRF?
7. Are concentrations of metals in soils or groundwater present at levels that warrant a risk assessment?
8. Are air sparging/SVE or MPE viable remediation technologies for treating contaminated soils and groundwater at Site 3?
9. Is MNA a technically viable treatment approach to combine with one or more of the source-remediation technologies evaluated under this study?

**STEP 3: Identify Inputs to the Decisions**

- Validated definitive analytical data for TPH-p, TPH-e, BTEX, PAHs, VOCs, and metals in samples of soil and groundwater. Soil samples will be collected at depths between 0 and 10 feet bgs to coincide with potential exposure scenarios. Data from monitoring for free product
- Field observations of soil cores for TPH-p or TPH-e in surface and subsurface soil.
- Field observations of soil cores for soil types.
- Validated definitive analytical data for VOCs in samples of soil near the contact with Bay Mud.
- Exploratory trenching in the area of industrial waste; trenching logs will describe the type, depth, thickness, and horizontal extent of waste.
- Results of field pilot testing of air sparging/SVE and MPE.
- Data for soil and groundwater samples analyzed for biochemical parameters to assess the feasibility and potential effectiveness of MNA.
- Results of field pilot testing of air sparging/SVE and MPE.
- Data for soil and groundwater samples analyzed for biochemical parameters to assess the feasibility and potential effectiveness of MNA.
- Analytical results for soil and groundwater samples will be used to calculate empirical soil-water equilibrium relationships for target compounds.

TABLE A-2 (Continued)

NAVY FUEL DEPOT POINT MOLATE, CALIFORNIA
QUALITY ASSURANCE PROJECT PLAN
WORKING DRAFT FIELD WORK PLAN FOR SITE 3
SUMMARY OF DATA QUALITY OBJECTIVES

**STEP 4: Define Study Boundaries**

- The lateral boundary of Site 3 includes the Treatment Ponds Area and the former FRF. (Proposed sampling locations presented on Plates 2-1 and 2-2 of the field work plan.)
- The vertical boundary of this study extends from the ground surface down to approximately 29 feet bgs (at the contact with Bay Mud).
- The temporal boundary of the study extends from May 2001 (utility clearance) to September 2001 (completion of data evaluation).

**STEP 5: Develop Decision Rules**

1. If soils are saturated with TPH-p or TPH-e such that free product is present at soil sampling locations, then these locations are to be included within the remediation area recommended for the EE/CA.

   If soils are not saturated with TPH-p or TPH-e such that free product is not present at soil sampling locations, or if no contamination is found, then these locations will not be included within the free product remediation area during the EE/CA.

2. If concentrations of TPH-p or TPH-e in soils are sufficiently high to cause concentrations in groundwater to exceed action levels, then these locations may be included in the remediation area recommended for the EE/CA.

   If concentrations of TPH-p or TPH-e in soils are not high enough to cause concentrations in groundwater to exceed action levels, then no further action will be recommended. However, if concentrations of TPH-p and TPH-e exceed action levels for soil, these locations will be included in the remediation area recommended for the EE/CA.

3. If concentrations of TPH-p, TPH-e, BTEX, or VOCs in groundwater samples exceed action levels, then these locations will be included within the remediation area recommended for the EE/CA.

   If TPH-p, TPH-e, BTEX, or VOC concentrations in groundwater samples do not exceed action levels, then these sampling locations will not be included within the remediation area recommended for the EE/CA and no further action will be recommended.

4. If contaminant concentrations in soils beneath the treatment ponds or the former FRF pose an unacceptable risk based on action levels, these areas may be included within the remediation area assumed for the EE/CA.

   If contaminant concentrations in soils beneath the treatment ponds or the former FRF do not pose an unacceptable risk to human or ecological receptors based on action levels, these areas will not be included in the remediation area recommended for the EE/CA.

5. If VOC concentrations are detected in soil samples at the contact with Bay Mud below the former sump pond, these areas will be included in the EE/CA.

   If VOC concentrations are not detected in soil samples at the contact with Bay Mud below the former sump pond, these areas will not be included in the EE/CA.

6. If there is a large volume of waste remaining within the former FRF, covering is a more likely alternative.

   If there is not a large amount of industrial waste remaining within the former FRF, excavation is a more likely alternative.

## TABLE A-2 (Continued)

## NAVY FUEL DEPOT POINT MOLATE, CALIFORNIA
## QUALITY ASSURANCE PROJECT PLAN
## WORKING DRAFT FIELD WORK PLAN FOR SITE 3
## SUMMARY OF DATA QUALITY OBJECTIVES

| STEP 5: Develop Decision Rules (Continued) |
|---|
| 7. If metal concentrations exceed preliminary screening criteria, these areas will be included in the EE/CA.<br><br>If metal concentrations do not exceed preliminary screening criteria, these areas will not be included in the EE/CA.<br><br>8. If air sparging/SVE or MPE are determined to be technically viable remediation technologies for Site 3, then the technically feasible technologies should be included for evaluation in the EE/CA.<br><br>Any tested technology (air sparging/SVE or MPE) that is determined not to be technically feasible will not be recommended as a remedial approach within the EE/CA.<br><br>9. If natural attenuation is indicated to be ongoing based on soil and groundwater data collected at Site 3, MNA should be evaluated as a potential option within the EE/CA.<br><br>If ongoing natural attenuation is not indicated by soil and groundwater data collected at Site 3, MNA will not be recommended as a potential remedial option within the EE/CA. |
| **STEP 6: Specify Tolerable Limits on Decision Errors** |
| • Because of the nature of the problem, use of a statistically based sampling design was limited (EPA 1999b); instead, judgmental sampling will be applied to delineate the extent of contaminated soil and groundwater, based on existing knowledge of site geology, hydrology, and distribution of contaminants.<br>• Measurement quality objectives for analytical data are specified in Section A5 of the QAPP. |
| **STEP 7: Optimize the Sampling Design** |
| • The design for soil sampling has been optimized based on a minimum of one soil boring, including historical and new soil borings, for every 125 square feet of soil within 150 feet of the shoreline, and a minimum of one soil boring within every 150 square feet of soil more than 150 feet from the shoreline.<br>• The design for groundwater sampling has been optimized based on a minimum of one monitoring well within every 150 square feet for groundwater within approximately 150 feet of the shoreline, and a minimum of one monitoring well within every 250 square feet for groundwater more than 150 feet from the shoreline.<br>• Exploratory trenching will be conducted approximately every 50 feet in the area of industrial waste. |

**Notes:**

[1] Action levels were presented in the Internal Draft Fuel Product Action Level Development Report (FPALDR), submitted in January 2001.

| | |
|---|---|
| bgs | Below ground surface |
| BTEX | Benzene, toluene, ethylbenzene, xylene |
| DQO | Data quality objectives |
| EE/CA | Engineering evaluation and cost analysis |
| EPA | U.S. Environmental Protection Agency |
| FRF | Fuel reclamation facility |
| GWTP | Groundwater treatment plant |
| MNA | Monitored natural attenuation |
| MPE | Multiphase extraction |
| PAH | Polynuclear aromatic hydrocarbon |
| SVE | Soil vapor extraction |
| TPH-e | Total petroleum hydrocarbons-extractable |
| TPH-p | Total petroleum hydrocarbons- purgeable |
| VOC | Volatile organic compound |
| WP | Work Plan |

### A1.2.1 Step 1 — State the Problem

Step 1 of the DQO process identifies the specific problem to be solved and describes the process for optimization of sampling design based on the seven-step DQO process (see Table A-2). Sufficient background information must be presented to provide a scientific and historical context for the proposed project. Section A3 of this QAPP provides the problem definition and background, including the purpose of the sampling and field pilot testing for Site 3 (Section A3.1) and a summary of previous investigations (Section A3.2). Section 1.1 of the work plan to which this QAPP is attached also discusses objectives and identifies data gaps to be addressed in the Site 3 sampling and field pilot testing. Specific problems to be addressed include:

- Petroleum hydrocarbons and chlorinated volatile organic compounds (VOCs) have been detected in soil samples from across the site by previous studies, but the distribution of total petroleum hydrocarbons-purgeable (TPH-p), total petroleum hydrocarbons-extractable (TPH-e); benzene, toluene, and ethylbenzene, and xylenes (BTEX); polynuclear aromatic hydrocarbons (PAH); and VOCs requires further delineation to define the recommended remediation area for evaluation in the Site 3 Engineering Evaluation and Cost Analysis (EE/CA).
- Petroleum hydrocarbons have been detected in groundwater samples from across the site during previous studies, but the distribution of TPH-p, TPH-e, BTEX, PAHs, and VOCs requires further delineation relative to preliminary soil and groundwater action levels to define the area for evaluation in the EE/CA.
- Data are required to evaluate whether metals have been released to soil or groundwater within the former Fuel Reclamation Facility (FRF) as a result of disposal of batteries
- The volume and extent of industrial waste at the FRF is unknown; a reliable estimate is necessary to evaluate alternatives for addressing this waste in the EE/CA
- Air sparging, soil vapor extraction (SVE), and multiphase extraction (MPE) will be evaluated in the EE/CA as technologies to address contaminated soils and groundwater at Site 3. Site-specific field pilot testing is required to adequately evaluate the technical and economic feasibility of these technologies at Site 3.
- Monitored natural attenuation (MNA) is to be evaluated in the EE/CA as a part of some potential remediation approaches to address contaminated soils and groundwater at Site 3. Collection of soil and groundwater samples for analysis of parameters specific to natural attenuation are required for this evaluation.

### A1.2.2 Step 2 — Identify the Decisions

Step 2 of the DQO process identifies the questions the investigation will attempt to resolve (see Table A-2). Section A4 of this document discusses the project objective and addresses the decisions that will be made during sampling and the FPT for Site 3; the decision statements are provided in Table A-2 and are listed below.

- Are soils saturated with TPH-p and TPH-e, and if so, does free product exist at these locations?
- Do TPH-p and TPH-e concentrations detected in soils result in concentrations in groundwater that exceed groundwater action levels?
- Do concentrations of dissolved TPH-p, TPH-e, BTEX, or VOCs in groundwater exceed action levels?
- Do soils below the former Fuel Reclamation Facility (FRF) or in the Treatment Ponds Area, including areas between the shoreline and the treatment ponds, pose an unacceptable risk to ecological or human receptors based on action levels?
- Does VOC contamination exist near the contact with Bay Mud below the former sump pond?
- What is the extent and volume of industrial waste at the FRF?
- Are concentrations of metals in soils or groundwater present at levels that warrant a risk assessment?
- Are air sparging-SVE or MPE viable remediation technologies for addressing contamination at Site 3?
- Is MNA a technically viable approach to combine with one or more source remediation technologies for addressing site contamination?

### A1.2.3 Step 3 — Identify Inputs to the Decisions

Step 3 describes the information to be obtained and the measurements to be taken to resolve the decision statement (EPA 2000). For many environmental studies, these data are generally chemical, geotechnical, hydrological, or ecological and are collected through field study and sampling. For this project, chemical data for soil and groundwater will be collected, validated, and assessed in order to: (1) further delineate the distribution of TPH-p, TPH-e, BTEX, PAHs, VOCs and metals; (2) define the recommended remediation area; and (3) identify a remedial approach. The information collected during the investigation will enable the Navy to make an informed choice of remedial actions. Necessary data include:

- Results of observations from soil borings and trenches, combined with validated definitive chemical data for TPH-p, TPH-e (as gasoline, diesel, and residual [bunker fuel]), BTEX, PAHs, VOCs, and metals, will be used to delineate the area of soil recommended for remediation.
- Results of monitoring for free product will be used to establish the area recommended for recovery of free product and soil remediation.
- Analytical results for TPH-p, TPH-e, BTEX, PAHs, VOCs, and metals in groundwater samples will be used to delineate the area recommended for remediation of groundwater.
- Validated definitive analytical data for VOCs in samples of soil near the contact with Bay Mud.

- Exploratory trenching in the area of industrial waste; trenching logs will describe the type, depth, thickness, and horizontal extent of waste.

- Analytical results for soil and groundwater sample will be used to calculate empirical soil-water equilibrium relationships for target compounds.

- Results of field pilot testing will be used to evaluate the technical feasibility and cost-effectiveness of air sparging-SVE and MPE to address contamination at Site 3.

- Analytical results for soil and groundwater samples for biochemical parameters, including (but not limited to) heterotrophic plate count, dissolved oxygen, pH, oxidation reduction potential, nitrate, total Kjeldahl nitrogen (TKN), orthophosphate, and petroleum hydrocarbon levels, will be used to evaluate the potential for MNA at Site 3.

### A1.2.4 Step 4 — Define the Study Boundaries

The spatial and temporal boundaries of the proposed investigation are described in Step 4 of the DQO process (see Table A-2). Step 4 defines when and where data are to be collected. Section B2 of this QAPP and Section 4.0 of the accompanying FSP describe in detail the proposed sampling design for this investigation. The physical boundaries of the study include:

- About 60 soil sample locations, not including QC samples, have been selected based on data gaps from previous site investigations. These locations will be within the Treatment Ponds Area and the former FRF. Soil borings will extend from grade to a maximum depth of approximately 29 feet below ground surface (bgs). Soil samples will not extend into the Bay Mud, which has been observed at depths of 15 to 29 feet bgs at Site 3. Soil sample locations are presented in Plate 2-4 of the accompanying FWP.

- About 36 groundwater samples will be collected at 36 locations. These groundwater sampling locations have been selected based on obtaining current site data from existing wells used for past sampling events, combined with data from new wells to be installed in areas that have not previously been sampled. Groundwater sampling locations will be within the Treatment Ponds Area and the former FRF. Groundwater sampling locations are presented in Plate 2-7 of the FWP. Screened intervals for groundwater monitoring wells will be based on field observations of soil contamination.

- Past soil boring logs will be combined with the results of the investigations associated with this FWP to develop a current site conceptual model of the distribution of hydrocarbon-saturated soils and free product across the site.

- The temporal boundary of this study will extend from May 2001 with utility clearance, through approximately September 2001 with completion of data evaluation.

Of the 36 judgmental groundwater samples, about 22 groundwater samples will be collected from existing well locations that have been selected to provide current groundwater data for comparison to previous site investigations and 14 groundwater samples will be collected from new wells to be installed in areas not previously sampled. Groundwater sampling locations will be within the Treatment Ponds Area and the former FRF. Duplicate groundwater samples will be collected from 10 percent of the monitoring wells.

The 14 new monitoring wells will be installed at selected locations to obtain groundwater samples from the first water-bearing zone encountered. Screened intervals in groundwater monitoring wells will be based on field observations of contamination in soil. Well installation, development, and groundwater sampling are discussed in detail in Sections 4.4 and 4.5 of the accompanying FSP.

Of the 60 soil samples collected, 23 surface samples will be collected (0 to 3 feet bgs), 23 samples will be collected between 5 to 10 feet bgs 10 soil samples will be collected from depths coincident with five of the new monitoring well screen intervals (see Table 4-1 of the FSP), and 4 soil samples will be collected at the total depth (bottom) of boring; specifically near or at the top of the Bay Mud. These locations are within the Treatment Ponds Area and the former FRF.

Three sets of soil gas samples will be collected for field pilot testing at Site 3. Soil gas samples will be collected from discharge sample ports at the test skid (vacuum blower or pump). A summary of sampling locations and associated laboratory analyses is presented in Table 4-3 of the accompanying FSP.

Proposed sampling locations for groundwater and soil samples are shown in Plates 2-2 and 2-4 of the FWP. All sampling locations will be clearly marked in the field and surveyed after sampling.

### A1.2.5 Step 5 — Develop a Decision Rule

Step 5 of the DQO process defines the statistical parameters of interest, specifies the action level, and integrates study outputs into a single statement that describes the logical basis for choosing among alternative actions. Step 5 essentially delineates the consequences of study results (see Table A-2). Decision rules may be formulated as "if, then" statements, in which the outcome of the investigation provides direction for the next stage of problem resolution. The following bullets present the decision rules formulated for the Site 3 sampling and pilot testing results.

- If soils are found to be saturated with hydrocarbons to the extent that free product is observed, then these locations are to be included with the recommended areas for remediation within the EE/CA.

  If soils are not saturated with TPH-p or TPH-e such that free product is not present at soil sampling locations, or if no contamination is found, then these locations will not be included with the free product remediation area during the EE/CA.

- If concentrations of TPH-p or TPH-e, detected in soil samples are sufficiently high to cause concentrations in groundwater to exceed action levels, as determined based on actual groundwater data or empirically derived equilibrium partitioning coefficients, then these locations may be included in the recommended remediation area for the EE/CA.

  If concentrations of TPH-p or TPH- concentrations in soils are not high enough to cause concentrations in groundwater to exceed actions levels, then no further action will be recommended. However, if concentrations of TPH-p and TPH-e exceed action levels for

soil, these locations will be included in the remediation area recommended for the EE/CA.

- If analytical results for groundwater indicate contaminant concentrations that exceed action levels, the locations the groundwater samples were collected may be included as part of the remediation area recommended for the EE/CA.

  If concentrations of TPH-p, TPH-e, BTEX, or VOCs in groundwater samples do not exceed action levels, then these sampling locations will not be included in the remediation area recommended for the EE/CA and no further action will be recommended.

- If contaminant concentrations in soil samples collected from the Treatment Ponds Area or the former FRF pose an unacceptable risk based on action levels, these areas may be included with the remediation area assumed for the EE/CA.

  If contaminant concentrations in soils beneath the treatment ponds or the former FRF do not pose an unacceptable risk to human or ecological receptors based on action levels, these areas will no be included in the recommended remediation area for the EE/CA.

- If VOCs are detected in soil samples at the contact with Bay Mud below the former sump pond, these areas will be included in the EE/CA

  If VOCs are not detected in soil samples at the contact with Bay Mud below the former sump pond, these areas will not be included in the EE/CA.

- The extent and volume of industrial waste disposed of at the FRF will be used to evaluate engineering alternatives in the EE/CA. If there is a large volume of waste, covering is a more likely alternative; if there is not a large amount of waste, excavation is a more likely alternative.

- If concentrations of metals exceed preliminary screening criteria, these areas will be included in the EE/CA

  If concentrations of metals do not exceed preliminary screening criteria, these areas will not be included in the EE/CA

- If the air sparging-SVE or MPE pilot test results indicate that these technologies are technically feasible approaches for remediation of soil or groundwater, the EE/CA is to include a cost evaluation of the technically feasible technologies.

  Any tested technology (air sparging/SVE, or MPE) that is determined not to be technically feasible will not be recommended as a remedial approach in the EE/CA.

- If the analytical results for soil and groundwater samples suggest that natural attenuation is occurring, MNA is to be included in one or more remediation alternatives evaluated in the EE/CA.

  If ongoing natural attenuation is not indicated by data for soil and groundwater collected at Site 3, MNA will not be recommended as a potential remedial option in the EE/CA.

### A1.2.6 Step 6 — Specify Limits on Decision Errors

Step 6 of the DQO process quantifies the acceptable limits on decision errors (see Table A-2). The limits are needed to define the uncertainty that will be acceptable to all stakeholders (such as regulatory agencies, citizens, and site owners). However, because of the use of a judgmental sampling approach in past investigations, existing knowledge of the contaminant plume, and the size of the site, a judgmental sampling approach was considered warranted (EPA 1999b). Measurement quality objectives for analytical data are specified in Section A5 of this QAPP.

### A1.2.7 Step 7 — Optimizing Sampling Design

Step 7 of the DQO process involves optimizing the sampling or experimental design based on current information. Because the DQO process is iterative, newly acquired data are used to refine sampling and evaluation strategies.

- The design for soil sampling has been optimized based on a minimum of one soil boring for every 125 square feet of soil within 150 feet of the shoreline, and a minimum of one soil boring within every 150 square feet of soil more than 150 feet from the shoreline within Site 3.
- The groundwater sampling design has been optimized based on a minimum of one monitoring well within every 150 square feet for groundwater within approximately 150 feet of the shoreline, and a minimum of one monitoring well within every 250 square feet for groundwater more than 150 feet from the shoreline within Site 3.

## A1.3 USAGE OF THE DOCUMENT

Each element of this QAPP is discussed in this document as it pertains to sampling and pilot testing at Site 3. The QAPP provides specific guidance and QA/QC criteria for collecting, evaluating, and submitting data while completing the sampling and testing at Site 3. All personnel working on the Site 3 project are required to read and comply with the procedures defined in this document to ensure the quality and usability of the data collected.

## A1.4 BACKGROUND

Section 2.0 of the work plan describes the location of NFD Point Molate Site 3, as well as the history of the base and base operations. Section 2.0 of the work plan contains the site description and history, the site climate, physiographic setting, geology, and hydrology.

## A2 PROJECT AND TASK ORGANIZATION

This section discusses management of the project at NFD Point Molate Site 3. A well-organized project team, combined with adequate experience and proper training, will promote consistent quality throughout the investigation. Sections A2.1 and A2.2 present the task organization for the project, including specific roles and responsibilities of project participants. Section A2.3 discusses training requirements for project members, and Section A2.4 lists the schedule for work to be conducted at Site 3.

### A2.1 PROJECT ORGANIZATION AND PERSONNEL

The following personnel are involved in field efforts at NFD Point Molate. In some cases, more than one responsibility has been assigned to one person.

| Name | Responsibility | Location | Telephone |
|---|---|---|---|
| Michelle Gallice-Sondrup | Navy Remedial Project Manager | Naval Facilities Engineering Command, San Diego, CA | (619) 532-0971 |
| Narciso A. Ancog | Navy QA Officer | Naval Facilities Engineering Command, San Diego, CA | (619) 532-2540 |
| Daniel Chow | Program Manager | TtEMI, San Francisco, CA | (415) 222-8222 |
| Greg Swanson | Program QA Manager | TtEMI, San Diego, CA | (619) 718-9676 |
| Brian Schuller | Installation Coordinator | TtEMI, Denver, CO | (303) 441-7912 |
| Brian Schuller | Project Manager | TtEMI, Denver, CO | (303) 441-7912 |
| Ron Ohta | Project QA manager | TtEMI, Sacramento, CA | (916) 853-4506 |
| Conrad Sherman | Health and Safety Program Manager | TtEMI, San Francisco, CA | (415) 222-8377 |
| Heidi Muench | Project Health and Safety Coordinator | TtEMI, Denver, CO | (406) 442-5588 |
| Nicole Sommers | Analytical Coordinator | TtEMI, Denver, CO | (303) 313-8282 |

### A2.2 PROJECT TEAM RESPONSIBILITIES

The roles and key responsibilities of each project team member are described in the following subsections, and an organization flow chart is shown in Figure A-1. The Navy Quality Assurance Officer (QAO) is responsible for quality assurance issues for all Navy CLEAN II work. The Navy QAO provides government oversight of the QA program, including review and sign-off on QAPPs and FSPs. The QAO provides quality-related direction through the contact technical representative to the quality manager. The

QAO has the authority to suspend affected project or site activities if SWDIV-approved quality requirements are not met.

**Navy Remedial Project Manager**

The Navy Remedial Project Manager (RPM) has overall responsibility for the Installation Restoration Program. The Navy RPM is directly responsible for project execution and coordination with base representatives, regulatory agencies, and the SWDIV management team.

The Navy RPM is responsible for the following:

- Providing site information and history
- Providing logistical assistance
- Specifying sites that require investigation
- Reviewing results and recommendations and providing management and technical oversight
- Verifying proper review and distribution of documents
- Communicating comments from technical reviewers to contractors
- Verifying that contractors address comments and take appropriate corrective actions
- Coordinating with regulatory agencies

**Navy Quality Assurance Officer**

The Navy QAO is responsible for QA issues for all Navy CLEAN II work. The Navy QAO provides government oversight of the QA program, including review and sign off on QAPPs and FSPs. The QAO provides quality-related direction through the contracting officer's technical representative to the quality manager. The QAO has authority to suspend affected project or site activities if SWDIV-approved quality requirements are not adequately met.

**TtEMI Program Manager**

The TtEMI Navy CLEAN II Program Manager (PM) is responsible for and has authority over all work performed by TtEMI personnel assigned to the Navy CLEAN II program. The PM establishes program

policies and procedures, monitors costs and performance, delegates authority, and resolves conflicts and problems. The TtEMI PM is responsible for:

- Verifying that contract requirements are met
- Providing necessary resources to the project team to allow adequate response to the requirements of the investigation
- Maintaining consistency in procedures and work products with other task orders
- Establishing and maintaining communication among the RPM, the Program QA Manager, the health and safety program manager, and project managers
- Providing technical oversight and review of the final project report
- Providing guidance to the project managers
- Assisting the CLEAN II Program QA Manager in resolving QA issues that cannot be handled at the CTO project manager or QC coordinator level
- Assisting the CLEAN II Program QA Manager in resolving issues with subcontractors
- Monitoring compliance of CTO project managers with orders and recommendations
- Establishing and supporting continuous quality improvement problem-solving teams and process improvement groups to follow through with program-specific quality and process improvement opportunities identified by the CLEAN II Program QA Manager and QC Coordinator
- Providing TtEMI CTO project managers with revised standard operating procedures (SOP) received from the CLEAN II Program QA Manager and ensuring that these improved SOPs are followed

**TtEMI Installation Coordinator**

The TtEMI Installation Coordinator (IC) has overall responsibility for all TtEMI activities at NFD Point Molate. These activities are divided into CTOs. The IC is responsible for overseeing all project activities and coordinating with subcontractors.

**TtEMI Project Manager**

The Project Manager is responsible for overseeing project activities and coordinating with subcontractors. The Project Manager is ultimately responsible for the timely completion of the project.

The responsibilities of the Project Manager are as follows:

- Verifying that QC requirements are fulfilled by team members
- Supervising the document control process
- Approving deliverables and associated documents before they are transmitted
- Establishing and maintaining communication among technical staff, program managers, QA officers, health and safety coordinators, and regulatory agencies
- Implementing programs and protocols related to the project
- Developing work plans that define the scope of major activities at the level of defensibility, documentation, and QC required for environmental measurements
- Developing specific QC procedures for major activities that produce or use environmental data
- Defining, reporting, and maintaining documentation of the precision, accuracy, representativeness, comparability, and completeness of data
- Working with program management, QC Coordinators, and other CTO Project Managers to develop, revise, and implement mechanisms, as needed, to identify QA problems and expedite corrective actions
- Verifying that data processing procedures are documented, routinely reviewed, and revised
- Verifying that the CTO project team fulfills the QC requirements of the work plan
- Maintaining and regularly reviewing QA records and forwarding copies to the QC Coordinators and CLEAN II Program QA Manager
- Overseeing the technical review and QC check for deliverables and approving data, reports, specifications, drawings, and documentation before they are transmitted
- Establishing and maintaining communication among the CTO technical staff, the TtEMI QC Coordinators, and the CLEAN II Program QA Manager
- Preparing QAPPs for any CTO that involves field data collection activities, such as sample collection, including specifying acceptance criteria for the quality of data
- Verifying by personal observation that appropriate sampling, field testing, and field analysis procedures, as specified in the work plan and QAPP, are followed and that correct QC checks are made
- Working with QC coordinators to implement quality improvements identified during audit and review of ongoing work
- Implementing and following approved SOPs received from the TtEMI PM
- Controlling the identification and handling of all documentation until it is turned over to designated document-control personnel

**TtEMI Program QA Manager**

The Program QA Manager is responsible for the quality of all work completed by TtEMI and its subcontractors under the Navy CLEAN II program. The Program QA Manager develops and maintains a comprehensive QA program and is responsible for audits, reviews of all work performed, and recommendations to technical staff and management relating to quality. The Program QA Manager has the following specific responsibilities:

- Developing and revising the TtEMI Navy CLEAN II QA program
- Assigning qualified personnel to serve as project QA managers
- Implementing and supervising the QA program with the assistance of QC coordinators and subcontractor project QA managers
- Coordinating and auditing the review of QC documentation and technical operations, as required
- Identifying nonconformance situations to the CLEAN II Program Manager and TtEMI Corporate QA Manager
- Providing guidance to CTO technical staff for QC program development and correcting nonconformance situations
- Preparing and revising SOPs and providing them to CTO Project Managers and technical staff
- Interacting with the Navy's appointed QAO about certification of laboratories and coordinating compliance with requirements by QA and technical staff
- Ensuring compliance with orders and making recommendations to the CLEAN II program manager and CTO Project Managers about corrective action
- Approving the waiver of requirements for a written QC procedure when SOPs are specified by the Navy and are available for use
- Communicating regularly with the CLEAN II Program Manager and providing a summary of quality improvement opportunities to the CLEAN II Program Manager for further action
- Communicating regularly with and supervising QA responsibilities of QC coordinators and coordinating and compiling quality improvement opportunities identified by QC coordinators
- Updating the TtEMI Corporate QA Manager on newly identified, ongoing, and completed program-specific quality improvement opportunities
- Communicating quality improvement opportunities identified by TtEMI to subcontractor QA managers and assisting subcontractor QA managers in pursuing quality improvement opportunities that will benefit the overall program QA effort

- Meeting regularly with the program managers, project managers, and QA managers
- Reviewing and approving the QAPP
- Conducting field audits to ensure that sampling activities are performed in accordance with the QAPP
- Approval of any deviation or modifications to approved protocols will be approved by the Program QA Manager

The Program QA Manager reports, as necessary, to the QA Corporate Manager and consults frequently with the PM and the QC Coordinators. The Program QA Manager refers QA issues or disputes that cannot be resolved within the Navy CLEAN II program to the TtEMI QA Corporate Manager.

**TtEMI Project QA Manager**

A senior technical staff member will serve as Project QA Manager and will be responsible for review of work completed by TtEMI. The Project QA Manager will audit and review work. The manager will provide recommendations about quality to the project manager and technical staff. The Project QA Manager will also regularly communicate with the CLEAN II Project QA Manager to discuss problems and resolutions. Specific responsibilities of the Project QA Manager are:

- Meeting regularly with the CLEAN II Program QA Manager
- Reviewing all deliverables before they are released to ensure conformance with QA/QC procedures and quality of the work product
- Providing recommendations to the Program QA Manager, as required, for corrective action related to all aspects of the work that do not meet program standards
- Providing guidance to project teams for QC program development and for correcting nonconformance situations
- Coordinating compliance of the QC and technical staff with specific QC requirements
- Ensuring compliance with orders and making recommendations to CTO Project Managers about corrective action
- Identifying quality improvement opportunities as part of the audit and review function
- Communicating quality improvement opportunities to the Program QA Manager or CTO Project Managers as appropriate
- Ensuring that the QAPP is prepared in accordance with EPA guidance documents
- Ensuring that all protocols described in the QAPP are met
- Providing guidance or assistance in resolving problems related to QA/QC topics

- Verifying that the specified data collection methods comply with QA/QC requirements and will yield data of the desired quality and integrity
- Reviewing, evaluating, and approving quality-related changes in the FSP and project work plan
- Ensuring that all nonconformances are identified and appropriate corrective actions are taken; providing assistance to the project managers with regard to corrective action; and, if necessary, soliciting involvement by the PM and Program QA Manager
- Conducting laboratory evaluations and audits to ensure that analyses are performed in accordance with the QAPP
- Communicating regularly with the Project Manager, Project QA Manager, and Analytical Coordinator to ensure the progress of QA tasks for the FPT
- Serving as the main contact for project QA matters and providing guidance on appropriate procedures to the Project Managers and support personnel

**TtEMI Technical Staff**

TtEMI technical staff will be responsible to the CTO Project Manager and Project QA Manager for completing project activities in compliance with approved SOPs, the QAPP, and other program and project QC guidelines and requirements. The technical staff has the following specific responsibilities:

- Collecting and generating field and laboratory data by carrying out activities consistent with the TtEMI Quality Management Plan
- Generating control and calibration data to support the evaluation of the quality and usability of field and laboratory data
- Documenting sample control and data management procedures
- Documenting the sources of all information acquired, including manual and computer calculations, engineering drawings, and equipment specifications

**TtEMI Health and Safety Program Manager**

The Health and Safety Program Manager (HASPM) is responsible for developing health and safety standards, implementing health and safety policies, and providing consultation to management for the Navy CLEAN program. The specific responsibilities of the HASPM are:

- Keeping management informed about the status of the Navy CLEAN II health and safety program
- Providing consultation on health and safety policy and procedural issues
- Participating in audits to evaluate compliance with the Health and Safety Plan (HASP) and the Navy CLEAN II health and safety program

- Reviewing the HASP for technical content and compliance with Navy CLEAN II health and safety program requirements
- Developing, implementing, and assessing the needs of the Navy CLEAN II health and safety program and informing the project health and safety coordinators of changes that occur in that program
- Providing consultation on health and safety policy and procedural issues as they are related to the Navy CLEAN II health and safety program.

**TtEMI Project Health and Safety Coordinator**

The Project Health and Safety Coordinator (PHSC) is responsible for developing, instituting, coordinating, and supervising the health and safety program. The responsibilities of the PHSC are:

- Preparing the HASP
- Providing assistance to the HASPM for development of the health and safety program, preparing training sessions, conducting accident investigations, and providing recommendations to prevent future accidents
- Ensuring that the HASP complies with federal, state, and local health requirements
- Coordinating with the on-site safety officers in implementing modifications to the HASP and providing consultation, when required
- Preparing materials to be used in the training program and ensuring that the TtEMI On-site Safety Manager is knowledgeable about requirements of the HASP
- Conducting periodic on-site visits to verify that site personnel adhere to site safety requirements
- Establishing and maintaining communication among the On-site Safety Manager, the project manager, and the CLEAN II HASPM
- Providing guidance on appropriate corrective action procedures to the Project Manager and support personnel

**TtEMI On-site Safety Manager**

The On-site Safety Manager is responsible for field implementation of the HASP and has the authority to correct and change site control measures and the required health and safety protection. They have primary on-site enforcement authority, as delegated by the Project Manager, for the policies and provisions of the health and safety program and the HASP. Responsibilities are as follows:

- Serving as the initial contact for site-specific health and safety activities
- Conducting briefing sessions for and providing documentation to TtEMI and subcontractor personnel concerning site-specific hazards, emergency procedures, and symptoms associated with exposure to specific site contaminants

- Documenting health and safety briefings, meetings, and training that are completed in the field
- Selecting the required personal level of protection based on guidance in the site-specific HASP and based on actual on-site operations
- Responsible for maintaining adequate supplies of safety materials in the field
- Conducting air monitoring to determine the appropriate selection of personal protective equipment (PPE) based on the required personal level of protection, evaluating changes in on-site operations and necessary changes in the personal level of protection, and documenting air monitoring operations and results of such monitoring
- Establishing, enforcing, and documenting decontamination operations for personnel and sampling equipment, sample containers, and heavy equipment
- Suspending any operation that threatens the health or safety of team members or the surrounding population and immediately notifying the Project Manager
- Identifying and posting locations and routes to medical facilities, arranging for emergency transportation to medical facilities, and posting emergency service telephone numbers
- Assuming the lead role for TtEMI during any medical emergency
- Along with other TtEMI field personnel, providing on-site cardiopulmonary resuscitation (CPR) and first aid, as necessary

**TtEMI Analytical Coordinator**

The TtEMI Analytical Coordinator works with the task manager during preparation of the FSP and QAPP. Tasks include coordinating the analytical tests with the information required from the field activity, setting up the contract analytical laboratories, overseeing all work conducted by contract laboratories, coordinating validation of analytical results, and providing the procurement office with the information required to procure any special analysis. The responsibilities of the Analytical Coordinator are:

- Verifying that the laboratory implements the requirements of the FSP and QAPP
- Coordinating with the contract laboratory on pickup and delivery schedules and QA/QC matters
- Conducting laboratory evaluations and audits
- Reviewing laboratory data before they are released
- Coordinating data validation activities

- Providing updates on the project to project QA officers and managers with regard to the QA/QC data
- Ensuring that field personnel have adequate sampling supplies and equipment

**TtEMI Field Team Leader**

The TtEMI Field Team Leader is responsible for field activities. The Field Team Leader will direct all on-site activities, including those of subcontractors, and will ensure that the field team adheres to procedures described in the FSP. The Field Team Leader will be responsible for reviewing field logbooks and any field sampling forms completed in the field. The Field Team Leader will also be the liaison between TtEMI and NFD Point Molate personnel during field work.

**TtEMI Database Manager**

The TtEMI Database Manager coordinates the loading and checking data in the database. The Database Manager is also responsible for interacting with the Analytical Coordinator during preparation of the FSP and QAPP to address sample identification issues. In addition, the Database Manager is responsible for working with the Analytical Coordinator and the Field Team Leader to prepare for the field sampling effort. The project Database Manager is responsible for all aspects of developing and monitoring the database under the guidance of the Project Manager, as follows:

- Designing the database
- Selecting software
- Coordinating with data submitters
- Logging and transferring data
- Entering and verifying data
- Developing screen and report format
- Archiving data
- Assisting users in accessing and retrieving data
- Documenting the database
- Distributing the database
- Verifying software verification and change approvals
- Verifying and documenting all changes to the existing data

## A2.3 SPECIAL TRAINING REQUIREMENTS AND CERTIFICATION

Personnel who work at a hazardous waste project site are required to meet the health and safety training requirements of Title 29 Code of Federal Regulations (29 CFR) Part 1910.120(e), as described in the following sections. Depending on individual responsibilities in the field and the complexity of a

particular project, on-site personnel may be required to meet special training requirements defined in the work plan for the CTO. The following sections describe the training requirements for TtEMI personnel and subcontractors.

### A2.3.1 Personnel Health and Safety Training

TtEMI personnel working on hazardous waste project sites who are responsible for the project or site activities are required to undergo specific training before participating in, managing, or supervising field activities. This training must thoroughly cover the following areas:

- Names of personnel and alternates responsible for health and safety at a hazardous waste project site
- Health, safety, and hazards present on each site
- Selection of the appropriate personal levels of protection
- Correct use of PPE
- Work practices to minimize risks from hazards
- Safe use of engineering controls and equipment on site
- Medical surveillance requirements, including recognition of symptoms and signs that might indicate overexposure to hazardous substances
- Contents of the site-specific HASP
- Appropriate action to take in emergency situations

TtEMI personnel engaged in activities that may expose workers to hazardous substances and health hazards will receive a minimum of 40 hours of formal instruction off site and at least 3 days of actual field experience on site under the supervision of a trained, experienced field supervisor.

Field personnel who are directly responsible for, or who supervise employees engaged in, hazardous waste operations also will also receive the 40 hours of initial training, 3 days of supervised on-site field experience under a trained supervisor, and at least 8 additional hours of specialized supervisor training.

The specialized training will include the requirements of the CLEAN II health and safety program, the PPE and personal level of protection programs, the spill containment program, and health-hazard monitoring procedures and techniques. TtEMI's On-Site Safety Manager will receive an additional 8 hours of supervisor training. The On-Site Safety Manager will also receive additional health and safety training, including training in operating monitoring instruments.

Written certificates will be presented to all employees who successfully complete the training. TtEMI employees engaged in work at hazardous waste sites are required to undergo 8 hours of annual refresher training to maintain certification.

The TtEMI Field Team Leader, who is the on-site manager with authority delegated by the project manager to direct field operations, will be fully trained in hazardous waste field operations and will ensure that all necessary preparation and coordination are complete before on-site work begins. That preparation generally consists of drafting project documents, such as the work plan, the FSP, the QAPP, and requests for bids and assisting in preparation of the site-specific HASP under the guidance of the Project Manager. In some instances, a Field Team Leader trains for this position by working on site as a team member before replacing the original Field Team Leader.

At least one member of every TtEMI field team will maintain current certification in the American Red Cross "Multimedia First Aid" and "Cardiopulmonary Resuscitation Modular," or equivalent. The HASPM ensures that appropriate field personnel maintain current certification in both first aid and CPR.

Copies of TtEMI's health and safety training records, including course completion certifications for the initial health and safety training, first aid, CPR, and refresher training, will be maintained in project files. The HASPM implements the training requirements by notifying employees when they are due for recertification, disseminating information about appropriate course, conducting or assisting in refresher training, and performing related tasks.

### A2.3.2 Subcontractor Training

Subcontractors that work on site will certify that their employees have been trained for work on hazardous waste project sites. The training will meet the Occupational Safety and Health Administration (OSHA) requirements at 29 CFR Part 1910.120(e). Before beginning work at the project site, the subcontractors will submit to the HASPM certification of training for each employee who will be involved in field work. Subcontractors also will ensure that these employees attend a pre-entry safety briefing. The subcontractors will also be responsible for providing their own safety equipment and PPE.

The pre-entry safety briefing is designed to inform subcontractor employees of the potential risks of working with hazardous materials, site-specific hazards, the required level of personal protection, and the correct use of PPE. This safety briefing is conducted by the on-site safety manager or other qualified person designated by the HASPM. Employees of associate and professional services firms and technical service subcontractors will attend a safety briefing before conducting on-site work. Construction service subcontractors are responsible for conducting their own safety briefings. TtEMI personnel may audit these briefings.

Job hazards for most environmental investigation field tasks are described in the basewide HASP (PRC Environmental Management, Inc. 1996). Section 4.0 of the basewide HASP discusses hazard identification and analysis and describes physical, industrial, chemical, radiation, and biological hazards. Site-specific hazards are also discussed in Section 7.0 of the attached work plan.

### A2.4 PROJECT SCHEDULE

The implementation schedule for sampling, analysis, and associated reporting is presented in Figure 12-1 of the work plan to which this QAPP is attached.

## A3 PROBLEM DEFINITION AND BACKGROUND

NFD Point Molate was a storage facility from 1943 through 1995 for jet turbine fuels (JP-5 and JP-8) and marine diesel fuel (F-76) and had a storage capacity of more than 40 million gallons. Other fuels have historically been stored at the facility, including bunker fuel, gasoline, and aviation gasoline. Fuel storage and supply ceased in May 1995. NFD Point Molate became a closing base under the Base Realignment and Closure (BRAC) IV Program on September 30, 1995. A more detailed description of the history of Site 3 is presented in the Phase II Remedial Investigation (RI) Report (TtEMI 2000a). Evaluating the extent of potential soil and groundwater contamination, combined with field pilot testing of selected technologies at Site 3, will allow selection of the appropriate remedial action. The purpose of this investigation is described further in Section A3.1. Previous investigations of Site 3 are summarized in Section A3.2 and are discussed in greater detail in Section 2.2 of the work plan.

### A3.1 PURPOSE OF INVESTIGATION

The purpose of the sampling and field pilot testing of Site 3 is to further delineate the extent of TPH-p, TPH-e, BTEX, PAHs, VOCs, and metals in soil, and TPH-p, TPH-e, BTEX, VOCs, and metals in groundwater. Collection of soil and groundwater samples for analysis of parameters specific to natural attenuation is required to determine whether natural attenuation is a potential remediation approach. Also, field pilot testing will be used to evaluate air sparging-SVE and MPE as possible remediation technologies for contaminated soil and groundwater. Sampling and field pilot testing will be conducted as part of the EE/CA for Site 3. The objectives of sampling and pilot testing are detailed in Section 1.1 of the work plan.

## A3.2 PREVIOUS INVESTIGATIONS

Previous investigations at Site 3 are described in Section 2.2 of the work plan to which this QAPP is attached. In summary, these investigations include a Site Inspection (PRC 1992), a Phase I RI (PRC 1994g), four quarterly groundwater monitoring events (PRC 1994a, 1994b, 1994d, 1995), a Phase II RI (TtEMI 2000a), and Phase I field pilot testing (TtEMI 1998).

# A4 PROJECT AND TASK DESCRIPTION

The following paragraphs summarize the objectives of and tasks necessary to complete sampling and the FPT for Site 3. The primary objectives, types of data to be collected, quality standards and criteria for those data, and project documentation are discussed below. The DQO steps for sampling and pilot testing at Site 3 are presented in Table A-2 of this QAPP. A general discussion of DQO steps is provided in Section A1.2 of this QAPP, and specific details related to each DQO step are discussed throughout this document.

## A4.1 PROJECT OBJECTIVES

The overall objectives of this investigation are to further delineate the extent of TPH-p, TPH-e, BTEX, VOCs, and metals in groundwater; and TPH-p, TPH-e, BTEX, PAHs, VOCs, and metals in soil to define the recommended remediation area. As noted in Section A3.1, standard methods of in situ remediation for TPH-p and TPH-e are not effective at all of Site 3 because of the relatively high viscosity and density of bunker fuel. Pilot testing will be used at Site 3 to evaluate the technical and economic feasibility of air sparging-SVE and MPE as possible remediation approaches for portions of Site 3 with primarily diesel fuel contamination. Collection of soil and groundwater samples for analysis of parameters specific to natural attenuation is required to evaluate whether natural attenuation is a potential remedial approach for all portions of Site 3. Specifically, the objectives of the work plan for Site 3 are:

- Further delineate the lateral and vertical extent of TPH-p, TPH-e, BTEX, PAHs, VOCs, and metals in soil to define the area recommended for remediation.
- Further delineate the lateral and vertical extent of TPH-p, TPH-e, BTEX, VOCs, and metals in groundwater to define the area recommended for remediation.
- Evaluate the technical feasibilities of air sparging-SVE and MPE through site-specific field pilot testing.
- Collection of soil and groundwater samples for analysis of parameters specific to natural attenuation to evaluate whether natural attenuation is a potential remediation approach.

## A4.2 PROJECT MEASUREMENTS

Groundwater samples will be analyzed for TPH-p (EPA 8015), TPH-e (EPA 8015), BTEX (EPA 8021), , metals (Contract Laboratory Program [CLP] metals), heterotrophic plate count (Total HPC) (SM 9215), TKN (SM 4500-NORGB), orthophosphate (o-$PO_4$) (EPA 365.1), dissolved ferrous iron (Fe (II)) (SM 3500-FeD), sulfate (EPA 300.0), and nitrate (EPA 300.0). Twelve groundwater samples collected from areas where VOCs (EPA 8260b) have previously been detected will be analyzed for VOCs. A total of 36 groundwater samples, not including QC samples, will be collected for laboratory analysis. Field measurements of groundwater, including pH, temperature, oxidation reduction potential, (ORP), dissolved oxygen (DO), and conductivity will be collected during the investigation. Details on groundwater sampling are provided in Section 4.5 of the accompanying FSP. All sampling locations will be clearly marked in the field and surveyed by land surveying techniques as soon as possible after sampling. Sampling locations and methods are described in Sections 4.5 of the accompanying FSP.

Soil samples will be analyzed for TPH-p (EPA 8015), TPH-e (EPA 8015), BTEX (EPA 8021), PAHs (EPA 8310), VOCs (EPA 8260b) , metals (CLP metals), and total HPC (SM 9215). A total of 60 soil samples, not including QC samples, will be collected for laboratory analysis. TPH-p, BTEX, and VOC samples will be collected and prepared using EPA Method 5035.

Soil gas samples will be analyzed by a California state-certified laboratory and approved by the Navy. Analyses include, TPH-diesel (modified National Institute for Occupational Safety and Health [NIOSH] 1550, VOCs (EPA TO-17). A total of three sets of soil gas samples will be collected for laboratory analysis. Field measurements of soil gas, including hydrocarbon concentration, oxygen, and carbon dioxide, will be collected during system monitoring. All field measurements will be conducted according to manufacturer recommendations for specific field instrumentation Section 4.6 of the associated FSP provides greater detail on soil gas sampling procedures.

Analytical methods were selected to provide data of necessary quality to meet the DQOs for this project and to maintain consistency and comparability with existing site data. The data collected during this study must be compared to previous data in order to meet project DQOs.

Development and decontamination water will be placed in containers and disposed of using the on-site wastewater treatment system.

## A4.3 PROJECT QUALITY STANDARDS AND CRITERIA

To promote the quality and consistency of data acquisition and evaluation during sampling and pilot testing, all project activities will be completed in accordance with this QAPP, the Field Work Plan, and the accompanying FSP. The QAPP describes the technical and quality objectives of the project, the

intended data collection methods that are appropriate for achieving project objectives, the assessment procedures adequate for confirming that data of the type and quality needed and expected are obtained, and any identified limitations on the use of these data.

Analytical data generated during this work will undergo validation and verification to promote defensible and acceptable quality. Data validation and usability are discussed further in Section D1 of this QAPP. An independent third-party contractor will validate data in accordance with SWDIV Environmental Work Instruction 4EN.1 (Navy 1999). At a minimum, 10 percent of the analytical data will be randomly selected and fully validated. All remaining analytical data will undergo cursory validation.

The assessment tools needed to verify that data quality is maintained throughout the study include QC reviews on project documents such as technical, editorial, and QC coordinator reviews; performance and system audits; and laboratory QA/QC procedures. Project audits are described further in Section C1.1 of this QAPP. Laboratory QA/QC procedures are addressed in Section B6 of this QAPP.

## A4.4 PROJECT DOCUMENTATION

The following sections describe how field documentation and records are maintained. Additional information about sample and location nomenclature is provided in Section 6.0 of the accompanying FSP. Sample documentation such as sample labels, chain-of-custody (COC) procedures, and packaging and shipping procedures, is discussed in Section B4 of this QAPP.

### A4.4.1 Field Forms

The following field forms will be maintained, as appropriate, for this field activity at NFD Point Molate:

- COC form
- Permanently bound field logbooks
- Extended COC form
- Groundwater sampling data sheet
- Borehole log
- Monitoring well installation record
- Well development data sheet
- Daily data quality control report

The Field Team Leader will be responsible for the maintenance of all field forms. These forms are presented in Appendix 1 of this QAPP and will be used as source documents in support of the NFD Point Molate database. The following general guidelines for maintaining field documentation will be used:

- Documentation will be completed in permanent black ink.
- All entries will be legible.
- Errors will be corrected by crossing out with a single line by dating and initialing the lineout.
- Any serialized documents will be maintained on site and referenced in the site logbook.

Field personnel will use permanently bound field logbooks with sequentially numbered pages to maintain field records. The front cover of the logbook will list the contract name and number, the CTO number, the site name, the names of subcontractors, the client, and the name of the project manager. All entries in the logbook will be dated and signed. The Field Team Leader will be responsible for maintaining the field logbook, including signing and dating on all entries within the logbook. At a minimum, the following information will be recorded in the field logbook:

- Name and affiliation of all personnel or visitors on site
- Log and summary of daily activities and significant events
- Notes of conversations with coordinating officials
- Identification numbers of instruments used
- Results of calibrations and field measurements
- Documentation of sampling activities
- Decontamination episodes
- Discussion of problems encountered and their resolution
- Discussion of deviations from the FSP, QAPP, or other governing documents
- Description of all photographs taken

## A5 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

The seven-step DQO process, described in EPA QA/G-4 (2000), was used in developing quality objectives for this work (see Table A-2). The first step of the DQO process, "state the problem," is discussed in Section A3 and in the following section (A5.1). The specific quality objectives and criteria for measurement data, as they apply to this project, are also discussed in the following sections.

## A5.1 PROJECT SCOPE AND ENVIRONMENTAL MEDIA

Soil samples will be collected from the former FRF, the Treatment Ponds Areas, and from the vicinity of former Tanks E, F, and G (which are in the Treatment Ponds Area or the former FRF area). The 60 soil samples, not including QC samples, that will be collected, were selected based on data gaps from previous site investigations. Of the 60 soil samples; 23 surface samples will be collected (0 to 3 feet bgs); 23 samples will be collected between 5 to 10 feet bgs ; 10 soil samples will be collected from depths coincident with five of the new monitoring well screen intervals (see Table 4-1 of the FSP) and 4 soil samples will be collected at the total depth (bottom) of the boring; specifically near or at the top of the Bay Mud. Soil samples will be analyzed for TPH-p, TPH-e, BTEX, PAHs, VOCs, metals, and HPC.

To satisfy the field pilot testing portion of sampling, soil gas samples will be collected to supply data for evaluating remedial technologies. Soil gas samples will be analyzed for TPH and VOCs.

Fourteen new monitoring wells will be installed and developed during this investigation. Groundwater samples will be collected from the new wells and 22 previously installed wells for a total of 36 groundwater samples. Duplicate samples will be collected at a frequency of 10 percent. Groundwater samples will be analyzed for TPH-p, TPH-e, BTEX, VOCs, metals, HPC, TKN, anions (sulfate, nitrate, and orthophosphate), and Fe(II). Field measurements of groundwater, including DO, pH, temperature, ORP, and conductivity, will be collected during the investigation.

A TtEMI subcontractor will conduct geophysical surveys. The surveys will be conducted to provide aerial coordinates necessary for locating the new monitoring wells and boring locations on site plans. Vertical survey data will also be entered into the project database for use in calculating water and product elevations based on field measurements.

Investigation-derived waste will be handled according to the procedures outlined in Section 4.9 of the FSP.

## A5.2 INTENDED DATA USERS AND USES

Data users include stakeholders, such as the regulatory agencies, the Navy, subcontractors to the Navy, and the general public. Data will be used to further (1) delineate the lateral and vertical extent of contamination, (2) to adequately identify the potential remediation approaches, and (3) evaluate whether any threat to human health or the environment exists at Site 3.

## A5.3 DATA TYPE AND QUANTITY

The data obtained from chemical analysis of the samples collected during the tasks covered by this work plan will be used to further delineate the extent of free product and residually saturated soils at site 3, further delineate the relative concentrations of hydrocarbons and other compounds in soils, to assess the dissolved hydrocarbon and VOC concentrations in groundwater, and to identify the most economic and technically feasible remediation approach for Site 3. The newly acquired data from this investigation will be compared with background levels to identify the lateral and vertical extent of contamination at Site 3.

Data obtained from laboratory analysis can best be categorized as definitive and will be used as the basis for appropriate decision-making. Definitive data are described in detail in the following subsection to establish that the data collected during this investigation will be of sufficient quality and quantity to meet the stated DQOs.

### A5.3.1 Definitive Data

Definitive data for this project will be generated off site in analytical laboratories using the methods described in Section B5 of this QAPP. Definitive data will be obtained from the analysis of soil and groundwater samples. Samples will be analyzed by Navy-approved and State of California-certified laboratories. QA/QC elements required for definitive data are as follows:

- Sample documentation (location, date and time collected, and batch)
- COC forms (when appropriate)
- Holding times
- Instrument calibration (mass spectrometer tuning)
- Sampling design (systematic, simple or stratified random, or judgmental)
- Initial and continuing calibration
- Determination and documentation of detection limits (instrument detection limits [IDL] and method detection limits [MDL])
- Analyte identification
- Analyte quantitation
- QC blanks (trip, method, and rinsate)
- Matrix spike (MS) recoveries

- Performance evaluation samples
- Matrix duplicate or determination of analytical error
- Field duplicates or determination of total sampling and measurement error

The MS and matrix spike duplicate (MSD) measures the precision of an analytical method and is indicative of matrix interference. An appropriate number of replicate aliquots, as specified in this QAPP, are collected from at least one thoroughly homogenized sample. A project-specific MS/MSD must be analyzed with each analytical batch of the project. Field duplicates provide an assessment of the overall precision of the measurement system, from sample acquisition through analysis. The variance, mean, coefficient of variation, and relative percent difference (RPD) are calculated for each matrix under investigation.

Field QC samples are collected in addition to field samples and are used in conjunction with laboratory QC samples to evaluate the quality of the data produced from the field sampling program. QC samples serve DQOs by meeting the established acceptance criteria specified in this QAPP and in each analytical method. Results for QC samples that do not meet the criteria because of matrix interference may serve as indicators of unacceptable data and may cause the laboratory to implement corrective action procedures or to qualify the data. Specific requirements for field and laboratory QC are presented in Section B6 of this QAPP.

## A5.4 ACCEPTABLE LEVEL OF CONFIDENCE IN THE DATA

Step 6 of the DQO process quantifies the acceptable limits on decision errors (see Table A-2). The limits are needed to define the uncertainty that will be acceptable to all stakeholders (such as regulatory agencies, citizens, and site owners). However, because of the nature and existing knowledge of the contaminants, coupled with the widespread contaminant distribution at Site 3, the use of a statistically based sampling design was limited (EPA 1999b). Instead, existing knowledge of site geology, hydrology, and distribution of contaminants will be applied to a judgmental sampling approach to delineate the extent of contaminated soil and groundwater.

## A5.5 SPECIFYING PERFORMANCE CRITERIA: PARCC PARAMETERS

All analytical results will be assessed according to the precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters described below. Precision and accuracy goals for each analytical method are presented in Appendix 3.

### A5.5.1 Precision

Precision is the degree of mutual agreement between individual measurements of the same property under prescribed similar conditions. Field sampling and laboratory analytical precision affect data precision. It is evaluated by collecting and analyzing field duplicates at a frequency of 10 percent. Laboratory analytical precision is evaluated by analyzing MS/MSDs at a rate of 5 percent of the total number of samples collected, or 1 MS/MSD per each project-specific analytical batch. The results of the duplicate analysis are used to calculate the RPD used for evaluating precision.

The RPD is calculated using the following formula:

$$RPD = \frac{|A - B|}{(A + B)/2} \times 100\%$$

Where A = first duplicate concentration
B = second duplicate concentration

Field measurement precision will be evaluated based on the results of field duplicate measurements. At least 10 percent of the field measurements for water and soil samples will be obtained in duplicate, and the results will be compared with established acceptance criteria provided in Appendix 3 of this QAPP.

Four factors may impair the precision of duplicate data: matrix interference, laboratory imprecision, sample heterogeneity, and the nature of the RPD calculation. Chemical constituents present in the field sample that interfere with accurate quantification of the target analytes cause matrix interference. Laboratory imprecision is a result of inconsistency in preparing and analyzing the samples.

Heterogeneity in soil samples is inherent because of the varied composition of natural materials and the subsequent difficulty in collecting a homogenous sample. Due to the heterogeneous nature of soil samples, field duplicate analytical results are used to determine sample variability and not for sampling precision. Sample variability is not an objective for this project, therefore, field soil sample duplicates will not be collected.

The control limits for precision on field duplicates and laboratory MSs are set at 25 percent RPD for water samples. The MS/MSD recovery limits are provided in Appendix 3. These control limits are

provided using professional judgment and are intended as guidelines for precision in the field and laboratory.

Laboratory imprecision and precision determination will require the analysis of a laboratory control spike/laboratory and spike duplicate (LCS/LCSD). If the LCS/LCSD do not met the QC criteria, the LCS/LCSD will be reanalyzed, as well as and all associated samples.

### A5.5.2 Accuracy

Accuracy is the degree of agreement between an analytical measurement and a reference accepted as a true value. The accuracy of a measurement system is affected by errors introduced through the sampling process by field contamination, sample preservation, and sample handling. Other factors that may affect accuracy are sample matrix, sample preparation, and analytical techniques. Sampling accuracy will be evaluated based on the results of the analysis of field blanks, trip blanks, and source-water blanks. The analytical laboratory will conduct a program of sample spiking to evaluate laboratory accuracy. This program includes analysis of the MS/MSD samples, LCS or blank spikes, surrogate standards, and method blanks. MS/MSD samples are prepared and analyzed at a frequency of 5 percent, LCS or blank spikes are analyzed at a frequency of 5 percent (or per analytical batch), and surrogate standards, where applicable, are added to every sample analyzed for organic constituents. The results of the spiked samples are used to calculate the percent recovery (%R) for evaluating accuracy.

%R is calculated using the following formula:

$$\text{Percent Recovery (\%R)} = \frac{S - C}{T} \times 100\%$$

Where
S = Measured spiked sample concentration
C = Sample concentration
T = True or actual concentration of the spike

Results that fall outside of the acceptance range specified in Appendix 3 of this QAPP will be evaluated further on the basis of other QC samples.

### A5.5.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent the characteristics of a population, parameter variations at a sampling point, or an environmental condition that they are intended to represent. Representativeness of data will be ensured through the use of established field and laboratory procedures and their consistent application. To aid in the evaluation of

the representativeness of the sample, field and laboratory blank samples and background samples will be evaluated for the presence of contaminants. Data determined to be nonrepresentative, by comparison with the existing data, will be used only if accompanied by appropriate qualifiers and limits of uncertainty.

### A5.5.4 Completeness

Completeness is a measure of the percentage of project-specific data that are usable and valid. Valid data are obtained when samples are collected and analyzed in accordance with QC procedures outlined in this QAPP, and when none of the QC criteria that affect data usability are exceeded. Other factors not related to the validity of the data can affect completeness, such as lost or broken samples. The project completeness value will be calculated when sampling has been completed and all data have been validated. Completeness will be calculated by dividing the number of useable sample results by the total number of planned sample results for this source removal. The completeness goal for this project is 90 percent.

### A5.5.5 Comparability

The comparability objective determines whether analytical conditions are sufficiently uniform for each analytical run to ensure that all of the reported data will be consistent. Comparability is ensured through the use of similar analytical methods from one investigation to the next. Analytical techniques that will be used for this field investigation are comparable to techniques used by previous investigators at NFD Point Molate.

## A5.6 DETECTION AND QUANTITATION LIMITS

Tables of detection limits for analytes specified for sampling and pilot testing are included in Appendix 2 of this QAPP. The IDL is the minimum concentration of an analyte that can be distinguished from the normal electronic noise of an analytical instrument. The quantitation limit represents the lowest concentration at which an analyte can be accurately and reproducibly quantified. The PRRL is a chemical-specific level that a laboratory should be able to routinely detect and quantitiate in a given sample matrix. The PRRL is usually defined in the analytical method or in project-specific documentation. Since both the project required reporting limits (PRRLs) and IDLs are significantly lower than regulatory standards the PRRLs are the minimum detection or quantitation limits that are required to meet the project objectives. Method references for this project are listed in Table B-2 of this QAPP.

PRRLs are the minimums that are required to meet project objectives. In this investigation, results for samples analyzed will be reported as estimated values if concentrations are less than the PRRL, but greater than sample-specific MDLs.

## A6 DOCUMENTATION AND RECORDS

Documentation is critical for evaluating the success of any activity. The following sections discuss the requirements of laboratories for preparing definitive data packages. The electronic data deliverable (EDD) delivered to the Navy at the conclusion of the work covered by this work plan will be in a format compatible with the Navy Environmental Data Transfer Standard (NEDTS).

### A6.1 SUMMARY DATA PACKAGE

The CLP-type summary data packages will be required for all analyses and will contain sample results (Form I) and all QA/QC summary forms (Forms II through X for organic compounds and Forms II through XIV for inorganic compounds) for all associated samples in one sample delivery group (SDG). Form I will include all sample results, corrected for dilution and soil moisture, as appropriate. If the client sample identification (ID) has been truncated because of software limitations, the complete sample ID will appear on Form I, either in the comments section or hand-printed after the truncated ID.

An SDG is a group of 20 or fewer samples for the same project received within a period of 14 days or less. An SDG is mainly a reporting format and is not limited to sample receipt groups, preparation batches, or analytical batches. The SDG name will be a unique number that is not an actual sample ID or a part of an actual sample ID. Data for all samples in the SDG will be submitted concurrently. Partial submittals are unacceptable. The subcontractor will provide TtEMI with two copies of the summary data package within 28 days after receiving the last sample in the SDG. This package will be part of the standard analytical service.

For ease of use, summary data packages should not be bound and should be separated by analysis. Each summary data package will consist of a case narrative, copies of all associated COC forms, sample results, and QA/QC summaries. The case narrative will include the following information:

- Subcontractor name, project name, CTO (project) number, project order number, SDG number, and a table that cross-references client and laboratory sample IDs
- Detailed documentation of all sample shipping and receiving, preparation, analytical, and quality deficiencies, including analyses performed without an American Association for Laboratory Accreditation certified standard

- Thorough explanation of all instances of manual integration
- Copies of all associated nonconformance and corrective action forms that will describe the nature of the deficiency and the corrective action taken
- Copies of all associated sample receipt notices

### A6.1.1 Organic Analysis

The following outline describes the format of the summary data package for organic analysis:

Section I - **Case Narrative**

1. Case narrative
2. Copies of nonconformance and corrective action forms
3. COC forms
4. Copies of sample receipt notices
5. Internal tracking documents, as applicable
6. Cross-reference tables for field sample ID and laboratory ID
7. Summary report of analytical results

Section II - **Sample Results** - Form I for the following:

1. Environmental samples, including dilutions and reanalysis
2. Tentatively identified compounds (TIC)

Section III - **QA/QC Summaries** - Forms II through VIII for the following:

1. System-monitoring compound and surrogate recoveries (Form II)
2. MS/MSD recoveries and RPDs (Forms I and III)
3. Blank spike or LCS recoveries (Forms I and III-Z)
4. Method blanks (Forms I and IV)
5. Performance check (Form V)
6. Initial calibrations with retention time information (Form VI)
7. Continuing calibrations with retention time information (Form VII)
8. Quantitation limit standard (Form VII-Z)
9. Internal standard areas and retention times (Form VIII)
10. Analytical sequence (Forms VIII-D and VIII-Z)
11. Gel permeation chromatography calibration (Form IX)
12. Matrix-specific MDL (Form XI-Z)

### A6.1.2 Inorganic Analysis

The following outline describes the format of the summary data package for inorganic analysis:

Section I - **Case Narrative**

1. Case narrative
2. Copies of nonconformance and corrective action forms

3. COC forms
4. Copies of sample receipt notices
5. Internal tracking documents, as applicable

Section II **Sample Results** - Form I for the following:

1. Environmental samples (including dilutions and reanalysis)

Section III **QA/QC Summaries** - Forms II through XIV for the following:

1. Initial and continuing calibration verifications (Form II)
2. CRDL standard (Form II)
3. Detection limit standard (Form II-Z)
4. Method blanks, continuing calibration blanks, and preparation blanks (Form III)
5. Inductively coupled plasma (ICP) interference-check samples (Form IV)
6. MS and post digestion spikes (Forms V and V-Z)
7. Sample duplicates (Form VI)
8. LCSs (Form VII)
9. Method of standard additions (Form VIII)
10. ICP serial dilution (Form IX)
11. IDLs (Form X)
12. ICP interelement correction factors (Form XI)
13. ICP linear working range (Form XII)

## A6.2 FULL DATA PACKAGE (CONTRACT LABORATORY PROGRAM AND CONTRACT LABORATORY-TYPE)

Full data packages will contain all the information from the summary data package and all associated raw data for samples in one SDG. When a full data package is required, the subcontractor will provide it to TtEMI within 35 days after receiving the last sample in the SDG. Unless otherwise requested, the subcontractor will deliver one copy of the full data package; no more than two copies will be requested. For ease of use, the full data package should be separated by analysis and should be bound. The full data package will consist of a case narrative, copies of all associated COC records, sample results, QA/QC summaries, and all associated raw data.

### A6.2.1 Organic Analysis

The following outline describes the format of the full data package for organic analysis:

Sections I, II, and III - **Summary Package**

Section IV - **Sample Raw Data** - indicated form, plus all associated raw data

1. Analytical results, including dilutions and reanalysis (Forms I and X)

2. TICs (Form I —PAH and VOC analyses only)

Section V - **QC Raw Data** - indicated form, plus all associated raw data

1. Method blanks (Form I)
2. MS/MSD samples (Form I)
3. Blank spikes or LCSs (Form I)

Section VI - **Standard Raw Data** - indicated form, plus all associated raw data

1. Performance check (Form V)
2. Initial calibrations, with retention time information and %RSD information (Form VI)
3. Continuing calibrations, with retention time information (Form VII)
4. Quantitation limit standard (Form VII-Z)

Section VII - **Other Raw Data**

1. Percent moisture for soil samples
2. Sample extraction and cleanup logs
3. Instrument analysis log for each instrument used (Form VIII-Z)
4. Standard preparation logs, including initial and final concentrations for each standard used
5. Formula and a sample calculation for the initial calibration
6. Formula and a sample calculation for water and soil sample results

### A6.2.2 Inorganic Analysis

The following outline describes the format of the full data package for inorganic analysis:

Sections I, II, III - **Summary Package**

Section IV - **Instrument Raw Data** - Sequential measurement readout records for ICP, graphite furnace atomic absorption (GFAA), flame atomic absorption, cold vapor mercury, cyanide, and other inorganic analyses, which will contain the following information:

1. Environmental samples, including dilutions and reanalysis
2. Initial calibration
3. Initial and continuing calibration verifications
4. Detection limit standards
5. Method blanks, continuing calibration blanks, and preparation blanks
6. ICP interference check samples
7. MS and post-digestion spikes
8. Sample duplicates
9. LCSs
10. Method of standard additions
11. ICP serial dilution

Section V - **Other Raw Data**

1. Percent moisture for soil samples
2. Sample digestion, distillation, and preparation logs, as necessary
3. Instrument analysis log for each instrument used

4. Standard preparation logs, including initial and final concentrations for each standard used
5. Formula and a sample calculation for the initial calibration
6. Formula and a sample calculation for water and soil sample results

## A6.3 DATA PACKAGE FORMAT

EDDs are required for all NFD Point Molate analytical results. An automated laboratory information management system (LIMS) must be used to produce the EDD. Manual creation of the deliverable (data entry by hand) is unacceptable. The laboratory will verify EDDs internally before they are issued. The EDD will correspond exactly to the hard-copy data. EDDs will be delivered in a format compatible with NEDTS. No duplicate data will be submitted.

Results that should be included in all EDDs are:

- Target analyte results for each sample and associated analytical methods requested on the COC form
- TIC results reported for the SVOC analyses
- Method and instrument blanks and preparation and calibration blank results reported for the SDG
- %Rs for the spike compounds in the MS, MSDs, blank spikes, or LCSs
- Matrix duplicate results reported for the SDG form
- The percent moisture or the percent solids for each solid sample; this determination will be made once for each solid sample listed on the COC form. The results for these determinations will be reported in the same manner as for all other target analyte results.
- All reanalyses, reextractions, or dilutions reported for the SDG, including those associated with samples and the specified laboratory QC samples

### A6.3.1 Data Storage and Disposal

Electronic and hard-copy data must be retained for a minimum of 3 and 10 years, respectively, after final data have been submitted. The subcontractor will use an electronic storage device or other similar storage device that is capable of recording data for long-term off-line storage.

## A6.4 DATA ARCHIVING AND RETRIEVAL

Field and analytical data collected for this project and other environmental investigations are critical to all site characterization efforts, comprehensive conceptual model development, risk assessments, and the selection of remedial actions to protect human health and the environment. An information management

system is needed to ensure efficient access to these data so that the goals of real-time and on-site decision-making can be achieved. Data collected during this investigation will be loaded into TtEMI's relational database and will be provided to the Navy in a format compatible with NEDTS for inclusion in the SWDIV environmental database.

### A6.4.1 Data Management Scheme

To satisfy long-term data management goals, the data will be loaded into the database system at TtEMI for storage, further manipulation, and retrieval after review and validation of off-site laboratory and field reports. The database will be used to provide data for chemical and geologic analysis and for preparing reports and graphic representations of the data. Additional data acquired from field activities will be recorded on field forms (see Appendix 1). These forms are reviewed for completeness and accuracy by the project chemist or geologist. All field forms and related COC forms are recorded in the database. Hard copies of forms, data, and COC forms are filed in a secure storage area, according to project and document control numbers. Laboratory data packages and reports will be archived at TtEMI or Navy offices. The remaining data will be archived at the off-site laboratory for a minimum of 10 years.

### A6.4.2 Data Management Strategy

Short- and mid-term strategies for data management require that the NFD Point Molate data set be updated monthly. The data consist of chemical and field data from Navy contractors. The Navy's contractors have entered previous NFD Point Molate data into an Oracle (Version 7.3) database, which can generate reports using available computer-aided drafting and design and contouring software. The electronic data delivered to the Navy at the conclusion of the sampling and testing will be in a format compatible with the NEDTS.

# B1 MEASUREMENT AND DATA ACQUISITION

This section describes requirements for the following:

- Sampling process design (Section B2)
- Sampling methods (Section B3)
- Collection, handling, and analysis of samples (Sections B4 and B5)
- QC samples and procedures (Section B6)
- Instrument calibration and maintenance (Section B7)
- Analytical supplies and miscellaneous equipment (B8)

This section provides sufficient detail to evaluate whether the methods used for this project have been verified and documented.

# B2 SAMPLING DESIGN (EXPERIMENTAL DESIGN)

This section contains the following information:

- Types of samples required
- A description of the sampling network design
- Sampling frequencies and matrices
- Measurement parameters of interest
- Design rationale

A tentative summary of the number of samples to be collected and the analyses required for each sample can be found in Table B-1. Analytical methods that will be used to analyze samples are presented in Section B5.

## B2.1 SAMPLING OVERVIEW

About 22 groundwater samples will be collected from existing well locations that have been selected based on data gaps from previous site investigations. Also, 14 groundwater samples will be collected from new wells to be installed in areas that have not previously been sampled. Groundwater sampling locations will be within the Treatment Ponds Area and the former FRF.

## TABLE B-1

## SITE 3 INVESTIGATION
## SAMPLING SUMMARY
## NFD POINT MOLATE

| Parameter | Analytical Method | Soil | Groundwater | Soil Vapor | Soil Vapor Duplicates (minimum of 10 percent) | Groundwater Duplicates (minimum of 10 percent) | MS/MSD (at 5 percent) | Equipment Rinsates[a] | Trip Blanks | Total Number of Samples |
|---|---|---|---|---|---|---|---|---|---|---|
| TPH-e | EPA 8015B | 59 | NA | NA | NA | NA | 3 | 3 | NA | 65 |
| TPH-e | EPA 8015B | NA | 36 | NA | NA | 4 | 2 | 4 | NA | 46 |
| TPH-p | EPA 8015B | NA | 36 | NA | NA | 4 | 2 | 4 | 2 | 48 |
| TPH-p | EPA 8015B/5035 | 59 | NA | NA | NA | NA | 3 | 3 | 4 | 69 |
| TPH-diesel | NIOSH 1550 | NA | NA | 3 | NA | NA | NA | NA | NA | 3 |
| BTEX | EPA-8021B | NA | 24 | NA | NA | 3 | 2 | 3 | 2 | 34 |
| BTEX | EPA 8021B/5035 | 34 | NA | NA | NA | NA | 2 | 2 | 4 | 42 |
| VOCs | EPA 8260B | NA | 12 | NA | NA | 1 | 1 | 1 | 1 | 16 |
| VOCs | EPA 8260B/5035 | 28 | NA | NA | NA | NA | 2 | 2 | 4 | 36 |
| VOCs | EPA TO-17 | NA | NA | 3 | NA | NA | NA | NA | NA | 3 |
| Metals | CLP Metals | NA | 2 | NA | NA | 1 | 1 | 1 | NA | 5 |
| Metals | CLP Metals | 8 | NA | NA | NA | NA | 1 | 1 | NA | 10 |
| HPC | SM 9215 | 5 | NA | NA | NA | NA | NA | NA | NA | 5 |
| HPC | SM 9215 | NA | 8 | NA | NA | 1 | NA | NA | NA | 9 |
| TKN | SM 4500-NORGB | NA | 8 | NA | NA | 1 | 1 | 2 | NA | 12 |
| o-$PO_4$ | EPA 365.1 | NA | 8 | NA | NA | 1 | 1 | 2 | NA | 12 |
| Fe (II) | SM 3500-FeD | NA | 8 | NA | NA | 1 | 1 | 2 | NA | 12 |
| Sulfate | EPA 300.0 | NA | 8 | NA | NA | 1 | 1 | 2 | NA | 12 |
| Nitrate | EPA 300.0 | NA | 8 | NA | NA | 1 | 1 | 2 | NA | 12 |
| PAHs | EPA 8310 | 47 | NA | NA | NA | NA | 3 | 3 | NA | 53 |

[a] Number of equipment rinsate samples is estimated based on 1 per day of sampling.

Notes:

BTEX Benzene, toluene, ethylbenzene, and xylene
CLP Contract Laboratory Program
Fe (II) Dissolved ferrous iron
o-$PO_4$ Orthophosphate
PAH Polynuclear aromatic hydrocarbons
TKN Total kjeldahl nitrogen
Total HPC Heterotrophic plate count
TPH-e Total petroleum hydrocarbons-extractable
TPH-p Total petroleum hydrocarbons-purgeable
TPH-diesel Total petroleum hydrocarbons as diesel
VOC Volatile Organic Compounds

[FPALDR]), scheduled for submittal in January 2001, several data gaps need to be filled. Sixty soil samples will be collected from locations that were selected based on data gaps from previous site investigations. These locations are within the Treatment Ponds Area and the former FRF. Proposed groundwater and soil sampling locations are shown in Plates 2-2 and 2-4 of the accompanying work plan. Duplicate groundwater samples will be collected from 10 percent of the total groundwater samples collected. All sampling locations will be clearly marked in the field and will be surveyed as soon as possible after sampling. Thirty-six groundwater samples, 60 soil samples, and the required QC samples will be collected. Groundwater samples will be analyzed for TPH-p, TPH-e, BTEX, VOCs, metals, HPC, TKN, orthophosphate, ferrous iron, sulfate, and nitrate. Soil samples will be analyzed for TPH-p, TPH-e, BTEX, VOCs, metals, HPC, and, PAHs. Field measurements of groundwater, including pH, DO, ORP, temperature, and conductivity, will be collected during the investigation. Additional information on the sampling design is presented in Section 3.0 and 4.0 of the work plan.

## B3 SAMPLING METHODS

This discussion describes the procedures for collecting samples and includes:

- Identification of all sampling methods to be used
- Implementation requirements
- Decontamination procedures
- Materials required

### B3.1 SAMPLE COLLECTION AND DECONTAMINATION

Fourteen monitoring wells will be constructed during this investigation. Screened intervals in the groundwater monitoring wells will be based on field observations of soil contamination. Monitoring wells will be installed in boreholes drilled using hollow-stem auger techniques. Monitoring well installation is described in greater detail in Section 4.4 of the accompanying FSP. Soil samples will be collected continuously in each borehole. Soil samples will be collected during drilling using a split spoon, as described in Section 4.3 of the FSP. For TPH-p, BTEX, and VOC analysis, a sample will be collected from the split spoon sample using an EnCore sampler. For the remaining soil analyses, TPH-e, PAHs, and metals, an 8-ounce jar will be used to collect soil samples from the split spoon. One groundwater sample will be collected from each of the new monitoring wells using traditional methods of purging three borehole volumes, followed by collection of a sample using a groundwater pump or bailer, as described in Section 4.5.2 of the FSP. Additional groundwater samples will be collected from 22 existing monitoring wells using the same collection and sampling procedures as above. Duplicate groundwater samples will be collected at a frequency of 10 percent. Field parameters (pH, DO, ORP, conductivity, and temperature) will be measured for each water sample.

All reusable sampling tools will be decontaminated between sampling locations. Soil sampling tools, including stainless-steel augers and split spoons, will be decontaminated by scrubbing in a solution of potable water and nonphosphate detergent (Alconox or Liquinox). The tools will then be double rinsed with distilled water. Sampling tools not used immediately after decontamination will be allowed to air dry and wrapped in plastic or aluminum foil. Decontamination fluids will be placed in containers and treated using the Site 3 groundwater treatment system currently operating at NFD Point Molate.

### B3.2 SAMPLING CONTAINERS, PRESERVATION, AND HOLDING TIMES

Analytical methods, type of sample containers to be used for each analysis, sample volumes required, preservation requirements for all samples, and maximum holding times for sample extraction and analysis are presented in Appendix 2 of this QAPP.

## B4 SAMPLE HANDLING, CUSTODY, AND SHIPPING PROCEDURES

Documentation and records, including field forms and field logbooks, are discussed in Section A4.4 of this QAPP. The sample handling and custody requirements for samples collected at NFD Point Molate are discussed in the following sections. The sections describe sample custody documentation and handling procedures to be followed in the field, during transportation of the samples to the laboratory, and at the laboratory.

### B4.1 SAMPLE CUSTODY PROCEDURES

Documentation during sampling is essential to ensure proper sample identification. Standard sample custody procedures will be used to maintain and document sample integrity during collection, transportation, storage, and analysis. Sample custody documents must be written in indelible black ink. The documents will be corrected by drawing one line through the incorrect entry, entering the correct information, and initialing and dating the correction. A sample is considered to be in custody if any one of the following statements applies:

- It is in a person's physical possession or view.
- It is in a secure area with restricted access.
- It is placed in a container and secured with an official custody seal such that the sample cannot be reached without breaking the seal.

Samples and documentation must be maintained in the custody of authorized personnel or under documented control in a secure area. Field team leaders are responsible for proper sample handling and documentation, so that possession and handling of individual samples can be traced from the time of collection to laboratory receipt. The laboratory's QA manager is responsible for establishing a sample control system that will allow sample possession to be traced from receipt by the laboratory to final sample disposition.

### B4.1.1 Sample Labels

A sample label will be affixed to all sample containers sent to the laboratory. This identification label will be completed with the following information written in indelible ink:

- Project name and site number
- Sample identification number
- Date and time of sample collection
- Preservative used
- Sample collector's initials
- Filtering (if applicable)
- Composite or grab
- Analysis required
- QC sample identification (if applicable)

If a sample is split with another party, sample labels with identical information will be attached to each sample container. After labeling, each sample will be refrigerated or placed in a cooler containing ice to maintain the sample temperature at 4 degrees Celsius (°C).

### B4.1.2 Custody Seals

Custody seals will be used on each sample transport container to ensure that no tampering occurs. Custody seals used during the project will consist of security tape with the date and initials of the sampler or field team leader. Sample transport containers will be sealed in this manner immediately after the samples are packaged. The tape will be placed such that the seal must be broken to gain access to the contents of the transport container.

### B4.1.3 Chain-of-custody Records

COC procedures provide an accurate written record that traces the possession of individual samples from the time of collection in the field until they are accepted at the laboratory. The COC record will also be used as documentation of the samples collected and the analysis requested. Appendix 1 to this QAPP provides an example of a COC record used by TtEMI. Laboratory-specific COC records may also be used depending on the site investigation. Information that the field personnel will record on the COC record includes:

- Project name and number
- Sample matrix type
- Name and signature of sampler
- Destination of samples (laboratory name)
- Sample identification number
- Date and time of collection
- Number and type of containers filled
- Analysis requested
- Preservatives used
- Filtering (if applicable)
- Signatures of individuals involved in transfer of custody (including date and time of transfer)
- Air bill number (if applicable)
- Relevant remarks related to sample analysis (such as samples selected for MS/MSD analysis)

Unused lines on the COC record will be crossed out. COC records initiated in the field will be signed by field personnel, the airbill number will be recorded, and the record will be placed in a plastic bag and taped to the inside of the shipping container used for sample transport. Copies of the COC record and the airbill will be retained and filed by field personnel prior to shipment. Multiple coolers may be sent in one shipment to the laboratory. Each cooler will contain a separate COC record of the samples. The outside of the coolers will be marked to indicate the number of coolers in the shipment.

### B4.1.4 Shipping Procedures

Samples collected during the field effort must be identified as environmental samples. Environmental samples are defined as samples of soil, groundwater, or other matrices that are not saturated or mixed with product material. U.S. Department of Transportation regulations will be followed during sample packaging and shipment. The following procedures meet these requirements and are explained in EPA guidance on field operations methods (EPA 1987):

- The cooler will be filled with bubble wrap, sample bottles, and packing material. Sufficient packing material will be used to prevent sample containers from making contact during shipment. Ice will be added to maintain the sample temperature at 4 °C during shipment.
- The COC records will be placed inside of a plastic bag. The bag will be sealed and taped to the inside of the cooler lid. The Federal Express airbill, if required, will be completed before the samples are handed over to the carrier. The laboratory will be notified if the sampler suspects that the sample contains any substance that would require laboratory personnel to take safety precautions.
- The cooler will be closed and taped shut with strapping tape around both ends. If the cooler has a drain, the drain will be taped shut both inside and outside of the cooler.
- Two signed custody seals will be placed on the cooler (one on the front and one on the back). Wide clear tape will be placed over the seals to prevent accidental breakage.
- The COC record will be transported inside of the sealed cooler. When the analytical laboratory receives the cooler, laboratory personnel will open it and sign the COC record to document the transfer of samples.

Samples may be held on site for more than 3 days during weekend field activities if there is no risk that analytical holding times will be exceeded. Samples collected on the weekend will be stored under refrigeration and shipped on the following Monday. Samples for analytes for which holding times are extremely short, such as 24 hours, will be shipped on the day of sampling. Collection of samples with extremely short holding times should not be scheduled for the weekend.

### B4.1.5 Cooler Receipt

Upon receiving a cooler, laboratory personnel will review the contents, sign the COC form and airbill, and retain both documents for their records. Information that will be recorded on the COC record or another appropriate document at the time of sample receipt will include:

- Status of the custody seals
- Temperature of the cooler

- Identification number of any broken sample containers
- Description of discrepancies between the COC records, sample labels, and requested analyses
- Observations of visible headspace in vials destined for VOC analysis, indicating inadequate sample collection procedures
- The pH of water samples received (the pH of VOC water samples will be documented at the time of analysis)
- Storage location of the sample and sample extracts

Laboratory personnel will contact the analytical coordinator about discrepancies in paperwork and sample preservation. Nonconformances and corrective actions should be documented in accordance with laboratory SOPs. These procedures will be available on file at the laboratory. After samples have been accepted, checked, and logged in, the laboratory must maintain them in a manner consistent with the custody and security requirements specified in the laboratory QA plan.

Samples and sample extracts will be assigned to a specific refrigerator in the laboratory. However, samples and sample extracts will be stored separately. VOC samples will be maintained in a separate refrigerator in an organic-free atmosphere. All laboratory refrigerators will be assigned numbers, and the refrigerator number will be recorded on a document that references the sample and extract locations. Only laboratory personnel will have access to the samples and will be required to sign a log sheet when removing samples and extracts from the refrigerators or replacing them. These log sheets will provide a COC record as the sample is moved within the laboratory. A COC record, similar to the record used for sampling procedures, will be completed for samples removed from the laboratory for disposal or other purposes. Laboratories will be accountable for all samples up until disposal.

## B5 ANALYTICAL METHODS REQUIREMENTS

Table B-2 presents analytical methods that will be used to analyze samples collected at Site 3. The analytical methods listed in Table B-2 were selected to provide data of the quality necessary to meet the DQOs for this project and to maintain consistency and comparability with existing site data. The data collected during the sampling and field pilot testing must be compared with previous data in order to meet project DQOs.

## TABLE B-2

## ANALYTICAL METHODS FOR NFD POINT MOLATE SITE 3

| Parameter | Method Number | Extraction Technique | Reference | Analyte List | Technique |
|---|---|---|---|---|---|
| TPH-p | CA LUFT &EPA 8015B | Purge and Trap/EPA 5035 | CA LUFT & SW-846 | Gasoline | GC/FID |
| TPH-e | CA LUFT & EPA 8015B | Sonication or Liquid-Liquid | CA LUFT & SW-846 | Diesel, Motor Oil, JP-5, JP-8 | GC/FID |
| TPH-diesel (Soil Vapor) | Modified NIOSH 1550 | Chemical Desorption ($CS_2$) | NIOSH 1550 | Diesel | GC/FID |
| BTEX | EPA 8021B | Purge and Trap | SW-846 | Benzene, Toluene, ethylbenzene, and xylene | GC/PID |
| VOCs | EPA 8260B | Purge and Trap/EPA 5035 | SW-846 | TCL + 30 TIC | GC/MS |
| VOCs (Soil Vapor) | EPA TO-17 | Thermal Desorption | EPA Compendium[1] | C3-C18 | GC/MS |
| Total Metals | CLP SOW/CLP Metals | ILM04.0 | EPA Inorganic SOW | TAL | ICP & AA |
| HPC | SM 9215 | NA | NA | NA | NA |
| TKN | SMEWW 4500-NORGB | Macro-Kjeldahl | SMEWW 1992 | Total Kjeldahl nitrogen | Distillation/calorimetric |
| o-$PO_4$ | EPA 300.0 | NA | EPA 1984 | Orthophosphate | Ion chromatography |
| PAHs | EPA 8310 | Sonication or Liquid-Liquid | SW-846 | TCL | HPLC |
| Fe (II) | SM 3500-FeD | EPA 3010A, 3020A, and 3050 | SW-846 | Ferrous iron | ICP & AA |
| Sulfate | EPA 300.0 | NA | EPA 1984 | Sulfate | Ion chromatography |
| Nitrate | EPA 300.0 | NA | EPA 1984 | Nitrate | Ion chromatography |

Notes:

[1] EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air
AA Atomic absorption spectroscopy
BTEX Benzene, toluene, ethylbenzene, xylene
EPA U.S. Environmental Protection Agency
Fe(II) Dissolved ferrous iron
FID Flame ionization detection
GC Gas chromatography
HPC Heterotrophic Plate count
HPLC High pressure liquid chromatography
ICP Inductively coupled plasma emission spectroscopy
LUFT Leaking underground fuel tank
MS Matrix spike
NORGB Nitrogen (organic) Macro-Kjeldahl method
0-$PO_4$ Orthophosphate
OLM Organic laboratory method
PAH Polynuclear aromatic hydrocarbon
PID Photo ionization detector
SOW Statement of work
SM Standard method
SVOC Semivolatile organic compound
TAL Target analyte list
TCL Target compound list
TDS Total dissolved solids
TIC Tentatively identified compound
TKN Total Kjeldahl nitrogen
TPH-e Total petroleum hydrocarbons-extractable
TPH-p Total petroleum hydrocarbons-purgeable
TSS Total suspended solids
VOCs Volatile organic compound

With approval from the Navy RPM, including the SWDIV QAO, other analytical methods approved by EPA and the Navy may be selected. Any modifications to the analytical methods presented in Table B-2 will be submitted to the Navy and regulatory agencies for review before use. A subcontract laboratory using methodologies approved by EPA for which it has been certified by the California Department of Health Services through the Environmental Laboratory Accreditation Program and approved by the Navy will analyze samples.

Analytical, data reporting, and validation procedures will be carried out in accordance with the protocols documented in this QAPP. Off-site laboratories will retain staff who have analytical expertise in (1) organic and inorganic analyses, (2) QA/QC procedures, (3) production of CLP-type data packages, and (4) operation and maintenance of the LIMS. The off-site laboratory will have sufficient qualified personnel and appropriate analytical instrumentation and sample storage available to technically and contractually carry out work required for NFD Point Molate.

## B6 QUALITY CONTROL REQUIREMENTS

The main functions of any sampling and analysis program are to obtain accurate, representative environmental samples and to provide valid analytical data. A program for evaluating field and laboratory data was developed to achieve these goals. The quality of the field data will be assessed through regularly scheduled collection and analysis of field QC samples. Laboratory QC samples will also be analyzed in accordance with referenced analytical method protocols to ensure that laboratory procedures and analyses are conducted properly.

The following subsections discuss the types of QC samples to be collected and analyzed for this project and their role in the assurance that project data are acceptable. QC procedures are not limited to those discussed in this section. Field and laboratory personnel, in accordance with specific method protocols, may implement additional procedures. The following subsections discuss field QC samples, field measurement QC procedures, laboratory QC samples, and laboratory QC procedures.

### B6.1 FIELD QUALITY CONTROL SAMPLES

QC samples are collected in the field and used to evaluate the validity of the field sampling effort. Field QC samples are collected for laboratory analysis to check sampling and analytical precision, accuracy, and representativeness. The following section discusses the types and purposes of field QC samples that will be collected for this project. Table B-3 provides a summary of the types and frequency of collection of field QC samples.

### B6.1.1 Field Duplicates

Field duplicate samples are two samples collected at the same time and from the same source that are submitted as separate samples to one laboratory for analysis. Collection and analysis of field duplicates allows evaluation of the consistency of the overall sampling and analytical system.

Field duplicates are collected at a frequency of 10 percent. Field duplicates are analyzed for the same parameters as the field samples collected during the event. Groundwater duplicates will be sampled from locations that have the greatest potential for contamination. These samples will be collected, numbered, packaged, and sealed in the same manner as other samples. They will be submitted blind to the laboratory. Table 4-2 in the accompanying FSP presents the groundwater samples to be submitted as duplicates.

Results of analysis of field duplicates are used to evaluate precision by calculating the RPD. Limits for precision are arbitrarily set at 25 percent for water matrices. A significant variance is commonly associated with soil duplicates because it is difficult to collect truly homogenous soil samples (EPA 1999b). Furthermore, soil duplicate samples are not representative of the same point. Because soil is not homogenous between two points, identical soil samples will not be collected. Due to the heterogeneous nature of soil samples, field duplicate analytical results are used to determine sample variability and not for sampling precision. Sample variability is not an objective for this project, therefore, field duplicates will not be collected.

### B6.1.2 Trip Blanks

A trip blank demonstrates that contamination is not originating from sample containers or from any factor during the transport of samples. A trip blank originates at the laboratory as a 40-milliliter vial typically used for VOC analysis. The vial is filled at the laboratory with reagent-grade, organic-free water. The trip blanks are then transported to the site with the empty containers that are used for sample collection. The trip blanks are stored at the site until the proposed field samples have been collected. One trip blank will accompany each sample transport container containing water samples for VOC analysis back to the laboratory for analysis. The trip blank is not opened until it is returned to the laboratory at the time of analysis. Trip blanks are analyzed only for VOCs.

## TABLE B-3
## FIELD QUALITY CONTROL SAMPLES

| Sample Type | Frequency of Analysis |
|---|---|
| Field duplicate (for groundwater samples only) | 10 percent |
| MS/MSD | 5 percent[a] |
| Equipment rinsate | 1 per day of sampling; not to exceed 5 percent of the total number of samples collected |
| Trip blank[c] | 1 per cooler containing water samples for VOC analysis |

Notes:

a MS/MSD sample pairs for water and soil samples will be included with each analytical batch. Matrix duplicates replace MSDs for inorganic analysis.
b A sampling event is defined as a period of time during which sampling activities occur. An extended absence, followed by a return to the site (between bimonthly sampling rounds, for example), would constitute two events.
c Trip blanks accompany samples to be analyzed for VOCs.
MS Matrix spike
MSD Matrix spike duplicate

### B6.1.3 Equipment Rinsates

The equipment rinsate demonstrates whether the decontamination procedure is effective in removing contaminants from field equipment used to collect samples. An equipment rinsate sample is a sample collected after a sampling device has been subjected to standard decontamination procedures. Appropriate water for the intended analysis will be poured over or through the sampling equipment, reserved in a sample container, and sent to the laboratory for analysis.

The presence of contamination in the equipment rinsate indicates that the cleaning procedure for field equipment is not effective, allowing for the possibility of cross-contamination. The frequency of collection for equipment rinsates has been established based on the activity-specific requirements of this project. Criteria used to determine the frequency of collection for equipment rinsates include such factors as the type of sampling equipment being used, the type of soil present at the site, and the expected level of contamination at the site. For sampling and pilot testing at Site 3, about one equipment rinsate will be collected per day of sampling. The number of equipment rinsates will not exceed 5 percent of the total number of samples collected. Rinsates will be analyzed for the same parameters as the field samples collected. During the data validation process, the results of the equipment rinsate analysis will be used to qualify data or to evaluate the levels of analytes in the field samples.

## B6.2 QUALITY CONTROL PROCEDURES FOR FIELD MEASUREMENTS

Field measurements of pH, temperature, and conductivity will be taken from the monitoring wells during groundwater sampling. TtEMI has implemented the following internal QC procedures to assess the quality of field measurements:

- Consistent use of SOPs
- Documentation of sampling procedures
- Documentation of field work
- Identification and correction of nonconformance situations through audit systems
- Communication with Navy personnel about work schedules, field procedures, subcontractors, and laboratory performance

The QC limits for pH, ORP, DO, conductivity, and temperature are presented in Table 3-5 (see Appendix 3).

## B6.3 LABORATORY QUALITY CONTROL SAMPLES

Laboratory QC samples are analyzed to evaluate the quality of the preparation and analysis of field samples. Laboratory QC samples are prepared and analyzed at the laboratory to assess analytical precision, accuracy, and representativeness. The types of laboratory QC samples that will be used are discussed in the following sections.

### B6.3.1 Method Blanks

Method blanks are prepared to determine whether contamination of the field sample is occurring in the laboratory during sample preparation or analysis. A method blank consists of laboratory organic-free water and is prepared and analyzed using the same methods and procedures and for the same parameters as the field samples. Method blanks are prepared at the frequency prescribed in the individual method.

### B6.3.2 Laboratory Control Samples or Blank Spikes

An LCS or blank spike originates in the laboratory as deionized or distilled water that has been spiked with standard reference materials of known concentration. An LCS or blank spike is analyzed to verify the precision and accuracy of laboratory procedures. LCSs and blank spikes are prepared and analyzed using the same procedures as field samples at the frequency prescribed in the individual method.

To verify the laboratories calibration standards, the laboratory must us a different calibration standard obtained from a different source. Appropriate laboratory-specific protocols will be followed to assess the usability of the data if LCS or blank spike percent recovery results used to determine accuracy or RPD results used to determine precision are outside of established acceptance limits.

### B6.3.3 Matrix Spike and Matrix Spike Duplicates

MS/MSD samples are analyzed to evaluate the suitability of an analytical method for a particular environmental sample matrix. The MS sample is prepared by adding a known concentration of target analytes to an aliquot of the field sample. To minimize errors, field samples will not be spiked in the field. Instead, samples will be spiked when they are prepared for analysis at the laboratory. MS/MSDs measure the efficiency of all of the steps of the analytical method in recovering target analytes from an environmental sample matrix. The %Rs will be calculated for each of the spiked analytes and used to evaluate analytical accuracy and any matrix interference in the recovery of analytes. RPD between spiked samples will be calculated to evaluate precision. An RPD, above the QC limits established, is an indication of inhomogeneous matrix. A percent recovery outside QC limits is an indication of matrix interference. For inorganic analyses, a matrix duplicate is analyzed in place of an MSD. Precision is based on comparison of the results for duplicate and original analyses.

MS/MSD samples are collected at a frequency of 5 percent. An additional sample volume will be collected for MS/MSD for water samples. MS/MSD for soil samples will be obtained from the same container as the field sample. If the MS and MSD percent recoveries used to assess accuracy or the RPD results used to assess precision are outside of established acceptance limits, and laboratory protocols specific to the method will be followed to evaluate data usability. LCS or blank spikes, if available, will be examined to determine the effect of the out-of-control event on reported results. Tables in Appendix 3 provide control limits for evaluating MS/MSD accuracy and precision.

### B6.3.4 Surrogate Standards

Surrogate standards consist of known concentrations of nontarget analytes, but of similar chemical nature as target analytes, are added to each sample, method blank, and MS/MSD before preparation and analysis of samples for organic parameters. The surrogate standard measures the efficiency of the analytical method in recovering target analytes from an environmental sample matrix.

Surrogate standards provide an indication of laboratory accuracy and matrix effects for every field and QC sample that is analyzed for volatile and extractable organic compounds. Surrogate compounds are used in the analysis of VOCs to monitor purge efficiency and analytical performance, while surrogates are used in the analysis of extractable organic compounds to monitor the extraction process and analytical performance.

Surrogate %Rs obtained from sample analysis are evaluated using statistically derived laboratory control limits. Factors such as matrix interference and high concentrations of analytes may affect surrogate recoveries. The effects of the sample matrix are frequently outside the control of the laboratory and may present unique problems. The review and validation of data based on specific sample results are frequently subjective and require analytical experience and professional judgment.

Laboratory personnel are required to re-extract (when applicable) and re-analyze samples when results for associated surrogates are outside of control limits. Data from both analyses of the samples in question are reported. The data will be qualified during review. EPA guidelines for evaluating organic analysis provide additional evaluation criteria (EPA 1994a). Tables in Appendix 3 provide guidelines for surrogate recovery for this project.

### B6.3.5 Internal Standards

Internal standards are compounds that are added to every VOC standard, method blank, MS/MSD, and sample or sample extract at a known concentration before instrument analysis. They are used as the basis for quantification of the target compounds. Internal standards ensure that gas chromatography (GC)/mass spectrometry sensitivity and response are stable during every analytical run. An internal standard is used to evaluate the efficiency of the sample introduction process and monitor the efficiency of the analytical procedure for each sample matrix encountered. Internal standards are also used in the analysis of organic compounds by GC to monitor retention time shifts. Laboratory personnel are required to reanalyze samples when internal standard recoveries are significantly lower than the minimum QC limits established. This is required to determine the cause of low recovery. Consistent low-recovery upon reanalysis will be indicative of possible matrix interference. Validation of internal standards data will be based on EPA protocol presented in guidelines for evaluating organic analyses (EPA 1994a).

## B6.4 LABORATORY CONTROL PROCEDURES

The laboratory will conduct the following QC procedures in addition to analyzing laboratory QC samples, as described in Section B6.3.

### B6.4.1 Method Detection Limit Studies

The MDL is a specified limit at which there is 99 percent confidence that the analyte concentration is greater than zero. The MDL takes into account sample matrix and preparation. The subcontract laboratory will demonstrate MDLs for all analyses, except inorganic analyses and physical properties test methods.

MDL studies will be conducted annually for soil and water matrices, or more frequently if any method or instrumentation changes. Each MDL study will consist of seven replicates spiked with all target analytes of interest at concentrations no greater than, and ideally smaller than, required quantitation limits. Replicates will be extracted and analyzed in the same manner as routine samples. If several instruments are used, each will be included in the MDL study. Reported MDLs will be representative of the least-sensitive instrument. MDLs must meet required quantitation limits. If not all MDLs meet required quantitation limits, the situation is considered to be out of control, and corrective action will be taken.

### B6.4.2 Instrument Detection Limit Studies

The IDL is the minimum concentration of a compound that can be distinguished from background noise by an analytical instrument. The IDL is a measurement of instrument sensitivity and does not take into account sample matrix and preparation. The subcontract laboratory will demonstrate IDLs for CLP inorganic analyses.

### B6.4.3 Sample Quantitation Limits

Sample quantitation limits (SQL) are also referred to as practical quantitation limits. The SQL takes into account changes in the preparation and analytical methodology that may alter the ability to detect an analyte, such as use of a smaller sample aliquot or dilution of the sample extract. Physical characteristics such as sample matrix and percent moisture that may alter the ability to detect the analyte are also considered. The laboratory will calculate and report SQLs for all environmental samples.

### B6.4.4 Control Charts

Control charts document data quality in graphic form for specific method parameters such as surrogates and blank spike recoveries. A collection of data points for each parameter is used to statistically calculate means and control limits for a given analytical method. This information is useful in determining whether chemical measurement systems are in control. In addition, control charts provide information about trends over time in specific analytical and preparation methodologies. It is recommended that subcontract

laboratories maintain control charts for organic and inorganic analyses. At a minimum, method-blank surrogate recoveries and blank spike recoveries should be charted for all organic methods. Blank spike recoveries should be charted for inorganic methods. If control charts exhibit out-of-control limits, the laboratory will initiate corrective action before continuing with analysis. Control charts should be updated monthly.

## B7 INSTRUMENT AND EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE REQUIREMENTS

The following sections discuss regularly scheduled preventive maintenance and calibration procedures that are used to keep all field and laboratory equipment in good working condition.

### B7.1 MAINTENANCE OF FIELD EQUIPMENT

Detailed information about maintenance and servicing of field equipment is available in the instruction manual of the specific instrument to be used. Field personnel will record service and maintenance information in field logbooks. Instrument problems encountered during field work will be recorded and remedied in the field, if possible. Spare batteries, bulbs, probes, and other parts will be kept on hand for replacement. Specific preventive maintenance procedures will follow manufacturer recommendations.

### B7.2 CALIBRATION OF FIELD ANALYTICAL EQUIPMENT

Equipment used during field activities will be calibrated at the beginning of each day of sampling. The frequency of calibration may depend on the type and stability of the equipment, the analytical methods employed, the intended use of the equipment, and the recommendation of the manufacturer. More detailed calibration procedures for equipment are available from the specific manufacturer instruction manuals. All calibration information will be recorded in a field logbook or on field forms. A label specifying the scheduled date of the next calibration will be attached to the field equipment. If this identification is not feasible, calibration records for the equipment will be readily available for reference.

Should any of the field equipment become inoperable, it will be removed from service and tagged to indicate that repair, recalibration, or replacement is needed. Field team leaders will be notified so that prompt service can be completed or substitute equipment can be obtained. Backup systems will be available for each instrument in use and will be calibrated before use in the field. Any action of this type will be reported in the daily field QC report. Corrective action measures are discussed in Section C1.2 of this QAPP.

## B7.3 MAINTENANCE OF LABORATORY EQUIPMENT

The off-site subcontract laboratories will prepare and follow a maintenance schedule for each instrument used to analyze samples collected from NFD Point Molate. All instruments will be serviced at scheduled intervals necessary to optimize factory specifications. Routine preventive maintenance and major repairs will be documented in a maintenance logbook. An inventory of items to be kept ready for use in case of instrument failure will be maintained and restocked, as needed. The list of spare parts will include equipment replacement parts subject to frequent failure, parts that have a limited lifetime of optimum performance, and parts that cannot be obtained in a timely manner.

A description of specific preventative maintenance procedures for laboratory equipment is available in the laboratory's QA plan and in the written SOPs maintained by the laboratory. These documents identify the personnel responsible for major, preventive, and daily maintenance procedures; the frequency and type of maintenance performed; and maintenance documentation procedures.

## B7.4 CALIBRATION OF LABORATORY ANALYTICAL EQUIPMENT

Laboratory instrument calibration procedures and frequencies will follow referenced analytical method requirements. Qualified analysts will calibrate the instrument and will document the procedure in an instrument logbook.

Laboratory calibration procedures and frequencies are listed in the subcontract laboratory's QA plan, the written SOPs maintained by the laboratory, and the analytical methods discussed in Section B5.1 of this QAPP. Laboratory instruments will be calibrated using the procedures and at the frequencies specified in analytical methods requirements.

### B7.4.1 Calibration Standards

The laboratory will obtain calibration standards from the EPA repository or commercial vendors for both inorganic and organic compounds. Stock solutions for calibration and other QC standards and other inorganic mixes will be made from certified reagent-grade chemicals or as specified in the method SOP. Stock standards will also be used for intermediate standards from which calibration standards are made. Special attention will be given to expiration dating, proper labeling, proper refrigeration, and freedom from contamination. Documentation related to receipt, mixing, and use of standards will be recorded in the appropriate laboratory logbook. Calibration standards will be certified and accompanied by a certificate of analysis issued by the vendor. Logbooks must be bound. Specific handling and documentation requirements for the use of standards will be provided in the selected laboratory's QA manual.

### B7.4.2 Corrective Action Procedures

Instrument malfunctions will require immediate corrective action. Actions should be documented in field or laboratory logbooks. No other formal documentation is required, unless data quality is adversely affected or further corrective action is necessary. On-the-spot corrective actions will be taken, as necessary, in accordance with the procedures described in the laboratory QA plan and SOPs. All analysis will be suspended if an instrument does not meet calibration and instrument performance criteria. Corrective action will be initiated immediately and analysis will be resumed once the problem is resolved.

## B8 INSPECTION AND ACCEPTANCE REQUIREMENTS FOR SUPPLIES

Analytical laboratories are required to provide certified clean containers for all analyses. The subcontract laboratories will maintain an inventory of the analytical supplies required for the analytical procedures, as described in Section B5.1.

Solvents and reagents used by the laboratories in all analytical procedures will be certified by vendors and be documented in a laboratory logbook, along with the certificate of analysis. At a minimum, information about the manufacturer, lot number, date received, and date opened should be included. Solvents and reagents will be tested for contamination before they are used. The results of this procedure and any other quality inspections will be documented in a laboratory notebook.

Off-site laboratories will maintain and follow a written SOP for decontamination of glassware used in analytical procedures. Off-site laboratories will check the calibration of all analytical balances and automatic pipettes daily and will document the results in a laboratory logbook. Analytical balances will be recalibrated, as necessary, in accordance with the laboratory's written SOPs.

Subcontractor laboratories will check the temperature daily of all refrigerators used to store NFD Point Molate samples, standards, extracts, and other consumables and will document measured temperatures in a laboratory logbook.

## B9 DATA MANAGEMENT

The following sections outline data management in the field and laboratory. EDDs generated from this work will be delivered to the Navy in a format compatible with NEDTS.

## B9.1 FIELD DATA MANAGEMENT

The TtEMI data and QA manager will be responsible for review, transfer, and storage of all data collected in the field for the facility. The TtEMI Field Team Leader will maintain documentation of sampling, logging, and field measurements. The TtEMI Field Team Leader will also maintain daily field progress reports and note any variance from SOPs.

## B9.2 LABORATORY DATA MANAGEMENT

When samples are received at the laboratory, the laboratory sample custodian will reconcile the information on the COC forms with the sample bottles received. The sample custodian will document any anomalies and report them to the laboratory project manager, who will contact the TtEMI Analytical Coordinator. Anomalies will be resolved with the TtEMI analytical coordinator. The information on the COC forms will then be entered into the laboratory's information management system.

Samples will be tracked from the time of receipt by the laboratory through each stage of sample preparation, analysis, and final reporting, using the laboratory's information management system. Data will be transferred either from the analytical instrument electronically to the laboratory's LIMS, or qualified personnel will enter the data through terminals. The laboratory will be responsible for tracking all QC parameters and sample results by SDG. Any data that exceed the specified QC limits specified for this project will be documented. QC anomalies that directly affect data quality will immediately be communicated to the TtEMI Analytical Coordinator. The laboratory will implement and document any corrective actions that result from QC anomalies. The contract laboratory will generate the EDDs and a CLP-type data package after all data have been reviewed and approved by the appropriate laboratory personnel. The EDDs and CLP-type data package will then be delivered to the TtEMI Analytical Coordinator.

The laboratory project manager will be responsible for proper sample handling and documentation from the time samples are received until the CLP-type data package and EDDs are submitted. The laboratory will use sample receipt forms and nonconformance memoranda to document and disseminate nonconformance information to the TtEMI analytical coordinator.

## B9.3 TETRA TECH EM INC. DATA MANAGEMENT

The laboratory will be responsible for sending a hard copy of the data package and the EDD on computer diskette to the TtEMI Analytical Coordinator. The EDD and hard-copy data will be checked to ensure that their format and content comply with TtEMI's specifications. Any errors or missing information detected will be thoroughly investigated. The laboratory will be required to regenerate the EDD or data package, if necessary.

A copy of the EDD and hard-copy data will be sent to an independent reviewer for data validation, as described in Section D1. The validator will apply qualifiers to the data, as appropriate. The TtEMI Analytical Coordinator will conduct a technical review of the data validation report, as described in Section D1. The validated data will be submitted to data entry staff for entry into the database. The final version of the data validation report will be stored with the hard-copy CLP-type report.

## C1 ASSESSMENTS AND RESPONSE ACTIONS

Oversight of QA activities will be completed through the use of three types of audits, described in the following subsection. Any problems encountered during the field investigation will require appropriate corrective action procedures to ensure that they do not go unresolved. This section describes the types of audits that may be completed, corrective action procedures that will be undertaken in the event of problems in the field or laboratory, and QA reports to management.

### C1.1 PERFORMANCE, SYSTEM, AND FIELD AUDITS

An audit evaluates the capability and performance of a measurement system or its components and identifies problems that warrant correction. Three types of audits may be conducted during the field work for this project: performance, system, and field. The Project QA Manager, project QA officers, or senior technical staff will complete audits at scheduled intervals. Auditors will be independent of the activities audited and will be selected by the Project QA Manager. Technical expertise and experience in auditing will be considered in selecting an auditor or audit team. The Navy QAO is responsible for QA issues for all Navy CLEAN II work and may conduct field and laboratory audits. The QAO provides quality-related direction through the contracting officer's technical representative to the quality manager. The QAO has authority to audit field and laboratory work and may suspend project or site activities if SWDIV-approved quality requirements are not adequately met.

The auditor or audit team will develop an individual plan to provide a basis for each audit. Audits may include reviews of project plan adherence, training status, health and safety procedures, QC data, calibrations, and conformance to sampling and field SOPs. Audits may also review compliance with laws, regulations, policies, and procedures. After an audit has been completed, the auditor or audit team will submit an audit report to the TtEMI Project Manager, PM, IC, and ultimately, the Navy RPM. This report will also be included in the project summary report. The Project QA Manager will coordinate a management review if any deficiencies are noted. Appendix 1 provides an example of an audit report form.

The auditor or audit team can issue a corrective action request form to identify and schedule specific corrective actions to be undertaken and completed by Project Managers. The auditor or audit team verifies that the corrective action has been completed. After corrective actions have been accepted and verified, the corrective action request form will be used to close the audit. Appendix 1 presents an example of a corrective action request form. A flow chart depicting the QA audit pathway is presented in Figure C-1.

### C1.1.1 Performance Audits

A performance audit is a review of existing project and QC data to evaluate the accuracy of a total measurement system or a component of the system. The Navy will conduct laboratory performance audits before samples are submitted to the laboratory for analysis. TtEMI will also conduct a laboratory audit once an approved laboratory has been selected. Internal audit routines for the laboratory are described in the laboratory QA plan and follow Navy Installation Restoration Chemical Data Quality Manual (IRDQM) (NFESC 1999).

### C1.1.2 System Audits

A system audit is used to verify adherence to QA policies and SOPs. This type of audit may consist of on-site review of measurement systems. In addition, procedures for measurement, QC, and documentation may be evaluated. The first system audit is conducted shortly after a system becomes operational and on a regularly scheduled basis thereafter.

### C1.1.3 Field Audits

A field audit involves an on-site visit by the auditor or audit team. Items to be examined include the availability and implementation of approved field procedures; calibration and operation of equipment; COC procedures; packaging, storage, and shipping of samples; health and safety procedures; documentation of procedures and instructions; and nonconformance documentation.

## C1.2 CORRECTIVE ACTION PROCEDURES

An effective QA program requires prompt and thorough correction of nonconformance conditions that affect quality. Rapid and effective corrective action minimizes the possibility of questionable data or documentation. Two types of corrective actions exist: immediate and long-term. Immediate corrective actions include correction of documentation deficiencies or errors, repair of inaccurate instrumentation, or correction of inadequate procedures. The source of the problem is generally obvious and can be corrected at the time it is observed. Long-term corrective actions are designed to eliminate the sources of problems. Examples of long-term corrective actions are correction of systematic errors in sampling or analysis and correction of procedures producing questionable results. Corrections can be made through additional personnel training, instrument replacement, or procedural improvements. One or more corrections may be necessary.

All QA problems and corrective actions will be documented to provide a complete record of QA activities and to help to identify needed long-term corrective actions. Defined responsibilities are required for

scheduling, performing, documenting, and ensuring the effectiveness of the corrective action. This section describes the corrective action procedures to be followed in the field and laboratory.

### C1.2.1 Field Procedures

Field nonconformance conditions are defined as occurrences or measurements that are either unexpected or that do not meet established acceptance criteria and will affect data quality if corrective action is not implemented. Examples of nonconformance are:

- Incorrect use of field equipment
- Improper sample collection, preservation, and shipment procedures
- Incomplete field documentation, including COC records
- Incorrect decontamination procedures
- Incorrect collection of QC samples

Corrective action procedures will depend on the severity of the nonconformance. In cases where field personnel implement immediate and complete corrective action, the corrective action will be recorded in the field logbook and summarized in the daily field progress report.

Nonconformances that have caused a substantial impact on data quality require the completion of a corrective action request form. This form may be filled out by an auditor or by any individual who suspects that any aspect of data integrity is being affected by a field nonconformance. Each form is limited to a single nonconformance. If additional problems are identified, multiple forms will be used for documentation. Appendix 1 presents an example of a corrective action request form.

Copies of the corrective action request form will be distributed to Project Managers, Field Team Leaders, the Project QA Manager, and the project file. The Project QA Manager will forward completed corrective action forms to the PM and the Program QA Manager. The Project Manager, Field Team Leader, and the Project QA Manager will meet to discuss the appropriate steps to resolve the problem, and will use the following list:

- Determine when and how the problem developed.
- Assign responsibility for investigation and documentation of the problem.
- Determine the corrective action to eliminate the problem.
- Design a schedule for completing the corrective action.
- Assign responsibility for implementing the corrective action.

- Document and verify that the corrective action has eliminated the problem.
- Notify the Navy of the problem and the corrective action taken.

The Project QA Manager uses a corrective action status report (see Appendix 1) to monitor the status of all corrective actions. The report will provide a brief discussion of the problem, the individual who identified it, and the personnel responsible for selecting and implementing the corrective action. The report will also list completion dates for each phase of the corrective action procedure and the due date for the Project QA Manager to review and check the effectiveness of the solution. Follow-up data will be listed to check that the problem has not reappeared. The follow-up review is conducted to ensure that the solution has adequately and permanently corrected the problem.

The Project QA Manager can require that data acquisition be limited or discontinued until the corrective action is complete and the nonconformance is eliminated. The Project QA Manager can also request the reanalysis of any or all data acquired since the system was last in control.

### C1.2.2 Laboratory Procedures

Internal laboratory procedures for corrective action and a description of out-of-control situations that require corrective action are contained in the laboratory QA plan. At a minimum, corrective action will be implemented when any of the following three conditions occur: control limits are exceeded, method QC requirements are not met, or sample holding times are exceeded. Out-of-control situations will be reported to the project analytical coordinator within 2 working days after they are identified. In addition, a corrective action report signed by the laboratory director or project manager and the laboratory QC coordinator will be provided to the project analytical coordinators.

## C1.3 REPORTS TO MANAGEMENT

Several reports will be prepared during field work at NFD Point Molate that will address QA issues. Each of these reports is summarized in this section.

### C1.3.1 Daily Quality Control Reports

The daily QC report will summarize daily field activities throughout the field program. This report will describe all work completed, including any QA/QC activities, health and safety activities, problems encountered, and corrective actions taken. The daily QC report is prepared by the Field Team Leader and

is submitted to the Project Manager. The content of the reports will be summarized and included in the final report submitted for the field investigation.

### C1.3.2 Project Monthly Status Report

A monthly status report (MSR) will be prepared by the Project Manager and submitted to the program managers and Project QA Manager. This report will include the following:

- Status of the project
- Any problems affecting QA and recommended solutions
- Objectives from the previous report that were achieved
- Objectives from the previous report that were not achieved
- Work planned for the next month

The aforementioned information will also be required from any subcontractors and will be included in the MSR.

### C1.3.3 Quality Control Summary Report

TtEMI will prepare a QC summary report (QCSR) and submit the report to the Navy RPM with the final report for the activity. The QCSR will include a summary and evaluation of the QC completed during the task and will indicate the duration and location of storage for the complete data packages. Particular emphasis will be placed on determining whether project DQOs were met and whether data are of sufficient quality to support required decisions.

# D1 DATA VALIDATION AND USABILITY

The following two sections discuss the requirements of and methods for review, verification, and validation of the data. Section D2 discusses the process for reconciling the data generated with the DQOs for the task.

## D1.1 DATA REVIEW, VERIFICATION, AND VALIDATION REQUIREMENTS

All data for this NFD Point Molate project will be reviewed and verified before they are entered into the database. At a minimum, 10 percent of the analytical data will be randomly selected and fully validated. The remaining 90 percent of the data will undergo cursory validation. Full and cursory validation requirements are described in Sections D1.2.3.2 and D1.2.3.3. An independent, third-party subcontractor will validate the data in accordance with EPA National Functional Guidelines.

## D1.2 VALIDATION AND VERIFICATION METHOD

Validation and verification of data generated during field activities are essential to obtaining data of defensible and acceptable quality. Verification methods for field and laboratory activities are presented in the following two sections; validation requirements are presented in Sections D1.2.3.1 through D1.2.3.4.

### D1.2.1 Verification of Field Data

Project team personnel will validate field data through reviews of data sets to identify inconsistencies or anomalous values. If possible, any inconsistencies discovered will be resolved immediately by seeking clarification from the field personnel responsible for data collection. To obtain defensible data, field personnel will be responsible for following the sampling and documentation procedures described in the accompanying FSP and in this QAPP.

Data values that are significantly different from the population are called "outliers." A systematic effort will be made to identify any outliers or errors before field and laboratory personnel report the data. Outliers can result from improper sampling or analytical methodology, matrix interference, data transcription errors, and calculation errors, or they may represent inherent variability in the sample. Outliers resulting from errors found during data verification will be identified and corrected. Outliers that cannot be attributed to analytical, calculation, or transcription errors will be reported in the case narrative section of the analytical report but will not necessarily be excluded from data analysis.

### D1.2.2 Verification of Laboratory Data

Laboratory personnel will verify analytical data at the time of analysis and reporting through reviews of the raw data for any nonconformance with analytical method requirements. Detailed procedures for laboratory verification and corrective action will be provided in the laboratory's QA plan.

### D1.2.3 Validation of Analytical Data

The following four sections describe the validation requirements for analytical data.

#### D1.2.3.1 Technical Requirements

An independent, third-party subcontractor will validate the data in accordance with EPA National Functional Guidelines. Additional guidelines can be found in "National Functional Guidelines for Organic Data Review (EPA 1999c) and National Functional Guidelines for Inorganic Data Review" (EPA 1994b).

#### D1.2.3.2 Cursory Data Validation

Cursory validation will be completed on 90 percent of the data for analysis of soil and groundwater samples by CLP and non-CLP methods. The data reviewer is required to notify TtEMI and request any missing information needed from the laboratory. Elimination of data from the review process is not allowed. Data will continue through the validation process and be qualified as necessary in accordance with established criteria. Data summary packages consist of sample results and QA/QC summaries including calibration and internal standard data. No guaranteed minimum number of samples will be required for an SDG; however, the maximum number of samples will not exceed 20.

#### D1.2.3.3 Full Data Validation

Full validation will be completed on data packages for analysis of soil and groundwater samples by CLP and non-CLP methods. The data reviewer is required to notify TtEMI and request any missing information needed from the laboratory. Elimination of data from the review process is not allowed. Data will continue through the validation process and be qualified as necessary in accordance with established criteria. Full validation will be required for 10 percent of an SDG. Data packages consist of sample results, QA/QC summaries (equivalent to CLP Forms I through X for organic analysis and Forms I through XIV for inorganic analysis), and raw data associated with the sample results and QA/QC summaries.

### D1.2.3.4 Criteria for Data Validation

QC criteria to be reviewed for both cursory and full validations are identified as follows:

Cursory Data Validation

- CLP Inorganic Analyses
  - Holding times
  - Calibration
  - Blanks
  - MS recovery
  - Matrix duplicate sample analysis
  - LCSs
  - Field duplicate sample analysis
  - ICP serial dilution
  - Overall assessment of data for an SDG

- Non-CLP Organic Analyses
  - Method compliance
  - Holding times
  - Calibration
  - Blanks
  - Surrogate recovery
  - MS/MSD recovery
  - LCSs or blank spike recovery
  - Internal standard performance
  - Other laboratory QC specified by the method
  - Overall assessment of data for an SDG
  - Field duplicate sample analysis

- Non-CLP Inorganic and Physical Analyses
  - Holding times
  - Calibration
  - Blanks
  - MS and MSD recovery
  - Internal standard performance
  - LCSs
  - Field duplicate sample analysis
  - Other laboratory QC specified by the method
  - Overall assessment of data for an SDG

Full Data Validation

- CLP Inorganic Analyses
  - Holding times
  - Calibration
  - Blanks
  - ICP interference check sample
  - LCSs
  - MS recovery
  - Field duplicate sample analysis
  - Matrix duplicate sample analysis
  - Sample results verification
  - ICP serial dilution
  - Overall assessment of data for an SDG
- Non-CLP Organic Analyses
  - Method compliance
  - Holding times
  - Calibration
  - Blanks
  - Surrogate recovery
  - MS/MSD recovery
  - LCS or blank spike
  - Internal standard performance
  - Field duplicate sample analysis
  - Other laboratory QC specified by the method
  - Detection limits
  - Compound identification
  - Compound quantitation
  - Sample results verification
  - Overall assessment of data for an SDG
- Non-CLP Inorganic and Physical Analyses
  - Holding times
  - Calibration
  - Blanks
  - MS/MSD recovery
  - Internal standard performance
  - LCS
  - Field duplicate sample analysis
  - Other laboratory QC specified by the method
  - Detection limits
  - Analyte identification
  - Analyte quantitation
  - Sample results verification
  - Overall assessment of data for an SDG

## D2 RECONCILIATION WITH DATA QUALITY OBJECTIVES

The first step of the DQA process is to evaluate whether project DQOs have been met (EPA 1998b). Goals of the Site 3 pilot tests, as specified in the project DQOs (see Table A-2), included (1) further delineate the lateral and vertical extent of TPH-p, TPH-e, BTEX, VOCs, and semivolatile organic compounds (PAHs) in soils and groundwater; (2) evaluate whether metals have been released to soil or groundwater within the former FRF due to disposal of batteries; (3) identify the extent of industrial waste still remaining within the former FRF; (4) field pilot testing to evaluate the technical and economic feasibility of the following remedial techniques: air sparging-SVE and MPE; and (5) collection of soil and groundwater samples for analysis of parameters specific to natural attenuation to determine if natural attenuation is a potential remedial approach. Data compiled for this project must be of sufficient quantity and known quality to be used in the assessment of Site 3.

Sampling and laboratory methods and procedures detailed throughout this QAPP should provide data of sufficient quality to assess the concentrations and extent of chemicals of concern throughout Site 3. Detected concentrations of site-related organic chemicals will be compared with historical concentrations to further evaluate the distribution of contaminants at the site. The organic chemical data will also be used to compare to the preliminary action levels specified in the FPALDR to establish recommended remediation areas at the site. Inorganic and other biochemical data will be used to evaluate the potential for natural attenuation of organic contaminants within the site saturated soils and groundwater.

## E1 REFERENCES


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# FIGURES

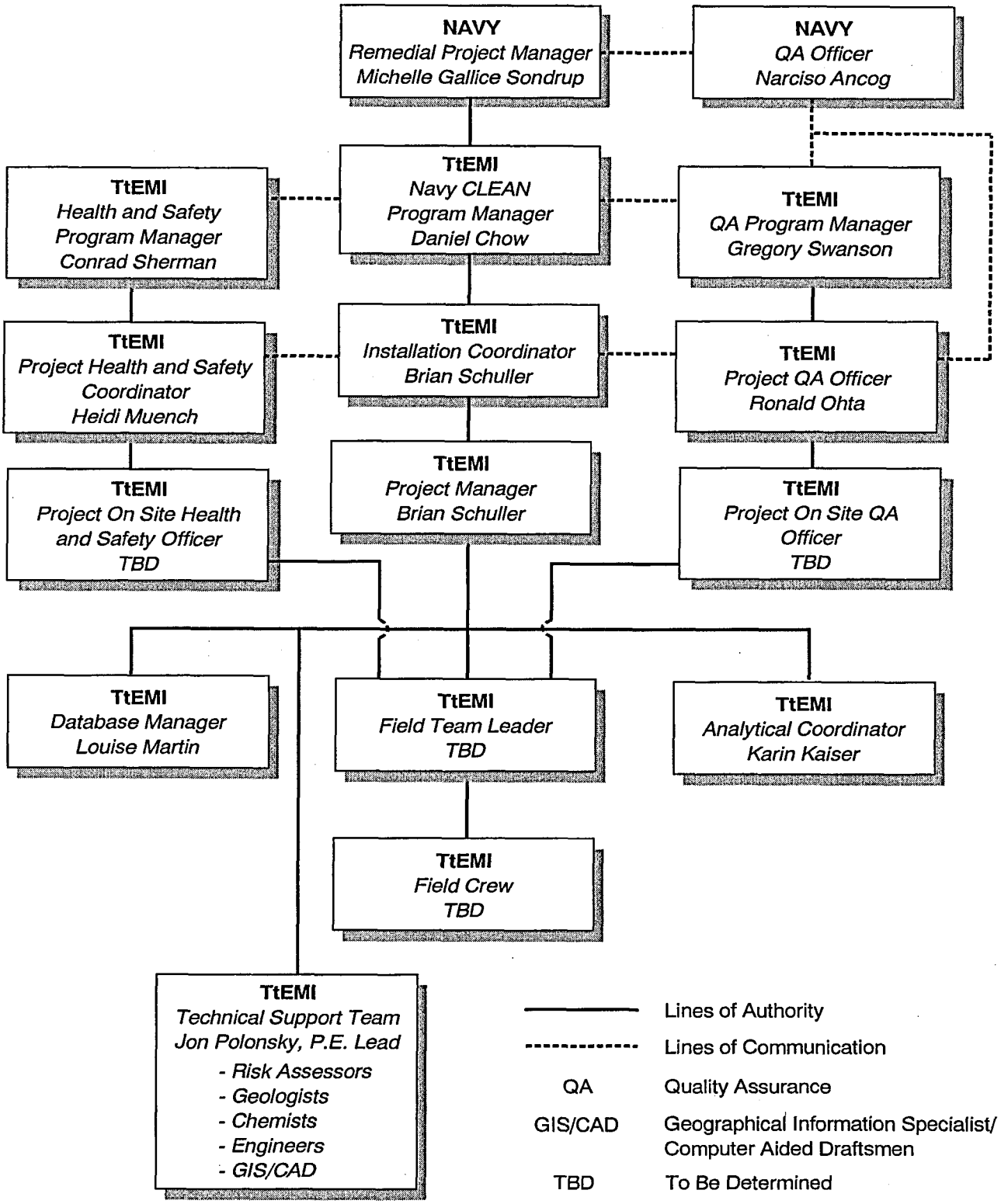


**FIGURE A-1**
**NFD POINT MOLATE**
**QUALITY ASSURANCE PROJECT PLAN**
**PROJECT ORGANIZATION CHART**

DATE: 5/11/01 DMF DN FILE NAME: NAVY\POINT MOLATE\CTO379C\0101\PROG_ORG.DSF

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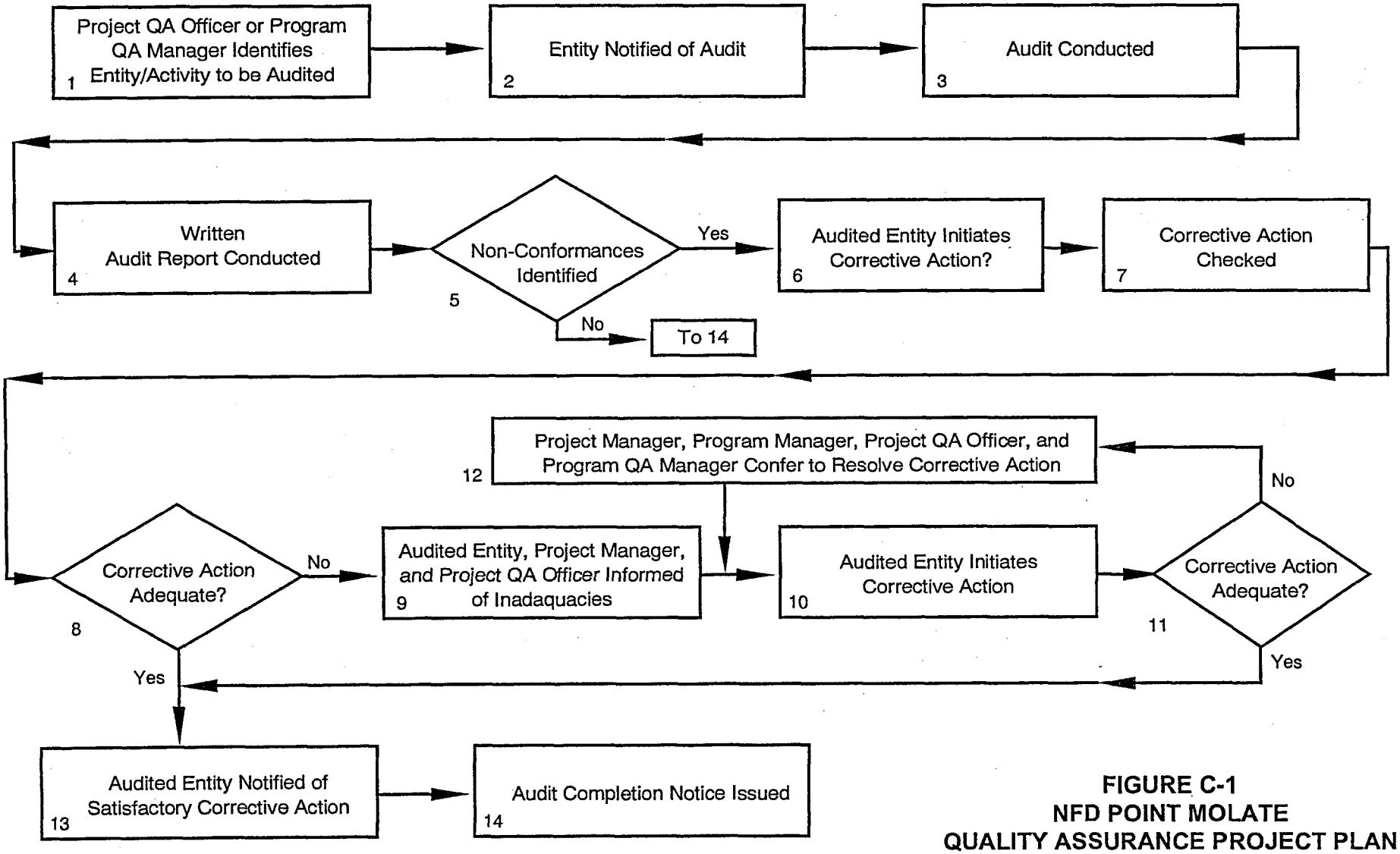


**FIGURE C-1**
**NFD POINT MOLATE**
**QUALITY ASSURANCE PROJECT PLAN**
**QA AUDIT FLOW CHART**

# APPENDIX 1

## FIELD FORMS
## QUALITY CONTROL REPORTS

Tetra Tech EM Inc.

**CHAIN-OF-CUSTODY #:** _____

Date: _____ Page ____ of ____

Destination: _____

| Project Name: | Project Charge No.: |
|---|---|
| Sampler(s): Printed name and signature | Technical contact: |

No./Container Types

Preservatives

Analyses Required

| Sample ID | Date of Collection | Time of Collection | Sample Medium | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| | SIGNATURE | NAME (print) | COMPANY | DATE | TIME |
|---|---|---|---|---|---|
| Relinqueshed by: | | | | | |
| Received by: | | | | | |
| Relinqueshed by: | | | | | |
| Received by: | | | | | |
| Relinqueshed by: | | | | | |
| Received by: | | | | | |

REMARKS: (Note: *Identify samples for which extra volume was collected for MS/MSD and record air bill number and any other pertinent information.*)

TURNAROUND TIME

AIRBILL #:

PO #:

Instructions: Under "Analyses Required," and "Field Sample Preparation," enter only one of the following two codes for each analysis requested and each sample listed:
U=UNPRESERVED SAMPLE; P=PRESERVED; F= FILTERED; B= FILTERED AND PRESERVED

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Tetra Tech EM Inc.
1099 18th Street, Suite 1960
Denver, CO 80202
(303) 295-1101

Tetra Tech EM Inc.

# EXTENDED CHAIN-OF-CUSTODY

Associated COC Number _____ Date: _____ Page _____ of _____

| Project Name | Project Job Number | Site/ Operable Unit |
|---|---|---|
| | | |
| **Sampler(s) Printed Name and Signature** | **Sampling Dates** | **Sample Company** |
| | | |

**THIS FORM IS FOR INTERNAL USE ONLY. DO NOT SEND TO LABORATORY!**

| Sample ID | Date of Collection | Investigation* | Point Name | Point Type* | Sample Medium* | Sample Type* | Duplicate ID [1] | Grab/ Comp. | Total Depth of Point | Top Sample Depth | Bottom Sample Depth |
|---|---|---|---|---|---|---|---|---|---|---|---|
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[1] *Indicate the normal sample ID number associated with each field duplicate (FD) in Duplicate ID field.*

**REMARKS:** *(Identify any equipment rinsates and trip blanks and the associated samples on this form.)*

| *Sample Medium | *Point Type | | *Sample Type | | *Investigation Code/Description |
|---|---|---|---|---|---|
| Air | MW | Monitoring Well | Norm | Real Sample | Example: UST_14 Site Cleanup at 14 former UST sites |
| Waste | SB | Soil Boring | FD | Field Duplicate | |
| Plants | GP | Geoprobe | ER | Equipment Rinsate | |
| Water | EXCV | Excavation Pit | FB | Field Blank | |
| Product | HP | Hydropunch | TB | Trip Blank | |
| Sediment | PZ | Piezometer | | | |
| Sludge | QC | Quality Control | | | |
| Soil | SL | Surface Location | | | |

# GROUND WATER SAMPLING DATA SHEET

PAGE ____ OF ____

WELL NAME _____

DATE _____

PR _____ STATION ELEVATION _____ GND ___ TOC ___ IMMISCIBLE PHASES PRESENT YES ___ NO ___

PROJECT No. _____ STATIC WATER LEVEL(from TOC) _____ TYPE _____

WELL LOCATION _____ WELL STICK UP _____ MEASURED WITH _____

SAMPLE DATE _____ STATIC ELEVATION _____ PID READINGS (backgrnd) _____

SAMPLING PERSONNEL _____ WELL DEPTH _____ MEAS ___ RPTD ___ PID READINGS (TOC) _____

_____ FEET OF WATER _____ WELL INSTALLED BY _____

SAMPLE ID _____ GALLONS/FOOT _____ INSTALLATION DATE _____

DUPLICATE ID _____ CASING VOLUME _____ DEVELOPMENT DATE(S) _____

FIELD CHEMISTRY CALIBRATIONS

DATE/TIME _____ SPEC. CONDUCTANCE: STANDARD _____ UMHOS/CM AT 25C READING _____ UMHOS/CM AT ___ C

pH: pH 4.00 = _____ AT _____ C pH 7.00 = _____ AT _____ C pH 10.00 = _____ AT _____ C SLOPE _____

DISSOLVED OXYGEN: D.O. METER _____ MG/L AT ___ C PID: CALIBRATION GAS _____ PPM _____ SPAN _____ READING _____

| | TIME | DISCHARGE RATE (GPM) | DISSOLVED OXYGEN (MG/L) | pH | Eh/ORP | TEMP (C) | SPECIFIC CONDUCT. (UMHOS/CM AT C) | TURBID. (NTU) | CUMULATIVE VOL. OF WATER REMOVED (PURGED) GALLONS | CASING VOLS. | PID/OVA READING LOCATION | VALUE | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PUMPED | | | | | | | | | | | | | |
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| BAILED | | | | | | | | | | | | | |
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PUMPED PARAMETERS STABLE (Y/N) | PUMPED=BAILED PARAMETERS (Y/N) | CONDITION OF WELL: _____

REMARKS _____

FIELD EQUIPMENT

pH METER _____ SERIAL NUMBER _____

SPEC. COND. METER _____ SERIAL NUMBER _____

PUMP _____ SERIAL NUMBER _____

BAILER _____ SIZE _____

WATER LEVEL METER _____ SERIAL NUMBER _____

METER _____ SERIAL NUMBER _____

FILTER APPARATUS _____ FILTERS _____

TEMPERATURE MEASURE _____

INTERFACE PROBE _____ SERIAL NUMBER _____

PID/OVA _____ SERIAL NUMBER _____

FIELD CHEMISTRY CALIBRATIONS

FRACTIONS _____

NUMBER OF BOTTLES _____

SAMPLE DEPTH _____

FIELD NOTEBOOK _____

SAMPLE METHOD _____

DISCHARGE WATER CONTAINERIZED

YES _____ NO _____

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Tetra Tech EM Inc.

# HYDROPUNCH/GEOPROBE/CPT/GRAB SOIL/SEDIMENT/WATER NEW LOCATION FORM

| Project Name and Number | Investigation Code* | Originating Consultant* |
|---|---|---|
| | | |

| Point Name | Point Type* | Origination date | Point Description | Total Depth (ft bgs) | Source of Location Data* |
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| Investigation Code: | Originating Consultant: | Point Type: | | Source of Location Data: |
|---|---|---|---|---|
| | TTEMI = Tetra Tech EM Inc.<br>MK = Morrison Knudsen<br>Other = Other company | SW = Surface Water<br>MW = Monitoring Well<br>SB = Soil Boring<br>SL = Surface Location (0'-2')<br>GP = Geoprobe/Simulprobe<br>HB = Hand Boring | DOM = Domestic Well<br>HP = Hydropunch<br>TANK = Underground Storage Tank<br>SPUNCH = Soil Punch<br>EXCV = Excavation<br>PROD = Production Well | Survey<br>GPS<br>Map |

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11/3/2000

**Tetra Tech EM Inc.**

# BOREHOLE LOG

SHEET ____ OF ____

| LOCATION OF BOREHOLE | JOB NO.: | BOREHOLE ID: |
|---|---|---|
| | CLIENT: | DEPTH TO WATER: |
| | SITE: | LOGGED BY: |
| | SUBSITE: | DRILLING DATE(S): |
| | DRILLING CO.: | DRILLING METHOD: |
| | PERSONNEL: | SAMPLING METHOD: |

| SAMPLE INTERVAL | | | BLOWS/ 6 IN. SAMPLE | TIME | PID READING | LABORATORY ANALYSIS | DEPTH IN FEET | USCS SOIL TYPE | SOIL DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|
| TOP | BOTTOM | RECOVERED | | | | | | | |
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S:\Geosciences Discipline\Field Forms\CAD Files\ BOREHOLE LOG FORM.dwg 02/23/2000 FORDD DN

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# MONITORING WELL INSTALLATION RECORD

**SURFACE COMPLETION**

ABOVE GROUND ☐

FLUSH MOUNT ☐

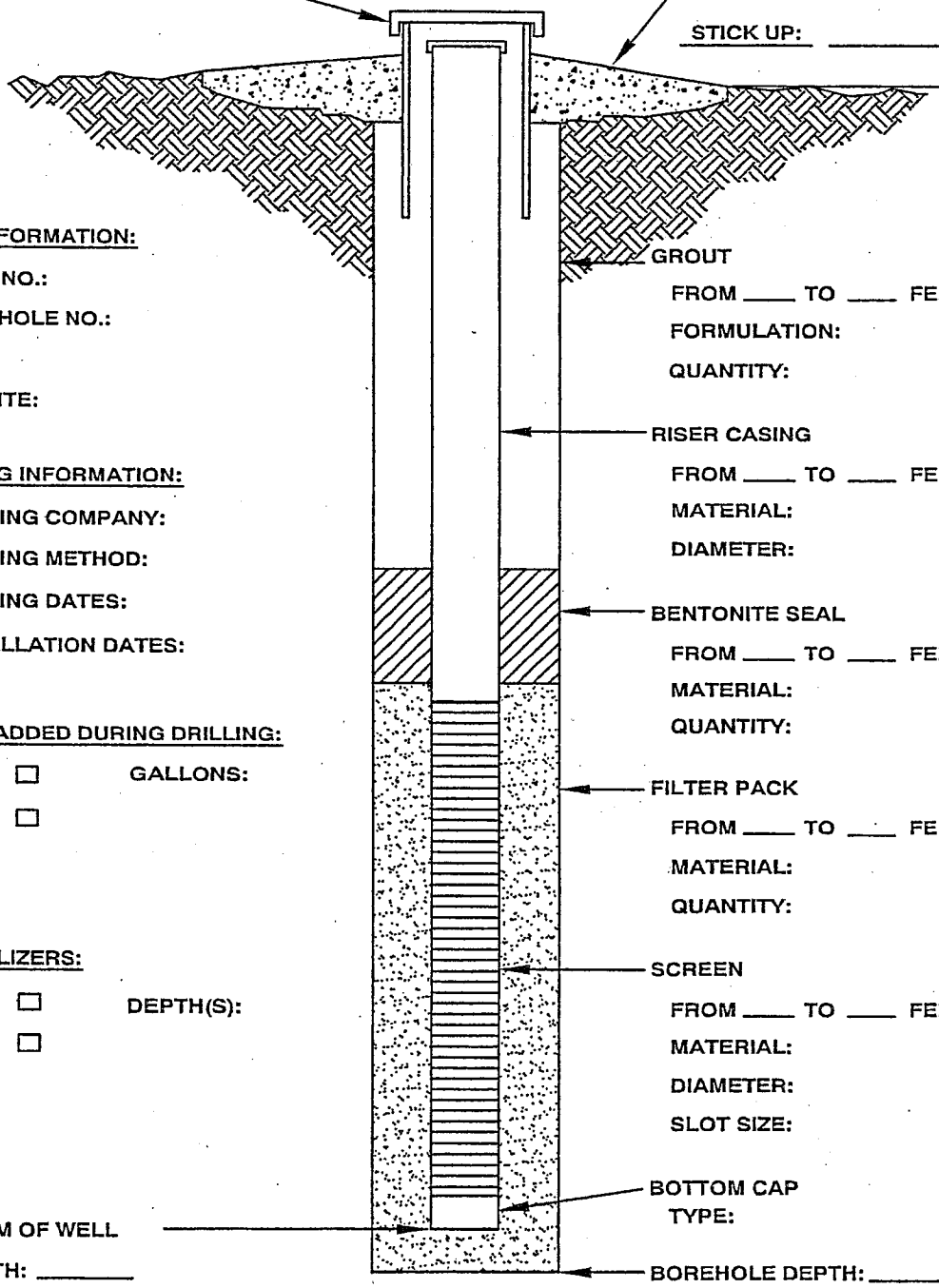
PROTECTIVE CASING

TYPE:

SURFACE SEAL

TYPE:

STICK UP: _____



**WELL INFORMATION:**

WELL NO.:

BOREHOLE NO.:

SITE:

SUBSITE:

GROUT

FROM ____ TO ____ FEET (BGS)

FORMULATION:

QUANTITY:

RISER CASING

FROM ____ TO ____ FEET (BGS)

MATERIAL:

DIAMETER:

**DRILLING INFORMATION:**

DRILLING COMPANY:

DRILLING METHOD:

DRILLING DATES:

INSTALLATION DATES:

BENTONITE SEAL

FROM ____ TO ____ FEET (BGS)

MATERIAL:

QUANTITY:

**WATER ADDED DURING DRILLING:**

YES ☐ GALLONS:

NO ☐

FILTER PACK

FROM ____ TO ____ FEET (BGS)

MATERIAL:

QUANTITY:

**CENTRALIZERS:**

YES ☐ DEPTH(S):

NO ☐

SCREEN

FROM ____ TO ____ FEET (BGS)

MATERIAL:

DIAMETER:

SLOT SIZE:

BOTTOM CAP

TYPE:

BOTTOM OF WELL

DEPTH: _____

BOREHOLE DEPTH: _____

BOREHOLE DIAMETER: _____ BACKFILL MATERIAL:

DEPTHS MEASURED IN
FEET BELOW GROUND SURFACE (BGS)

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Sheet ___ of ___

# WELL DEVELOPMENT DATA SHEET

**BORING NO.** _____ **WELL NO.** _____

Project _____
Project No. _____
Date(s) of Installation _____
Date(s) of Development _____
Personnel/Company _____
_____
Type of Rig Used _____

Casing Diameter/Type _____
Borehole Diameter _____
Screened Interval(s) _____
Total Length of Well Casing _____
Measured Total Depth (TOC) Initial _____
Final _____
Initial Depth to Water
(TOC) _____ Date _____ Time _____
Stabilized Depth to Water
(TOC) _____ Date _____ Time _____

DEVELOPMENT

TECHNIQUE(S) EQUIPMENT TYPE/CAPACITY

____ Jetting (Airlift) _____
____ Surge Block _____
____ Bailing _____
____ Pumping _____
____ Other _____

FLUIDS ADDED

Lost Drilling Fluid: _____ Gallons
Lost Purge Water: _____ Gallons
Water During Installation: _____ Gallons
Total Fluids Added: _____ Gallons
Source of Added Water: _____
Ground Water Quality Parameters of
Added Water Measured: Y N
Sample Collected of Added Water: Y N
Sample Designation of Added Water: _____

PURGE VOLUME CALCULATION

Casing Volume: _____ Ft. of water
x _____ Gallons/Foot
= _____ Gallons per Single Casing Volume
Sand Pack Volume: _____ Ft. of Saturated Sand Pack
x _____ Gallons/Foot (borehole diameter)
= _____ Gallons (in borehole)
- _____ Gallons of Casing Volume
= _____ x 0.3 (Assuming porosity = 30%)
= _____ Gallons Within Sand Pack
Single Purge Volume: _____ Gallons (Casing Vol. + Sand Pack Vol. + Fluids Added)
Minimum Purge Volume: _____ Gallons
Actual Purge Volume: _____ Gallons
Volume Measured by: _____
Rate of Development _____ Gallons/Minute (Hour,Day)
Pumping Rate/Depth _____ @ _____ Ft. (Below Grd.)
Immiscible Phases Present: Y N Thickness _____

INSTRUMENT CALIBRATION

pH Meter: _____ Spec. Conductance Meter: _____
pH 4.0 = _____ @ _____ °C Standard _____ µmhos/cm@ 25°C
pH 7.0 = _____ @ _____ °C Reading _____ µmhos/cm @ _____ °C
pH 10.0 = _____ @ _____ °C Turbidity Meter: _____
Dissolved Oxygen Meter: _____ Other: _____

| Total Volume Discharged | Rate of Discharge | Time | Temp | pH | Specific* Conductance | Turbidity or D.O. | Clarity, Odor, PID Readings, Other: |
|---|---|---|---|---|---|---|---|
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Development Completed at _____ Gallons Discharged. Date: _____ Time: _____
Criteria: _____ Personnel: _____

* Specific Conductance readings temperature compensated to 25°C, if not, report temperatures at which reading obtained

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# DAILY DATA QUALITY REPORT

| | | |
|---|---|---|
| | DATE: | TEMPERATURE: |
| | DAY: | WIND: |
| | WEATHER: | HUMIDITY: |

| | |
|---|---|
| PROJECT: | CONTRACT NUMBER: |
| TtEMI PROJECT NUMBER: | |

**PERSONNEL ON SITE**

**SUBCONTRACTOR(S) ON SITE**

**EQUIPMENT ON SITE**

**WORK PERFORMED, INCLUDING SAMPLING**

**QUALITY CONTROL ACTIVITIES**

**HEALTH AND SAFETY LEVELS AND ACTIVITIES**

**PROBLEMS ENCOUNTERED/CORRECTIVE ACTIONS TAKEN**

# DAILY DATA QUALITY REPORT

| DEVIATIONS FROM THE FIELD WORK PLAN | |
|---|---|
| | |
| **SPECIAL NOTES** | |
| | |
| **TOMORROW'S EXPECTATIONS** | |
| | |
| **DISTRIBUTION:** | **SUBMITTED BY:**<br><br>**REVIEWED BY:** |

Audit Report

Tetra Tech EM Inc.

Date of Audit:_____/_____/_____

CTO Project/
CTO Project No._____

CTO Project
Manager:_____

Audit Team Members:_____

Brief Description of CTO:

_____

_____

Audit Summary:

_____

_____

Corrective Action Required:

_____

_____

Quality Improvement Opportunities:

_____

_____

Remarks:

_____

_____

Auditor Signature:_____ Date:_____

cc: TtEMI Program QA Manager

CTO Corrective Action Request Form
(Page 1 of 2)

Tetra Tech EM Inc.

CTO Project/
CTO Project No._____ Date:_____

Location:_____

To (CTO Project Manager):_____

From (Audit Team Members):_____

Description of Problem:

_____

_____

_____

_____

_____

Corrective Action Requested:

_____

_____

_____

_____

The above correction action must be completed by:_____

Corrective Action Taken:

_____

_____

_____

_____

CTO Corrective Action Request Form
(Page 2 of 2)

CTO Project Manager:_____
(Subcontractor QA Manager)

**Acknowledgement of Receipt**

_____
(Date and Initial)

**Corrective Action Completed**

_____
(Date and Initial)

Audit Team Members:

Corrective Action *is / is not* satisfactory

_____
(Date and Initial)

Remarks:_____

_____

_____

_____

_____

QC Coordinators:

Corrective Action *is / is not* satisfactory

_____
(Date and Initial)

Remarks:_____

_____

_____

_____

_____

cc: Program QA Manager

# Quality Assurance Corrective Action Status Report

Tetra Tech EM Inc.

CTO Project/
CTO Project No._____ QC Level:_____

Project Manager:_____ Date:_____/_____/_____

| Corrective Action Number | Brief Description | Originator Initials and Date | Determination and Implementation | | | | Effectiveness | |
|---|---|---|---|---|---|---|---|---|
| | | | Initials | Due Date | Initials | Due Date | Due Date | Follow-up Date |
| | | | | | | | | |
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# APPENDIX 2

## SAMPLE METHODS, CONTAINERS, VOLUMES, PRESERVATION REQUIREMENTS, AND HOLDING TIMES

## CONTRACT-REQUIRED QUANTITATION AND DETECTION LIMITS

# TABLE 2-1

## NFD POINT MOLATE
## SAMPLE METHODS, CONTAINERS, PRESERVATION, AND HOLDING TIMES
## SITE 3 FIELD PILOT TESTING

| Parameter | Matrix | Method Reference | Sample Volume[a] | Preservative Requirements | Holding/Analysis Time[b] |
|---|---|---|---|---|---|
| TPH-e | Water | EPA 8015 | Two 1-liter ambers | NA | 14 days/40 days |
| TPH-e | Soil | EPA 8015 | One 8-ounce jar | NA | 14 days/40 days |
| TPH-diesel | Soil vapor | Modified NIOSH 1550 | Sorbent tube | Cool, 4°C | 30 days |
| TPH-p | Water | EPA 8015 | Two 40-ml vials | HCl | 14 days |
| TPH-p | Soil | EPA 8015 | 3 encore samplers | Cool, 4°C | 48 hrs/14 days |
| VOCs | Water | EPA 8260 | Two 40-mL vials | HCl (pH<2.0), Cool, 4°C | 14 days |
| VOCs | Soil | EPA 8260 | 3 encore samplers | Cool, 4°C | 48 hrs/14 days |
| VOCs | Soil vapor | EPA TO-17 | Sorbent tube | Cool, 4°C | 30 days |
| PAHs | Soil | EPA 8310 | One 8-ounce jar | Cool, 4°C | 14 days/40 days |
| BTEX | Water | EPA 8021 | Two 40-mL vials | HCl | 14 days |
| BTEX | Soil | EPA 8021 | 3 encore samplers | Cool, 4°C | 48hrs/14 days |
| Metals | Water | CLP Metals | One 1-liter poly | Filter, $HNO_3$ to pH<2 | Hg, 38days in glass,13days in plastic; others 6 months |
| Metals | Soil | CLP Metals | One 8-ounce amber jar | Cool, 4°C | Hg, 28 days; others 6 months |
| HPC | Water | SM 9215 | One 125-ml poly | Sodium thiosulfate | 24 hr |
| HPC | Soil | SM 9215 | One 4-ounce jar | NA | none |
| TKN | Water | 4500-NORGB | One 1-liter poly | NA | 28 days |
| o-$P0_4$ | Water | EPA 300.0 | One 500-ml poly | NA | 48 hours |
| Ferrous Iron | Water | SM 3500-FeD | One 250-ml poly | NA | 24 hours |
| Sulfate | Water | EPA 300.0 | One-1 liter poly | NA | 28 days |
| Nitrate | Water | EPA 300.0 | One 1-liter poly | NA | 48 hours |

Notes:

a All sample containers should have Teflon-lined caps

b X days/Y days: Refers to the number to the maximum number of days from sampling to extraction/the maximum number of days from extraction to analysis

ASTM American Society for Testing and Materials

BTEX Benzene, toluene, ethylbenzene, xylene

C Celsius

EPA U.S. Environmental Protection Agency

HCl Hydrochloric acid

Hg Mercury

$HNO_3$ Nitric acid

HPC Heterotrophic plate count

mL Milliliter

o-$P0_4$ Orthophosphate

PAHs Polynuclear aromatic hydrocarbons

TKN Total kjedahl nitrogen

TPH-e Total petroleum hydrocarbons (extractable)

VOCs Volatile organic compounds

## TABLE 2-2

## NFD POINT MOLATE
## VOLATILE ORGANIC COMPOUNDS
## CONTRACT-REQUIRED QUANTITATION LIMITS

| Volatile Organic Compounds | Water PRRL (µg/L) | Water PRG[c] (µg/L) | Soil PRRL (µg/kg) [a] | Soil PRG[b,c] (µg/kg) |
|---|---|---|---|---|
| 1,1,1-Trichloroethane | 1 | NA | 10 | NA |
| 1,1,2,2-Tetrachloroethane | 1 | NA | 10 | NA |
| 1,1,2-Trichloroethane | 1 | NA | 10 | NA |
| 1,1-Dichloroethane | 1 | NA | 10 | NA |
| 1,1-Dichloroethene | 1 | NA | 10 | NA |
| 1,2-Dichloroethane | 1 | NA | 10 | NA |
| 1,2-Dichloroethene | 1 | NA | 10 | NA |
| 1,2-Dichloropropane | 1 | NA | 10 | NA |
| 2-Butanone | 1 | NA | 10 | NA |
| 2-Hexanone | 1 | NA | 10 | NA |
| 4-Methyl-2-pentanone | 1 | NA | 10 | NA |
| Acetone | 1 | NA | 10 | NA |
| Benzene | 1 | 510 | 10 | 600 |
| Bromodichloromethane | 1 | NA | 10 | NA |
| Bromoform | 1 | NA | 10 | NA |
| Bromomethane | 1 | NA | 10 | NA |
| Carbon disulfide | 1 | NA | 10 | NA |
| Carbon tetrachloride | 1 | NA | 10 | NA |
| Chlorobenzene | 1 | NA | 10 | NA |
| Chloroethane | 1 | NA | 10 | NA |
| Chloroform | 1 | NA | 10 | NA |
| Chloromethane | 1 | NA | 10 | NA |
| cis-1,3-Dichloropropene | 1 | NA | 10 | NA |
| Dibromochloromethane | 1 | NA | 10 | NA |
| Ethylbenzene | 1 | 43 | 10 | 840,000 |
| Methylene chloride | 1 | NA | 10 | NA |
| Styrene | 1 | NA | 10 | NA |
| Tetrachloroethene | 1 | NA | 10 | NA |
| Toluene | 1 | 1,000 | 10 | 530,000 |
| Total xylenes | 1 | 130 | 10 | 1,080,000 |
| trans-1,3-Dichloropropene | 1 | NA | 10 | NA |
| Trichloroethene | 1 | NA | 10 | NA |
| Vinyl chloride | 1 | NA | 10 | NA |

Notes:

a Quantitation limits listed for soil analysis are based on wet weight. The quantitation limits reported by the laboratory for soil and other solid matrices, calculated on dry-weight basis as required by the contract, will be higher.

b Action level based on fuel constituents present at <10 feet below ground surface

c Compounds with NA for PRGs are not defined in the FPALDR; alternative action levels are to be developed as necessary

µg/kg Micrograms per kilogram

µg/L Micrograms per liter

PRG Preliminary remediation goal

PRRL Project required reporting limit

## TABLE 2-3

## NFD POINT MOLATE
## MISCELLANEOUS ANALYSES
## PROJECT REQUIRED REPORTING LIMIT

| Analyte | Analytical Method | Water PRRL | Water PRG[1] | Soil PRRL | Soil PRG[1] |
|---|---|---|---|---|---|
| TPH-Purgeable Gasoline | CA LUFT &EPA8015B | 50μg/L | 1,200μg/L | 0.5mg/kg | 1,030mg/kg |
| TPH-Extractables Diesel | CA LUFT &EPA8015B | 100μg/L | 2,200μg/L | 10mg/kg | 1,380mg/kg |
| JP-5 | CA LUFT &EPA8015B | 100μg/L | NA | 10mg/kg | NA |
| Bunker Fuel | CA LUFT &EPA8015B | 100μg/L | NA | 10mg/kg | NA |

Notes:

[1] PRGs have been defined in the Fuel Product Action Level Development Report

CA LUFT California leaking underground fuel tank
EPA U.S. Environmental Protection Agency
mg/kg Milligrams per kilogram
PRG Preliminary remediation goal
μg/L Micrograms per liter

## TABLE 2-4

## NFD POINT MOLATE
## POLYNUCLEAR AROMATIC HYDROCARBONS
## PROJECT REQUIRED REPORTING LIMIT

| Analyte | Analytical Method | Soil PRRL | Soil PRG[1] |
|---|---|---|---|
| Acenaphthene | EPA 8310 | 20 µg/kg | NA |
| Acenaphthylene | EPA 8310 | 30 µg/kg | NA |
| Anthracene | EPA 8310 | 2 µg/kg | 5,900,000 µg/kg |
| Benzo(a)pyrene | EPA 8310 | 3 µg/kg | 40 µg/kg |
| Benzo(b)flouranthene | EPA 8310 | 3 µg/kg | 430 µg/kg |
| Benzo(k)flouranthene | EPA 8310 | 2 µg/kg | 430 µg/kg |
| Benzo(a)anthracene | EPA 8310 | 3 µg/kg | 430 µg/kg |
| Chrysene | EPA 8310 | 2 µg/kg | 4,300 µg/kg |
| Naphthalene | EPA 8310 | 15 µg/kg | 480,000 µg/kg |
| Phenanthrene | EPA 8310 | 2 µg/kg | 600,000 µg/kg |
| Pyrene | EPA 8310 | 2 µg/kg | 620,000 µg/kg |

Notes:

[1] PRGs have been defined in the Fuel Product Action Level Development Report

EPA U.S. Environmental Protection Agency
NA Not applicable
PRG Preliminary remediation goal
PRRL Project required reporting limit
µg/L Micrograms per liter
µg/kg Micrograms per kilogram

## TABLE 2-5

## NFD POINT MOLATE
## AROMATIC VOLATILES
## PROJECT REQUIRED REPORTING LIMIT

| Analyte | Analytical Method | Water PRRL | Water PRG[1] | Soil PRRL | Soil PRG[1] |
|---|---|---|---|---|---|
| Benzene | EPA 8021B | 0.5 µg/L | 510 µg/L | 0.5 µg/kg | 600 µg/kg |
| Toluene | EPA 8021B | 0.5 µg/L | 1,000 µg/L | 0.5 µg/kg | 530,00 µg/kg |
| Ethylbenzene | EPA 8021B | 0.5 µg/L | 43 µg/L | 0.5 µg/kg | 840,000 µg/kg |
| Xylenes | EPA 8021B | 1 µg/L | 130 µg/L | 1 µg/kg | 1,080,000 µg/kg |

Notes:

[1] PRGs have been defined in the Fuel Product Action Level Development Report

EPA U.S. Environmental Protection Agency
PRG Preliminary remediation goal
PRRL Project required reporting limit
µg/L Micrograms per liter
µg/kg Micrograms per kilogram

## TABLE 2-6

## NFD POINT MOLATE
## CLP METALS
## PROJECT REQUIRED DETECTION LIMITS

| Analyte | Water PRDL (µg/L) | Water PRG[a] (µg/L) | Soil PRDL[b] (mg/kg) | Industrial Soil PRG[c] (mg/kg) |
|---|---|---|---|---|
| Aluminum | 50 | NA | 10 | 100,000 |
| Antimony | 5.0 | 500 | 1.0 | 820 |
| Arsenic | 5 | 36 | 1.0 | 2.7 |
| Barium | 20 | NA | 4.0 | 100,000 |
| Beryllium | 1.0 | NA | 0.2 | 2,200 |
| Cadmium | 2.0 | 9.3 | 0.4 | 810 |
| Calcium | 5.0 | NA | 1,050 | NA |
| Chromium($Cr^{+6}$) | 5.0 | 50 | 1.0 | 64 |
| Cobalt | 5.0 | NA | 1.0 | 100,000 |
| Copper | 5.0 | 3.1 | 1.0 | 76,000 |
| Iron | 100 | NA | 20 | 100,000 |
| Lead | 3.0 | 8.1 | 1.0 | 750 |
| Lithium | 100 | NA | 1 | 41,000 |
| Magnesium | 5,000 | NA | 1,000 | NA |
| Manganese | 10 | NA | 3.0 | 32,000 |
| Mercury | 0.1 | 0.94 | 0.1 | 610 |
| Molybdenum | 5.0 | NA | 1.0 | 10,000 |
| Nickel | 20.0 | 8.2 | 0.4 | 41,000 |
| Potassium | 5000 | NA | 1,000 | NA |
| Selenium | 5.0 | 71 | 1.0 | 10,000 |
| Silver | 5.0 | NA | 1.0 | 10,000 |
| Sodium | 5000 | NA | 1,000 | NA |
| Thallium | 2.0 | NA | 0.4 | 130 |
| Vanadium | 10.0 | NA | 2.0 | 14,000 |
| Zinc | 10.0 | 81 | 2.0 | 100,000 |

Notes:

[a] Water PRGs are based on NOAA Screening Quick Reference Tables (Sept.1999) for aquatic (marine) ecological receptors under a chronic exposure; action levels for analytes with NA have not been defined and alternative action levels will be developed as necessary.

[b] PRDLs listed for soil analysis are based on wet weight. The PRDLs reported by the laboratory for soil and other solid matrices, calculated on dry-weight basis as required by the contract, will be higher.

[c] Soil PRGs are based on EPA Region 9(www.epa.gov/region09/waste/sfund/prg/)

| | |
|---|---|
| CLP | Contract laboratory program |
| µg/L | Micrograms per liter |
| mg/kg | Milligrams per kilogram |
| NA | Not available |
| PRDL | Project-required detection limit |
| PRG | Preliminary Remedial Goal (EPA 1999a) |

# APPENDIX 3

# PRECISION AND ACCURACY GOALS

## TABLE 3-1

## NFD POINT MOLATE
## GROUNDWATER FIELD MEASUREMENTS: pH, TEMPERATURE, AND CONDUCTIVITY
## PRECISION AND ACCURACY GOALS

| Analyte | Accuracy Goal |
|---|---|
| pH | ± 0.1 pH unit |
| Temperature | ± 0.1 °C |
| Conductivity | 20 $\mu$mhos/cm |

Notes:

| | |
|---|---|
| °C | Degrees in celsius |
| RPD | Relative percent difference |
| µmhos/cm | Micromhos per centimeter |

## TABLE 3-2

## NFD POINT MOLATE
## VOLATILE ORGANIC COMPOUNDS/METHOD CLP VOC METHOD
## PRECISION AND ACCURACY GOALS

### Matrix Spike Limits

| Analyte | Matrix Spike Compound | Water | | Soil | |
|---|---|---|---|---|---|
| | | Percent Recovery | RPD | Percent Recovery | RPD |
| VOCs | 1,1-Dichloroethene | 61-145 | 14 | 59-172 | 22 |
| | Trichloroethene | 71-120 | 14 | 62-137 | 24 |
| | Chlorobenzene | 75-130 | 13 | 60-133 | 21 |
| | Toluene | 76-125 | 13 | 59-139 | 21 |
| | Benzene | 76-127 | 11 | 66-142 | 21 |

### Surrogate Recovery Limits

| Analyte | Surrogate Compound | Water Percent Recovery | Soil Percent Recovery |
|---|---|---|---|
| VOCs | Toluene-$d_8$ | 88-110 | 84-138 |
| | 4-Bromofluorobenzene | 86-115 | 59-113 |
| | 1,2-Dichloroethane-$d_4$ | 76-114 | 70-121 |

Notes:

CLP Contract Laboratory Program
RPD Relative percent difference
VOC Volatile organic compound

TABLE 3-3

# NFD POINT MOLATE
# TOTAL PETROLEUM HYDROCARBONS-PURGEABLE AND EXTRACTABLE
# PRECISION AND ACCURACY GOALS

**Surrogate Recovery Limits**

| Analyte | Surrogate Compound | Water Percent Recovery | Soil Percent Recovery |
|---|---|---|---|
| TPH-p | Bromoflourobenzene | 75-125 | 75-125 |

**Surrogate Recovery Limits**

| Analyte | Surrogate Compound | Water Percent Recovery | Soil Percent Recovery |
|---|---|---|---|
| TPH-e | Bromobenzene | NA | 60-140 |
| | Hexacosane | NA | 60-140 |
| | Octacosane | 60-140 | NA |

Notes:

NA Not applicable
TPH-p Total purgeable hydrocarbons-purgeable
TPH-e Total purgeable hydrocarbons-extractable

## TABLE 3-4

## NFD POINT MOLATE
## CLP METALS
## PRECISION AND ACCURACY GOALS

| Analysis | Matrix Spike[a] | | Surrogates[a] |
|---|---|---|---|
| | % Recovery | RPD | % Recovery |
| Metals | 70-130 | 35 | NA |

Notes:

[a] Listed criteria will apply to all water and soil matrices.
NA Not available
RPD Relative percent difference

APPENDIX 4

U.S ENVIRONMENTAL PROTECTION AGENCY METHOD TO-17

EPA/625/R-96/010b

# Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air

## Second Edition

## Compendium Method TO-17

## Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes

Center for Environmental Research Information
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, OH 45268

January 1999

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Method TO-17
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DISCLAIMER

***This Compendium has been subjected to the Agency's peer and administrative review, and it has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.***



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# METHOD TO-17

## Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes

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# METHOD TO-17

## Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes

### 1. Scope

1.1 This document describes a sorbent tube/thermal desorption/gas chromatographic-based monitoring method for volatile organic compounds (VOCs) in ambient air at 0.5 to 25 parts per billion (ppbv) concentration levels. Performance criteria are provided as part of the method in Section 14. EPA has previously published Compendium Method TO-1 describing the use of the porous polymer Tenax® GC for sampling nonpolar VOCs and Compendium Method TO-2 describing the use of carbon molecular sieve for highly volatile, nonpolar organics (1). Since these methods were developed, a new generation of thermal desorption systems as well as new types of solid adsorbents have become available commercially. These sorbents are used singly or in multisorbent packings. Tubes with more than one sorbent, packed in order of increasing sorbent strength are used to facilitate quantitative retention and desorption of VOCs over a wide volatility range. The higher molecular weight compounds are retained on the front, least retentive sorbent; the more volatile compounds are retained farther into the packing on a stronger adsorbent. The higher molecular weight compounds never encounter the stronger adsorbents, thereby improving the efficiency of the thermal desorption process.

1.2 A large amount of data on solid adsorbents is available through the efforts of the Health and Safety Laboratory, Health and Safety Executive (HSE), Sheffield, United Kingdon (UK). This group has provided written methods for use of solid adsorbent packings in monitoring workplace air. Some of their documents on the subject are referenced in Section 2.2. Also, a table of information on safe sampling volumes from their research is provided in Appendix 1.

1.3 EPA has developed data on the use of solid sorbents in multisorbent tubes for concentration of VOCs from the ambient air as part of its program for methods development of automated gas chromatographs. The experiments required to validate the use of these sorbent traps include capture and release efficiency studies for given sampling volumes. These studies establish the validity of using solid adsorbents for target sets of VOCs with minimal (at most one hour) storage time. Although questions related to handling, transport and storage of samples between the times of sampling and analysis are not addressed, these studies provide information on safe sampling volumes. Appendix 2 delineates the results of sampling a mixture of humidified zero air and the target VOCs specified in the Compendium Method TO-14 (2) using a specific multisorbent.

1.4 An EPA workshop was convened in November of 1995 to determine if a consensus could be reached on the use of solid sorbent tubes for ambient air analysis. The draft method available at the workshop has evolved through several reviews and modifications into the current document. The method is supported by data reported in the scientific literature as cited in the text, and by recent experimental tests performed as a consequence of the workshop (see Table 1).

1.5 The analytical approach using gas chromatography/mass spectroscopy (GC/MS) is identical to that mentioned in Compendium Method TO-15 and, as noted later, is adapted for this method once the sample has been thermally desorbed from the adsorption tube onto the focusing trap of the analytical system.



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1.6 Performance criteria are given in Section 14 to allow acceptance of data obtained with any of the many variations of sampling and analytical approaches.

## 2. Summary of Method

2.1 The monitoring procedure involves pulling a volume of air through a sorbent packing to collect VOCs followed by a thermal desorption-capillary GC/MS analytical procedure.

2.2 Conventional detectors are considered alternatives for analysis subject to the performance criteria listed in Section 14 but are not covered specifically in this method text.

2.3 Key steps of this method are listed below.

2.3.1 Selection of a sorbent or sorbent mix tailored for a target compound list, data quality objectives and sampling environment.

2.3.2 Screening the sampling location for VOCs by taking single tube samples to allow estimates of the nature and amount of sample gases.

2.3.3 Initial sampling sequences with two tubes at nominally 1 and 4 liter total sample volumes (or appropriate proportional scaling of these volumes to fit the target list and monitoring objectives).

2.3.4 Analysis of the samples and comparison to performance criteria.

2.3.5 Acceptance or rejection of the data.

2.3.6 If rejection, then review of the experimental arrangement including repeat analysis or repeat analysis with backup tubes and/or other QC features.

*[Note: EPA requires the use of distributed volume pairs (see Section14.4) for monitoring to insure high quality data. However, in situations where acceptable data have been routinely obtained through use of distributed volume pairs and the ambient air is considered well characterized, cost considerations may warrant single tube sampling. Any attendant risk to data quality objectives is the responsibility of the project's decision maker.]*

2.4 Key steps in sample analysis are listed below.

2.4.1 Dry purge of the sorbent tube with dry, inert gas before analysis to remove water vapor and air. The sorbent tube can be held at temperatures above ambient for the dry purge.

2.4.2 Thermal desorption of the sorbent tube (primary desorption).

2.4.3 Analyte refocusing on a secondary trap.

2.4.4 Rapid desorption of the trap and injection/transfer of target analytes into the gas chromatograph (secondary desorption).

2.4.5 Separation of compounds by high resolution capillary gas chromatography (GC).

2.4.6 Measurement by mass spectrometry (MS) or conventional GC detectors (only the MS approach is explicitly referred to in Compendium Method TO-17; an FID/ECD detector combination or other GC detector can be used if Section 14 criteria are met. However, no explicit QA guidelines are given here for those alternatives).



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2.5 The target compound list (TCL) is the same as listed in Compendium Method TO-15 (i.e., subsets of the 97 VOCs listed as hazardous pollutants in Title III of the Clean Air Act Amendments of 1990). Only a portion of these compounds has been monitored by the use of solid adsorbents. This method provides performance criteria to demonstrate acceptable performance of the method (or modifications of the method) for monitoring a given compound or set of compounds.

## 3. Significance

3.1 This method is an alternative to the canister-based sampling and analysis methods that are presented in Compendium Methods TO-14 and TO-15 and to the previous sorbent-based methods that were formalized as Compendium Methods TO-1 and TO-2. All of these methods are of the type that include sampling at one location, storage and transport of the sample, and analysis at another, typically more favorable site.

3.2 The collection of VOCs in ambient air samples by passage through solid sorbent packings is generally recognized to have a number of advantages for monitoring. These include the following:

- The small size and light weight of the sorbent packing and attendant equipment.
- The placement of the sorbent packing as the first element (with the possible exception of a filter or chemical scrubber for ozone) in the sampling train so as to reduce the possibility of contamination from upstream elements.
- The availability of a large selection of sorbents to match the target set of compounds including polar VOC.
- The commercial availability of thermal desorption systems to release the sample from the sorbent and into the analytical system.
- The possibility of water management using a combination of hydrophobic sorbents (to cause water breakthrough while sampling); dry gas purge of water from the sorbent after sampling; and splitting of the sample during analysis.
- The large amount of literature on the use of sorbent sampling and thermal desorption for monitoring of workplace air, particularly the literature from the Health and Safety Executive in the United Kingdom.

3.3 Accurate risk assessment of human and ecological exposure to toxic VOCs is an important goal of the U. S. Environmental Protection Agency (EPA) with increased emphasis on their role as endocrine disrupters. Accurate data is fundamental to reaching this goal. The portability and small size of typical sampling packages for sorbent-based sampling and the wide range of sorbent choices make this monitoring approach appealing for special monitoring studies of human exposure to toxic gases and to use in network monitoring to establish prevalence and trends of toxic gases. Microenvironmental and human subject studies are typical of applications for Compendium Method TO-17.

3.4 Sorbent-based monitoring can be combined with canister-based monitoring methods, on-site autoGC systems, open path instrumentation, and other specialized point monitoring instruments to address most monitoring needs for volatile organic gases. More than one of these approaches can be used simultaneously as a means to check and insure the quality of the data being produced.



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3.5 In the form specified in Compendium Method TO-17, sorbent sampling incorporates the distributed volume pair approach that provides inherently defensible data to counter questions of sample integrity, operator performance, equipment malfunction during sampling, and any other characteristic of sample collection that is not linear with sampling volume.

3.6 In keeping with the consensus of EPA scientists and science advisors, the method is performance-based such that performance criteria are provided. Any modification of the sorbent approach to monitoring for VOCs can be used provided these criteria are met.

## 4. Applicable Documents

### 4.1 ASTM Standards

- Method D1356 *Definition of Terms Relating to Atmospheric Sampling and Analysis*
- Method E260 *Recommended Practice for General Gas Chromatography*
- Method E355 *Practice for Gas Chromatography Terms and Relationships*

### 4.2 EPA Documents

- *Technical Assistance Document for Sampling and Analysis Toxic Organic Compounds in Ambient Air*, U. S. Environmental Protection Agency, EPA-600/4-83-027, June 1983.
- *Quality Assurance Handbook for Air Pollution Measurement Systems*, U. S. Environmental Protection Agency, EPA-600/R-94-038b, May 1994.
- *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air: Methods TO-1 and TO-2*, U. S. Environmental Protection Agency, EPA 600/4-84-041, April 1984.
- *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air: Method TO-14, Second Supplement*, U. S. Environmental Protection Agency, EPA 600/4-89-018, March 1989.
- *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air: Method TO-15*, U. S. Environmental Protection Agency, EPA 625/R-96-010b, January 1997.

### 4.3 Other Documents

- MDHS 3 - Generation of Test Atmospheres of Organic Vapors by the Syringe Injection Technique, *Methods for the Determination of Hazardous Substances (MDHS)*, Health and Safety Laboratory, Health and Safety Executive, Sheffield, UK.
- MDHS 4 - Generation of Test Atmospheres of Organic Vapors by the Permeation Tube Method, *Methods for the Determination of Hazardous Substances (MDHS)*, Health and Safety Laboratory, Health and Safety Executive, Sheffield, UK.
- MDHS 72 - Volatile Organic Compounds in Air, *Methods for the Determination of Hazardous Substances (MDHS)*, Health and Safety Laboratory, Health and Safety Executive, Sheffield, UK.
- TAD - *Technical Assistance Document (TAD) on the Use of Solid Sorbent-based Systems for Ambient Air Monitoring*, Perkin Elmer Corp., 50 Danbury Rd., Wilton, CT 06897, USA.



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## 5. Definitions

*[Note: Definitions used in this document and any user-prepared Standard Operating Procedures (SOPs) should be consistent with those used in ASTM D1356. All abbreviations and symbols are defined within this document at the point of first use.]*

5.1 **Thermal Desorption**-the use of heat and a flow of inert (carrier) gas to extract volatiles from a solid or liquid matrix directly into the carrier gas and transfer them to downstream system elements such as the analytical column of a GC. No solvent is required.

5.2 **Two-stage Thermal Desorption**-the process of thermally desorbing analytes from a solid or liquid matrix, reconcentrating them on a focusing tube and then rapidly heating the tube to "inject" the concentrated compounds into the GC system in a narrow band of vapor compatible with high resolution capillary gas chromatography.

5.3 **Sorbent Tube (Also referred to as 'tube' and 'sample tube')**-stainless steel, glass or glass lined (or fused silica lined) stainless steel tube, typically 1/4 inch (6 mm) O.D. and of various lengths, with the central portion packed with greater than 200 mg of solid adsorbent material, depending on density and packing bed length. Used to concentrate VOCs from air.

5.4 **Focusing Tube**-narrow (typically <3mm I.D.) tube containing a small bed of sorbent, which is maintained near or below ambient temperature and used to refocus analytes thermally desorbed from the sorbent tube. Once all the VOCs have been transferred from the sorbent tube to the focusing tube, the focusing tube is heated very rapidly to transfer the analytes into the capillary GC analytical column in a narrow band of vapor.

5.5 **Cryogen (Also referred to as 'cryogenic fluid')**-typically liquid nitrogen, liquid argon, or liquid carbon dioxide. In the present context, cryogens are used in some thermal desorption systems to cool the focusing tube.

5.6 **High Resolution Capillary Column Chromatography**-conventionally describes fused silica capillary columns with an internal diameter of 320 µm or below and with a stationary phase film thickness of 5 µm or less.

5.7 **Breakthrough Volume (BV)**-volume of air containing a constant concentration of analyte which may be passed through a sorbent tube before a detectable level (typically 5%) of the analyte concentration elutes from the nonsampling end. Alternatively, the volume sampled when the amount of analyte collected in a back-up sorbent tube reaches a certain percentage (typically 5%) of the total amount collected by both sorbent tubes. These methods do not give identical results. For purposes in the document the former definition will be used.

5.8 **Retention Volume (RV)**-the volume of carrier gas required to move an analyte vapor plug through the short packed column which is the sorbent tube. The volume is determined by measuring the carrier gas volume necessary to elute the vapor plug through the tube, normally measured at the peak response as the plug exits the tube. The retention volume of methane is subtracted to account for dead volume in the tube.



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5.9 Safe Sampling Volume (SSV)-usually calculated by halving the retention volume (indirect method) or taking two-thirds of the breakthrough volume (direct method), although these two approaches do not necessarily give identical results. The latter definition is used in this document.

5.10 Sorbent Strength—term used to describe the affinity of sorbents for VOC analytes. A stronger sorbent is one which offers greater safe sampling volumes for most/all VOC analytes relative to another, weaker sorbent. Generally speaking, sorbent strength is related to surface area, though there are exceptions to this. The SSVs of most, if not all, VOCs will be greater on a sorbent with surface area "10n" than on one with a surface area of "n". As a general rule, sorbents are described as "weak" if their surface area is less than 50 $m^2g^{-1}$ (includes Tenax®, Carbopack™/trap C, and Anasorb® GCB2), "medium strength" if the surface area is in the range 100-500 $m^2g^{-1}$ (includes Carbopack™/trap B, Anasorb® GCBI and all the Porapaks and Chromosorbs listed in Tables 1 and 2) and "strong" if the surface area is around 1000 $m^2g^{-1}$ (includes Spherocarb®, Carbosieve™ S-III, Carboxen™ 1000, and Anasorb® CMS series sorbents.)

5.11 Total Ion Chromatogram (TIC)-chromatogram produced from a mass spectrometer detector operating in full scan mode.

5.12 MS-SCAN-mode of operation of a GC mass spectrometer detector such that all mass ions over a given mass range are swept over a given period of time.

5.13 MS -SIM-mode of operation of a GC mass spectrometer detector such that only a single mass ion or a selected number of discrete mass ions are monitored.

5.14 Standard Sorbent (Sample) Tube-stainless steel, glass or glass lined (or fused silica lined) stainless steel tube, 1/4 inch (6 mm) O.D. and of various lengths, with the central portion packed with ≥200 mg of solid adsorbent material depending on sorbent density. Tubes should be individually numbered and show the direction of flow.

5.15 Time Weighted Average (TWA) Monitoring-if air is sampled over a fixed time period - typically 1,3, 8 or 24 hours, the time weighted average atmospheric concentration over the monitoring period may be calculated from the total mass of analyte retained and the specific air volume sampled. Constraints on breakthrough volumes make certain combinations of sampling time and flow rates mutually exclusive.

## 6. Overview of Methodology

*[Note: The following is intended to provide a simple and straightforward method description including the example of a specific sampling problem. Although specific equipment is listed, the document is intended only as an example and equipment mentioned in the text is usually only one of a number of equally suitable components that can be used. Hence trade names are not meant to imply exclusive endorsement for sampling and analysis using solid sorbents. Later sections in the text give guidance as to what considerations should be made for a number of VOC monitoring applications.]*



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## 6.1 Selection of Tube and Sorbent

6.1.1 Select a tube and sorbent packing for the sampling application using guidance from Tables 1 and 2 on sorbent characteristics as well as guidance from Appendix 1 and Table 3 on safe sampling volumes and breakthrough characteristics of sorbents.

6.1.2 As an example, assume the TCL includes a subset of the compounds shown in Table 3. In this case, the multisorbent tube chosen consists of two sorbents packed in a 1/4 inch O.D., 3.5" long glass tube in the following order and amounts: 160 mg of Carbopack™ graphitized carbon black (60/80 mesh) and 70 mg of Carboxen™-1000 type carbon molecular sieve (60/80 mesh). This is an example of Tube Style 2 discussed Section 9.1.3.2.

6.1.3 Pack the tube with the adsorbent by using the guidance provided in Section 10.1 or buy a prepacked tube from a supplier. In the example, tubes were purchased from Supelco Inc., Supelco Park, Bellefonte, PA 16823-0048.

## 6.2 Conditioning the Tube

6.2.1 Condition newly packed tubes for at least 2 hours (30 mins for preconditioned, purchased tubes) at 350°C while passing at least 50 mL/min of pure helium carrier gas through them.

*[Note: Other sorbents may require different conditioning temperatures - see Table 2 for guidance.]*

Once conditioned, seal the tube with brass, 1/4 inch Swagelok® -type fittings and PTFE ferrules. Wrap the sealed tubes in uncoated aluminum foil and place the tubes in a clean, airtight, opaque container.

6.2.2 A package of clean sorbent material, e.g. activated charcoal or activated charcoal/silica gel mixture, may be added to the container to ensure clean storage conditions.

6.2.3 Store in a refrigerator (organic solvent-free) at 4°C if not to be used within a day. On second and subsequent uses, the tubes will generally not require further conditioning as above. However, tubes with an immediate prior use indicating high levels of pollutant trace gases should be reconditioned prior to continued usage.

## 6.3 Sampling Apparatus

6.3.1 Select a sampling apparatus with accommodations for two sampling tubes capable of independent control of sampling rate at a settable value in the range 10 to 200 mL/min. Laboratory and field blanks must also be included in the monitoring exercise.

6.3.2 Backup tubes may be required to determine the cause of any problem if performance criteria, outlined in Section 14, are not met.

## 6.4 Sampling Rates

6.4.1 Select sampling rates compatible with the collection of 1 and 4 liter total sample volume (or of proportionally lower/higher sampling volumes).

6.4.2 Air samples are collected over 1 hour with a sampling rate of 16.7 mL/min and 66.7 mL/min, respectively.



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## 6.5 Preparing for Sample Collection

6.5.1 At the monitoring location, keep the tubes in their storage and transportation container to equilibrate with ambient temperature.

6.5.2 Using clean gloves, remove the sample tubes from the container, take off their caps and attach them to the sampling lines with non-outgassing flexible tubing. Uncap and immediately reseal the required number of field blank tubes.

6.5.3 Place the field blank tubes back in the storage container. If back-up tubes are being used, attach them to the sampling tubes using clean, metal Swagelok® type unions and combined PTFE ferrules.

## 6.6 Set the Flow Rates

6.6.1 Set the flow rates of the pump using a mass flow monitor.

6.6.2 The sampling train includes, from front to back, an in-line particulate filter (optional), an ozone scrubber (optional), a sampling tube, a back-up tube if any is being used, and a flow controller/pump combination.

6.6.3 Place the mass flow monitor in line after the tube. Turn the pump on and wait for one minute. Establish the approximate sampling flow rate using a dummy tube of identical construction and packing as the sampling tube to be used. Record on Field Test Data Sheet (FTDS), as illustrated in Figure 1.

6.6.4 Place the sampling tubes to be used on the sampling train and make final adjustments to the flow controller as quickly as possible to avoid significant errors in the sample volume.

6.6.5 Adjust the flow rate of one tube to sample at 16.7 mL/min. Repeat the procedure for the second tube and set the flow rate to 66.7 mL/min. Record on FTDS.

## 6.7 Sample and Recheck Flow Rates

6.7.1 Sample over the selected sampling period (i.e., 1-hour). Recheck all the sampling flow rates at the end of the monitoring exercise just before switching off each pump and record on FTDS.

6.7.2 Make notes of all relevant monitoring parameters including locations, tube identification numbers, pump flow rates, dates, times, sampled volumes, ambient conditions etc. on FTDS.

## 6.8 Reseal the Tubes

6.8.1 Immediately remove the sampling tubes with clean gloves, recap the tubes with Swagelok® fittings using PTFE ferrules, rewrap the tubes with uncoated Al foil, and place the tubes in a clean, opaque, airtight container.

6.8.2 If not to be analyzed during the same day, place the container in a clean, cool (<4°C), organic solvent-free environment and leave there until time for analysis.

## 6.9 Selection of Thermal Desorption System

6.9.1 Select a thermal desorption system using the guidance provided in Section 8.

6.9.2 Place the thermal unit in a ready operational status.



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## 6.10 Dry Purge the Tubes and Prepare for Thermal Desorption

6.10.1 Remove the sampling tubes, any backup tubes being used, and blanks from the storage area and allow the tubes to come to room temperature. Using clean gloves, remove the Swagelok®-type fittings and dry purge the tubes with a forward (sampling direction) flow of, for example, 50 mL/min of dry helium for 4 minutes (see Section 7.2 concerning dry purging).

*[Note: Do not dry purge the laboratory blanks.]*

6.10.2 Reseal the tubes with Teflon® (or other) caps compatible with the thermal desorber operation. Place the sealed tubes on the thermal desorber (e.g., Perkin Elmer Model ATD 400 Automated System or equivalent). Other thermal desorbers may have different arrangements for automation. Alternatively, use equivalent manual desorption.

## 6.11 Check for System Integrity

6.11.1 Check the air tightness of the seals and the integrity of the flow path.
6.11.2 Guidance is provided in Section 11.2 of this document.

## 6.12 Repurge of Tube on the Thermal Desorber/Addition of Internal Standard

6.12.1 Because of tube handling after dry purge, it may be necessary to repurge each of the tubes with pure, dry helium (He) before analysis in order to eliminate any oxygen.
6.12.2 If the initial dry purge can be performed on the thermal desorber so as to prevent any further exposure of the sorbent to air, then this step is not necessary. Proceed with the addition of an internal standard to the sorbent tube or the focusing tube.

## 6.13 Thermally Desorb the Packing

6.13.1 Reverse the flow direction of He gas, set the flow rate to at least 30 mL/min, and heat the tube to 325 °C (in this case) to achieve a transfer of VOCs onto a focusing tube at a temperature of 27 °C. Thermal desorption continues until all target species are transferred to the focusing trap. The focusing trap is typically packed with 20 mg of Carbopack™ B (60/80 mesh) and 50 mg of a Carboxen™ 1000-type sorbent (60/80 mesh).

## 6.14 Trap Desorption and GC/MS Analysis

6.14.1 After each tube is desorbed, rapidly heat the focusing trap (to 325 °C in this example) and apply a reverse flow of at least 3 mL/min of pure helium carrier gas. Sample splitting is necessary to accommodate the capillary column. Analytes are transferred to the column in a narrow band of vapor.
6.14.2 The GC run is initiated based on a time delay after the start of thermal desorption. The remaining part of the analytical cycle is described in Section 3 of Compendium Method TO-15.

## 6.15 Restoring the Tubes and Determine Compliance with Performance Standards



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6.15.1 When tube analysis is completed, remove the tubes from the thermal desorber and, using clean gloves, replace the Teflon® caps with Swagelok fittings and PTFE ferrules, rewrap with aluminum foil, replace in the clean, airtight container, and re-store the tubes in a cool environment (<4°C) until the next use.

6.15.2 Using previously prepared identification and quantification subroutines, identify the target compounds and document the amount of each measured compound (refer to the Section 3 of Compendium Method TO-15). Compare the results of analysis for the distributed volume pair taken during each sampling run and use the comparison to determine whether or not the performance criteria for individual sampling events have been met. Also examine the results of any laboratory blanks, field blanks, and any backup tube being used. Accept or reject the data based on the performance criteria (see Section 14).

### 6.16 Record and Store Data

6.16.1 Accurately retrieve field data (including the tube identification number) from the FTDS. The data should include a sampling site identifier, time of sample initiation, duration of sampling, air pump identification, flow rate, and other information as appropriate.

6.16.2 Store GC/MS data in a permanent form both in hard copy in a notebook and in digital form on a disk. Also store the data sheet with the hard copy.

*[Note: Sections 7 through 14 below elaborate on the method by providing important information and guidance appropriate to explain the method as outlined in Section 6 and also to generalize the method for many applications. Section 14 gives the performance criteria for the method.]*

## 7. Interferences and Limitations

### 7.1 Interference from Sorbent Artifacts

#### 7.1.1 Minimizing Artifact Interference.

7.1.1.1 Stringent tube conditioning (see Section 10.2.1) and careful tube capping and storage procedures (see Section 10.2.2) are essential for minimizing artifacts. System and sorbent tube conditioning must be carried out using more stringent conditions of temperature, gas flow and time than those required for sample analysis.

7.1.1.2 A reasonable objective is to **reduce artifacts to 10% or less of individual analyte masses** retained during sampling. A summary of VOC levels present in a range of different atmospheric environments and the masses of individual components collected from 1, 2 or 10 L samples of air in each case is presented in Table 4.

7.1.1.3 Given that most ambient air monitoring is carried out in areas of poor air quality, for example in urban, indoor and factory fenceline environments where VOC concentrations are typically above 1 ppb, Table 4 demonstrates that the mass of each analyte retained will, therefore, range from ~5 ng to ~10 $\mu$g in most monitoring situations. Even when monitoring 'ultraclean' environments, analyte masses retained will usually exceed 0.1 ng (3).

7.1.1.4 Typical artifact levels for 1/4 inch O.D. tubes of 3.5" length range from 0.01 ng and 0.1 ng for carbonaceous sorbents and Tenax® respectively. These levels compare well with the masses of analytes collected - even from sub-ppb atmospheric concentrations (see Table 4). Artifact levels are around 10 ng for Chromosorb® Century series and other porous polymer sorbents. However, these types of sorbents can still be used for air monitoring at low ppb levels if selective or mass spectrometer detectors are used or if the blank profile of the tube demonstrates that none of the sorbent artifacts interfere analytically with the compounds of interest.



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7.1.1.5 Some varieties of charcoal contain metals which will catalyze the degradation of some organic analytes during thermal desorption at elevated temperatures thus producing artifacts and resulting in low analyte recoveries.

7.1.2 Artifacts from Long-term Storage of Blank Tubes.

7.1.2.1 Literature reports of the levels of artifacts on (a) Carbotrap/pack™ C, Carbotrap/pack™ B and Carbosieve™ SIII multi-bed tubes and (b) Tenax® GR tubes, by workers sealing the tubes using metal Swagelok®-type caps and PTFE ferrules with multi-tube, glass storage jars are reported to be between 0.01 ng [after 1-2 months (4)] and 0.1 ng [after 6 months (5)] for (a) and (b) respectively.

7.1.2.2 Artifact levels reported for other porous polymers are higher - for example 5 ng for Chromosorb 106 after 1 week (5). More information is given in the Technical Assistance Document (TAD) referred to in Section 4.3.

7.1.3 Artifacts Generated During Sampling and Sample Storage.

7.1.3.1 Benzaldehyde, phenol and acetophenone artifacts are reported to be formed via oxidation of the polymer Tenax® when sampling high concentration (100-500 ppb) ozone atmospheres (6).

7.1.3.2 Tenax® should thus be used with an ozone scrubber when sampling low levels (<10 ppb) of these analytes in areas with appreciable ozone concentrations. Carbotrap™/pack type sorbents have not been reported to produce this level of artifact formation. Once retained on a sorbent tube, chemically stable VOCs, loaded in laboratory conditions, have been shown to give good recoveries, even under high ozone concentrations for storage of a year or more (7-9).

## 7.2 Minimizing Interference from Water

### 7.2.1 Selection of Hydrophobic Sorbents

7.2.1.1 There are three preferred approaches to reducing water interference during air monitoring using sorbent tubes. The first is to minimize water collection by selecting, where possible, a hydrophobic sorbent for the sample tube.

7.2.1.2 This is possible for compounds ranging in volatility from n-C5 (see SSVs listed in Appendix 1). Tenax®, Carbotrap™ or one of the other hydrophobic sorbents listed in Table 2 should be used.

*[Note: It is essential to ensure that the temperature of the sorbent tube is the same and certainly not lower than ambient temperature at the start of sampling or moisture will be retained via condensation, however hydrophobic the sorbent.]*

### 7.2.2 Sample Splitting

7.2.2.1 If the sample loading is high, it is usually possible to eliminate sufficient water to prevent analytical interference by using sample splitting (10).

7.2.2.2 Sample may be split either (1) between the focusing trap and the capillary column (single splitting) during trap (secondary) desorption or (2) between both the tube and the focusing trap during primary (tube) desorption and between the focusing trap and the column during secondary (trap) desorption (see Section 8.2.3) (double splitting). It may, in fact, be necessary to split the sample in some cases to prevent overloading the analytical column or detector.

### 7.2.3 Dry Purge

7.2.3.1 The third water management method is to "dry purge" either the sorbent tube itself or the focusing trap or both (11-13). Dry purging the sample tube or focusing trap simply involves passing a volume of pure, dry, inert gas through the tube from the sampling end, prior to analysis.



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7.2.3.2 The tube can be heated while dry purging at slightly elevated temperatures (11). A trap packing combination and a near ambient trapping temperature must be chosen such that target analytes are quantitatively retained while water is purged to vent from either the tube or trap.

## 7.3 Atmospheric Pollutants not Suitable for Analysis by this Method

7.3.1 Inorganic gases not suitable for analysis by this method are oxides of carbon, nitrogen and sulfur, $O_3$ and other permanent gases. Exceptions include $CS_2$ and $N_2O$.

7.3.2 Other pollutants not suitable are particulate pollutants, (i.e., fumes, aerosols and dusts) and compounds too labile (reactive) for conventional GC analysis.

## 7.4 Detection Limits and Maximum Quantifiable Concentrations of Air Pollutants

7.4.1 Detection limits for atmospheric monitoring vary depending on several key factors. They are:

- Minimum artifact levels.
- GC detector selection.
- Volume of air sampled. The volume of air sampled is in turn dependent upon a series of variables including SSVs (see Section 10.8, Table 1 and Appendix 1), pump flow rate limitations and time-weighted-average monitoring time constraints.

7.4.2 Generally speaking, detection limits range from sub-part-per-trillion (sub-ppt) for halogenated species such as $CCl_4$ and the freons using an electron capture detector (ECD) to sub-ppb for volatile hydrocarbons in 1 L air samples using the GC/MS operated in the full SCAN mode.

7.4.3 Detection limits are greatly dependent upon the proper management of water for GC capillary analysis of volatile organics in air using sorbent technology (14).

## 7.5 Suitable Atmospheric Conditions

### 7.5.1 Temperature range.

7.5.1.1 The normal working range for sorbent packing is 0-40°C (8).

7.5.1.2 In general, an increase in temperature of 10°C will reduce the breakthrough volume for sorbent packings by a factor of 2.

### 7.5.2 Humidity.

7.5.2.1 The capacity of the analytical instrumentation to accommodate the amount of water vapor collected on tubes is usually the limitation in obtaining successful results, particularly for GC/MS applications. This limitation can be extreme, requiring the use of a combination of water management procedures (see Section 7.2).

7.5.2.2 The safe sampling volumes of VOCs on hydrophobic adsorbents such as Tenax®, other porous polymers, Carbotrap™ and Carbopack™ are relatively unaffected by atmospheric humidity. Spherocarb® or carbonized molecular sieve type sorbents such as Carbosieve™ SIII and the Carboxens® are affected by high humidity, however, and SSVs should typically be reduced by a factor of 10 at 90-95% RH (8). Hydrophilic zeolite molecular sieves cannot be used at all at high humidity.

### 7.5.3 Wind speeds.

7.5.3.1 Air movement is not a factor indoors or outdoors at wind speeds below 10 miles per hour (<20 km per hour).



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7.5.3.2 Above this speed, tubes should be orientated perpendicular to the prevailing wind direction and should be sheltered from the direct draft if wind speeds exceed 20 miles per hour (30-40 km per hour) (see Section 10.5).

7.5.4 High concentrations of particulates.

7.5.4.1 It may be necessary to connect a particulate filter (e.g., a 2 micron Teflon® filter or short clean tube containing a loose plug of clean glass wool) to the sampling end of the tube in areas of extremely high particulate concentrations.

7.5.4.2 Some compounds of interest may, however, be trapped on the Teflon® or on the glass wool. Particulates trapped on the sorbent tube have the potential to act as a source or sink for volatiles, and may remain on the tube through several cycles of sampling and desorption. Frequent replacement of the particulate filter is therefore recommended.

## 8. Apparatus Selection and Preparation

### 8.1 Sample Collection

8.1.1 Selection of Tube Dimensions and Materials.

8.1.1.1 The most extensively used sorbent tubes are 1/4 inch O.D. stainless steel or 6 mm O.D. stainless steel or glass. Different suppliers provide different size tubes and packing lengths; however, 3.5 inch long tubes with a 6 cm sorbent bed and 1/4 inch O.D. stainless steel (see Figure 2) were used to generate the SSV information presented in Appendix 1.

8.1.1.2 As an approximate measure, for sorbents contained in equal diameter tubes the breakthrough volume is proportional to the bed-length (weight) of sorbent. Therefore, doubling the bed-length would approximately double the SSV (15).

8.1.1.3 Stainless steel (304 or "GC" grade) is the most robust of the commonly available tube materials which include, in addition, glass, glass-lined, and fused silica lined tubing. Tube material must be chosen to be compatible with the specifics of storage and transport of the samples. For example, careful attention to packaging is required for glass tubes.

8.1.2 Tube Labeling.

8.1.2.1 Label sample tubes with a unique identification number and the direction of sampling flow. Stainless steel tubes are most conveniently labeled by engraving. Glass tubes are best labeled using a temperature resistant paint. If empty sample tubes are obtained without labels, it is important to label and condition them before they are packed with adsorbent.

8.1.2.2 Recondition prepacked, unlabeled tubes after the tube labeling process and record the blank chromatogram from each tube. Record in writing the details of the masses and/or bed lengths of sorbent(s) contained in each tube, the maximum allowable temperature for that tube and the date each tube was packed or repacked.

8.1.3 Blank and Sampled Tube Storage Apparatus.

8.1.3.1 Seal clean, blank sorbent tubes and sampled tubes using inert, Swagelok®-type fittings and PTFE ferrules. Wrap capped tubes individually in uncoated aluminum foil. Use clean, sealable glass jars or metal cans containing a small packet of activated charcoal or activated charcoal/silica gel for storage and transportation of multiple tubes. Store the multi-tube storage container in a clean environment at 4°C.

8.1.3.2 Keep the sample tubes inside the storage container during transportation and only remove them at the monitoring location after the tubes have reached ambient temperature. Store sampled tubes in a refrigerator at 4°C inside the multi-tube container until ready for analysis.



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*[Note: The atmosphere inside the refrigerator must be clean and-free of organic solvents.]*

**8.1.4 Selection of Sampling Pumps.**

**8.1.4.1** The selected monitoring pump(s) should be capable of operating in the range 10 to 200 mL/min. Label the pumps with a unique identification number and operate them according to manufacturer's guidelines.

**8.1.4.2** Constant mass flow type pumps are ideal for air monitoring as they deliver a constant flow rate for a wide range of tube impedances. They thus compensate for moderate impedance variations between the sorbent tubes in use. The pump should meet US criteria for intrinsic safety where applicable. Connect the pump to the non-sampling end of the sample tube by means of flexible, nonoutgassing tubing.

**8.1.5 Parallel Sampling onto Multiple Tubes with a Single Pump.**

**8.1.5.1** Select a sample collection system for collecting samples onto 2 tubes in parallel.

**8.1.5.2** If a single pump is used for both tubes, ensure that the flow rates will be controlled at a constant flow rate during sampling and that the two flow rates can be independently controlled and stabilized.

**8.1.6 Apparatus for Calibrating the Pumped Air Flow.**

**8.1.6.1** Calibrate the pump with the type of sorbent tube to which it will be connected during the monitoring exercise. Use the actual sampling tube to fine tune the sampling flow rate at the start of sample collection.

**8.1.6.2** Use a flow meter certified traceable to NIST standards.

**8.1.7 Sorbent Tube Protection During Air Sample Collection.**

**8.1.7.1** Protect sorbent tubes from extreme weather conditions using shelters constructed of inert materials. The shelter must not impede the ingress of ambient air.

**8.1.7.2** If the atmosphere under test contains significant levels of particulates - fume, dust or aerosol, connect a Teflon® 2-micron filter or a (metal, glass, glass-lined or fused silica lined stainless) tube containing a short plug of clean glass wool prior to the sampling end of the tube and using inert, Swagelok®-type fittings and PTFE ferrules for fitting connections.

## 8.2 Apparatus

**8.2.1 Essential Sample Protection Features of the Thermal Desorption Apparatus.**

**8.2.1.1** As thermal desorption is generally a one shot process, (i.e., once the sample is desorbed it cannot readily be reinjected or retrieved), stringent sample protection measures and thorough preanalysis system checks must form an integral part of the thermal desorption-GC procedure and should be systematically carried out.

**8.2.1.2** The sample integrity protection measures and preanalysis checks required include:

- Sealed tubes. Sample tubes awaiting analysis on an automated desorption system must be completely sealed before thermal desorption to prevent ingress of VOC contaminants from the laboratory air and to prevent losses of weakly retained analytes from the tube.
- Inert and heated sample flow path. To eliminate condensation, adsorption and degradation of analytes within the analytical system, the sample flow path of manual and automated thermal desorbers should be uniformly heated (minimum temperature range 50° - 150°C) between the sample tube and the GC analytical column. The components of the sample flow path should also, as far as possible, be constructed of inert materials, i.e., deactivated fused silica, glass lined tubing, glass, quartz and PTFE.
- Tube leak testing. This activity must not jeopardize sample integrity.
- Leak testing of the sample flow path. This activity must not jeopardize sample integrity.
- System purge. Stringent, near-ambient temperature carrier gas purge to remove oxygen.
- Analytical system. "Ready" status checks.



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8.2.2 Thermal Desorption Apparatus.

8.2.2.1 Two-stage thermal desorption is used for the best high resolution capillary chromatography (i.e., analytes desorbed from the sorbent tube must be refocused before being rapidly transferred to the GC analytical column). One type of analyte refocusing device which has been successfully used is a small sorbent trap (17). One cryogen-free trap cooling option is to use a multistage Peltier electrical cooler (18,19).

8.2.2.2 Closed cycle coolers are also available for use. At its low temperature, the trap must provide quantitative analyte retention for target compounds as well as quantitative and rapid desorption of target analytes as high boiling as n-$C_{12}$. The peak widths produced must be compatible with high resolution capillary gas chromatography.

8.2.2.3 Typical key components and operational stages of a two-stage desorption system are presented in Figure 3(a) - (f) and a stepwise description of the thermal desorber operation is presented in Section 11.3.

8.2.3 Sample Splitting Apparatus.

8.2.3.1 Sample splitting is often required to reduce water vapor interference, for the analysis of relatively high concentration (>10 ppb level) air samples, when large volume air samples are collected, or when sensitive selective detectors are in use.

8.2.3.2 Sample splitting is one of the three key approaches to water management detailed in this method (see Section 7.2). Moisture management by sample splitting is applicable to relatively high concentrations (≥10 ppb) or large volume air samples or to analyses employing extremely sensitive detectors - for example, using the ECD for low levels of tetrachloroethylene. In these cases the masses of analytes retained by the sorbent tube when monitoring such atmospheres is large enough to allow, or even require, the selection of a high split ratio (>10:1) during analysis to avoid overloading the analytical column or detector. The mass of water retained by the sorbent tube during sample collection may be sufficiently reduced by the split alone to eliminate the need for further water management steps.

8.2.4 The Thermal Desorber - GC Interface.

8.2.4.1 Heat the interface between the thermal desorber and the GC uniformly. Ensure that the interface line is leak tight and lined with an inert material such as deactivated fused silica.

8.2.4.2 Alternatively, thread the capillary column itself through the heated transfer line/interface and connected directly into the thermal desorber.

*[Note: Use of a metal syringe-type needle or unheated length of fused silica pushed through the septum of a conventional GC injector is not recommended as a means of interfacing the thermal desorber to the chromatograph. Such connections result in cold spots, cause band broadening and are prone to leaks.]*

8.2.5 GC/MS Analytical Components. This method uses the GC/MS description as given in Compendium Method TO-15, Section 7.

8.3 Tube Conditioning Apparatus

8.3.1 Tube Conditioning Mode

8.3.1.1 Condition freshly packed tubes using the analytical thermal desorption apparatus if it supports a dedicated 'tube conditioning mode' (i.e., a mode in which effluent from highly contaminated tubes is directed to vent without passing through key parts of the sample flow path such as the focusing trap).

8.3.2 Stand Alone System

8.3.2.1 If such a tube conditioning mode is not available, use separate stand-alone tube conditioning hardware.



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8.3.2.2 The tube conditioning hardware must be leak-tight to prevent air ingress, allow precise and reproducible temperature selection (±5°C), offer a temperature range at least as great as that of the thermal desorber and support inert gas flows in the range of 50 to 100 mL/min.

*[Note: Whether conditioning is carried out using a special mode on the thermal desorber or using separate hardware, pass effluent gases from freshly packed or highly contaminated tubes through a charcoal filter during the process to prevent desorbed VOCs polluting the laboratory atmosphere.]*

## 9. Reagents and Materials

### 9.1 Sorbent Selection Guidelines

**9.1.1 Selection of Sorbent Mesh Size.**

9.1.1.1 Sieved sorbents of particle size in the range 20 to 80 mesh should be used for tube packing.

9.1.1.2 Specific surface area of different sorbents is provided in Table 2.

**9.1.2 Sorbent Strength and Safe Sampling Volumes.**

9.1.2.1 Many well-validated pumped and diffusive sorbent tube sampling/thermal desorption methods have been published at the relatively high atmospheric concentrations (i.e., mid-ppb to ppm) typical of workplace air and industrial/mobile source emissions (8, 20-30).

9.1.2.2 These methods show that SSVs are unaffected by analyte concentrations far in excess of the 25 ppb upper limit of this method. The effect of humidity on SSVs is discussed in Section 7.5 and Table 2.

9.1.2.3 Select a sorbent or series of sorbents of suitable strength for the analytes in question from the information given in Tables 1 and 2 and Appendices 1 and 2. Where a number of different sorbents fulfill the basic safe sampling volume criteria for the analytes in question, choose that (or those) which are hydrophobic and least susceptible to artifact formation. Keep the field sampling volumes to 80% or less of the SSV of the least well-retained analyte. Using one of the two procedures given in Section 10.8, check the safe sampling volumes for the most volatile analytes of interest on an annual basis or once every twenty uses of the sorbent tubes whichever occurs first.

**9.1.3 Three General-Purpose 1/4 Inch or 6 mm O.D. Multi-Bed Tube Types.**

*[Note: The three general-purpose tubes presented in this section are packed with sorbents in the mesh size range of 20-80 mesh. The difference in internal diameter between standard glass and stainless steel tubes will result in different bed volumes (weights) for the same bed length.]*

9.1.3.1 **Tube Style 1** consists of 30 mm Tenax®GR plus 25 mm of Carbopack™ B separated by 3 mm of unsilanized, preconditioned glass or quartz wool. Suitable for compounds ranging in volatility from n-$C_6$ to n-$C_{20}$ for air volumes of 2 L at any humidity. Air volumes may be extended to 5 L or more for compounds ranging in volatility from n-$C_7$.

9.1.3.2 **Tube Style 2** consists of 35 mm Carbopack™ B plus 10 mm of Carbosieve™ SIII or Carboxen™ 1000 separated by glass/quartz wool as above. Suitable for compounds ranging in volatility from n-$C_3$ to n-$C_{12}$ (such as "Compendium Method TO-14 air toxics") for air volumes of 2 L at relative humidities below 65% and temperatures below 30°C. At humidities above 65% and ambient temperatures above 30°C, air volumes should be reduced to 0.5 L. Air volumes may be extended to 5 L or more for species ranging in volatility from n-$C_4$. A dry purge procedure or a large split ratio must be used during analysis when humid air has been sampled on these tubes.



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9.1.3.3 Tube Style 3 consists of 13 mm Carbopack™ C, 25 mm Carbopack™ B plus 13 mm of Carbosieve™ SIII or Carboxen™ 1000 all separated by 3 mm plugs of glass/quartz wool as above. Suitable for compounds ranging in volatility from n-$C_3$ to n-$C_{16}$ for air volumes of 2 L at relative humidities below 65 percent and temperatures below 30°C. At humidities above 65 percent and ambient temperatures above 30°C, air volumes should be reduced to 0.5 L. Air volumes may be extended to 5 L or more for compounds ranging in volatility from n-$C_4$. A dry purge procedure or a large split ratio must be used during analysis when humid air has been sampled on these tubes.

*[Note: These multi-bed tubes are commercially available prepacked and preconditioned if required.]*

*[Note: These general purpose multi-bed tubes are only recommended for monitoring unknown atmospheres or wide volatility range sets of target analytes. Most routine monitoring of industrial air (for example at factory fencelines) only involves monitoring a few specific target analytes such as benzene, toluene, ethylbenzene, and xylenes (BTEX), carbon disulfide ($CS_2$) or 1,1,1-trichloroethane. Single-bed sorbent tubes selected from the options listed in Appendix 1 are typically used in these cases.]*

*[Note: In the interests of minimizing water retention it is advisable to stick to hydrophobic (i.e., weak and medium strength) sorbents whenever possible; this generally is the case when components more volatile than n-$C_6$ are not of interest.]*

## 9.2 Gas Phase Standards

### 9.2.1 Standard Atmospheres.

9.2.1.1 Standard atmospheres must be stable at ambient pressure and accurate (±10%). Analyte concentrations and humidities should be similar to those in the typical test atmosphere. Standard atmospheres must be sampled onto conditioned sorbent tubes using the same pump flow rates as used for field sample collection.

9.2.1.2 If a suitable standard atmosphere is obtained commercially, manufacturer's recommendations concerning storage conditions and product lifetime should be rigidly observed.

### 9.2.2 Concentrated, Pressurized Gas Phase Standards.

9.2.2.1 Use accurate (± 5%), concentrated gas phase standards in pressurized cylinders such that a 0.5 - 5.0 mL gas sampling volume (GSV) loop contains approximately the same masses of analytes as will be collected from a typical air sample. Introduce the standard onto the sampling end of conditioned sorbent tubes using at least ten times the loop volume of pure helium carrier gas to completely sweep the standard from the GSV.

9.2.2.2 Manufacturer's guidelines concerning storage conditions and expected lifetime of the concentrated gas phase standard should be rigidly observed.

## 9.3 Liquid Standards

### 9.3.1 Solvent Selection.

9.3.1.1 If liquid standards are to be loaded onto sorbent tubes for calibration purposes, select a solvent for the standard that is pure (contaminants <10% of minimum analyte levels) and that, if possible, is considerably more volatile than the target analytes. This then allows the solvent to be purged and eliminated from the tube during the standard preparation process.

9.3.1.2 Methanol most commonly fills these criteria. If the target analyte range includes very volatile components, it will not be possible to do this. In these cases, select a pure solvent which is readily chromatographically resolved from the peaks/components of interest (ethyl acetate is commonly used) or use a



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gas phase standard. Test the purity of the solvent by comparing an analysis of the prepared standard with an analysis of pure solvent under identical chromatographic conditions.

**9.3.2 Liquid Standard Concentrations.**

**9.3.2.1** Liquid standards should be prepared so that the range of analyte masses introduced onto the tubes is in the same order as the range of masses expected to be collected during sampling.

**9.3.2.2** Concentrations of benzene in urban air may be expected to range from 0.5-25 ppb. Thus if 5 L air samples were to be collected at approximately 25°C, the masses of benzene collected would range from around 8 ng (0.5 ppb level) to around 400 ng (25 ppb level).

*[Note: The above calculation was derived from Boyle's law (i.e., 1 mole of gas occupies around 25 L at 25° C and 760 mm Hg).*

- *25 L of pure benzene vapor contains 78 g benzene*
- *5 L of pure benzene vapor contains 15.6 g benzene*
- *5 L of a 1 ppm benzene atmosphere contains 15.6 μg benzene*
- *5 L of a 100 ppb benzene atmosphere contains 1560 ng benzene*
- *5 L of a 1 ppb benzene atmosphere contains 15.6 ng benzene.]*

**9.3.3 Loading Liquid Standards onto Sorbent Tubes.**

9.3.3.1 Introduce 0.1 - 10 μL aliquots of the liquid standards onto the sampling end of conditioned sorbent tubes using a conventional 1/4 inch GC packed column injector and a 1, 5 or 10 μL syringe. The injector is typically unheated with a 100 mL/min flow of pure carrier gas. The solvent and analytes should completely vaporize and pass onto the sorbent bed in the vapor phase. It may be necessary to heat the injector slightly (typically to 50°C) for analytes less volatile than n-$C_{12}$ to ensure that all the liquid vaporizes.

**9.3.3.2** The sample tube should remain attached to the injector until the entire standard has been swept from the injector and onto the sorbent bed. If it has been possible to prepare the liquid standard in a solvent which will pass through the sorbent while analytes are quantitatively retained (for example, methanol on Tenax® or Carbopack™ B), the tube should not be disconnected from the injector until the solvent has been eliminated from the sorbent bed - this takes approximately 5 minutes under the conditions specified. Once the tube has been disconnected from the injector, it should be capped and placed in an appropriate storage container immediately.

*[Note: In cases where it is possible to purge the solvent from the tube while quantitatively retaining the analytes, a 5-10 μL injection should be made as this can usually be introduced more accurately than smaller volumes. However, if the solvent is to be retained in the tube, the injection volume should be as small as possible (0.5 - 1.0 μL) to minimize solvent interference in the subsequent chromatogram.]*

**9.3.3.3** This method of introducing liquid standards onto sorbent tubes via a GC injector is considered the optimum approach to liquid standard introduction as components reach the sorbent bed in the vapor phase (i.e., in a way which most closely parallels the normal air sample collection process). Alternatively, liquid standards may be introduced directly onto the sorbent bed via the non-sampling end of the tube using a conventional GC syringe.

*[Note: This approach is convenient and works well in most cases, but it may not be used for multi-bed tubes or for wide boiling range sets of analytes and does not allow solvent to be purged to vent.]*



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## 9.4 Gas Phase Internal Standards

9.4.1 The ideal internal standard components are:

- chemically similar to the target analytes
- extremely unlikely to occur naturally in the atmosphere under test
- readily resolved and distinguished analytically from the compounds of interest
- stable in the vapor phase at ambient temperature
- compatible with metal and glass surfaces under dry and humid conditions
- certified stable in a pressurized form for a long time period (i.e., up to 1 year).

9.4.2 Deuterated or fluorinated hydrocarbons usually meet all these criteria and make perfect internal standards for MS based systems. Typical compounds include deuterated toluene, perfluorobenzene and perfluorotoluene. Multiple internal standards should be used if the target analytes cover a very wide volatility range or several different classes of compound.

9.4.3 Obtain a pressurized cylinder containing accurate (±5%) concentrations of the internal standard components selected. Typically a 0.5 to 5.0 mL volume of this standard is automatically introduced onto the back of the sorbent tube or focusing trap after the tube has passed preliminary leak tests and before it is thermally desorbed. The concentration of the gas should be such that the mass of internal standard introduced from the GSV loop is approximately equivalent to the mass of analytes which will be sampled onto the tube during sample collection. For example, a 1 L air sample with average analyte concentrations in the order of 5 ppb, would require a 10 ppm internal standard, if only 0.5 mL of the standard is introduced in each case.

## 9.5 Commercial, Preloaded Standard Tubes

9.5.1 Certified, preloaded commercial standard tubes are available and should be used for auditing purposes wherever possible to establish analytical quality control (see Section 14). They may also be used for routine calibration. Suitable preloaded standards should be accurate within ±5% for each analyte at the microgram level and ±10% at the nanogram level.

9.5.2 The following information should be supplied with each preloaded standard tube:

- A chromatogram of the blank tube before the standard was loaded with associated analytical conditions and date.
- Date of standard loading
- List of standard components, approximate masses and associated confidence levels
- Example analysis of an identical standard with associated analytical conditions (these should be the same as for the blank tube)
- A brief description of the method used for standard preparation
- Expiration date

## 9.6 Carrier Gases

Inert, 99.999% or higher purity helium should be used as carrier gas. Oxygen and organic filters should be installed on the carrier gas lines supplying the analytical system. These filters should be replaced regularly according to the manufacturer's instructions.



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## 10. Guidance on Sampling and Related Procedures

### 10.1 Packing Sorbent Tubes

#### 10.1.1 Commercial Tubes

10.1.1.1 Sorbent tubes are commercially available either prepacked and preconditioned or empty.

10.1.1.2 When electing to purchase empty tubes and pack/condition them as required, careful attention must be paid to the appropriate manufacturer's instructions.

#### 10.1.2 Tube Parameters

10.1.2.1 Key parameters to consider include:

- Sorbent bed positioning within the tube. The sampling surface of the sorbent bed is usually positioned at least 15 mm from the sampling end of the tube to minimize sampling errors due to diffusive ingress. The position of the sorbent bed must also be entirely within that section of the tube which is surrounded by the thermal desorption oven during tube desorption.
- Sorbent bed length. The sorbent bed must not extend outside that portion of the tube which is directly heated by the thermal desorption oven.
- Sorbent mesh size. 20 to 80 mesh size sorbent is recommended to prevent excessive pressure drop across the tube which may cause pump failure. It is always recommended that sorbents be sieved to remove "fines" (undersized particles) before use.
- Use of appropriate sorbent bed retaining hardware inside the tube. Usually 100 mesh stainless steel gauzes and retaining springs are used in stainless steel tubes and unsilanized, preconditioned glass or quartz wool in glass tubes.
- Correct conditioning procedures. See Table 2 and Section 10.2.
- Bed separation. If a single tube is to be packed with two or three different sorbents, these must be kept in discreet beds separated by ~3 mm length plugs of unsilanized, preconditioned glass or quartz wool or glass fiber disks and arranged in order of increasing sorbent strength from the sampling end of the tube. Do not use sorbents of widely different maximum temperatures in one tube or it will be difficult to condition the more stable sorbents without exceeding the maximum recommended temperature of the less stable sorbents.

*[Note: Silanized glass or quartz wool may be used for labile species such as sulfur or nitrogen containing compounds but should not be taken to temperatures above 250° C.]*

- Compression of bed. The sorbent bed must not be compressed while packing the tube. Compression of the sorbent can lead to excessive tube impedance and may produce "fines".

10.1.2.2 Tubes packed with porous polymer sorbents (Chromosorbs®, Porapaks® and Tenax®) should be repacked after 100 thermal cycles or if the performance criteria cannot be met. Tubes packed with carbonaceous sorbents such as Spherocarb®, Carbotrap™, Carbopack™, Carbosieve™ SIII and Carboxens® should be repacked every 200 thermal cycles or if the safe sampling volume validation procedure fails.



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## 10.2 Conditioning and Storage of Blank Sorbent Tubes

### 10.2.1 Sorbent Tube Conditioning.

10.2.1.1 The success of sorbent tube sampling for ppb and sub-ppb level air monitoring is largely dependent on artifact levels being at significantly lower levels (<10%) than the masses of analytes collected during air monitoring. A summary of recommended conditioning parameters for various individual sorbents and multibed tubes is given in Table 2. 1/4 inch O.D. sorbent tubes may be adequately conditioned using elevated temperatures and a flow of ultra-pure inert gas. Washing or any other preconditioning of the bulk sorbent is not usually necessary. Appropriate, dedicated tube conditioning hardware should be used for tube conditioning unless the thermal desorption system offers a separate tube conditioning mode.

10.2.1.2 The tube conditioning temperatures and gas flows recommended in Table 2 should be applied for at least 2 hours when a tube is packed with fresh adsorbent or when its history is unknown.

Sorbent tubes which are:

- desorbed to completion during routine analysis (as is normally the case)
- stored correctly (see Section 10.2.2)
- re-issued for air sampling within 1 month (1 week for Chromosorb®, Tenax® and Porapak® porous polymers)
- and are to be used for atmospheres with analytes at the 10 ppb level or above

do not usually require any reconditioning at all before use. However, tubes to be used for monitoring at lower levels should be both reconditioned for 10-15 minutes using the appropriate recommended conditioning parameters and put through a "dummy" analysis using the appropriate analytical conditions to obtain blank profiles of each tube before they are issued for sampling.

10.2.1.3 Analytical system conditioning procedures are supplied by system manufacturers. Generally speaking, both system and sorbent tube conditioning processes must be carried out using more stringent conditions of temperature, gas flow and time than those required for sample analysis - within the maximum temperature constraints of all the materials and equipment involved.

### 10.2.2 Capping and Storage of Blank Tubes.

10.2.2.1 Blank tubes should be capped with ungreased, Swagelok®-type, metal screw-caps and combined PTFE ferrules. The screw caps should be tightened by hand and then an extra 1/4 turn with a wrench. If uncoated aluminum foil is required, tubes should be wrapped individually.

10.2.2.2 Batches of blank, sealed tubes should be stored and transported inside a suitable multi-tube container.

## 10.3 Record Keeping Procedures for Sorbent Tubes

Sample tubes should be indelibly labeled with a unique identification number as described in Section 8.1.2. Details of the masses and/or bed lengths of sorbent(s) contained in each tube, the maximum allowable temperature for that tube and the date each tube was packed should be permanently recorded. A record should also be made each time a tube is used and each time the safe sampling volume of that tube is retested so that its history can be monitored. If a tube is repacked at any stage, the records should be amended accordingly.



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## 10.4 Pump Calibration and Tube Connection

### 10.4.1 Tube Deployment

10.4.1.1 Once at ambient temperature, remove the tubes from the storage container, uncap and connect them to the monitoring pumps as quickly as possible using clean, non-outgassing flexible tubing. Multi-bed sorbent tubes must be orientated so that the air sample passes through the series of sorbents in order of increasing sorbent strength (i.e., weaker sorbent first). This prevents contamination of the stronger adsorbent with less volatile components.

10.4.1.2 In all cases the sampling end of the tube must be clearly identified and recorded.

10.4.1.3 A typical sampling configuration for a distributed volume pair of sampling tubes is shown in Figure 4.

### 10.4.2 Pump Calibration

10.4.2.1 Pumps should be calibrated according to the manufacturer's instructions, preferably at the monitoring location immediately before sampling begins or, alternatively, in a clean environment before the tubes and pumps are transported to the monitoring site. The apparatus required is described in Section 8.1.6. Details of the pump flow rate delivered with a given identified tube and the flow rate, stroke rate or pressure selected on the pump itself should be recorded together with the date.

10.4.2.2 The pump flow rate should be retested at the end of each sampling period to make sure that a constant pump rate was maintained throughout the sample collection period. The flow rate measured at the end of sampling should agree within 10% with that measured at the start of the sampling period for the sample to be considered valid and the average value should be used.

## 10.5 Locating and Protecting the Sample Tube

The sampling points of individual sorbent tubes or sequential tube samplers should not be unduly influenced by nearby emission sources unless the emission source itself is specifically being monitored. Common sense generally determines the appropriate placement. Field notes on the relative location of known emission sources should be part of the permanent record and identified on the FTDS. Some shelter or protection from high winds (see Section 8.1.7) other extreme weather conditions and high levels of particulates is required for the sample tube if it is to be left unattended during the monitoring period.

## 10.6 Selection of Pump Flow Rates and Air Sample Volumes

### 10.6.1 Flow Rate Selection

10.6.1.1 For 1/4 inch O.D. tubes, 50 mL/min is the theoretical optimum flow rate (31). However, negligible variation in retention volume will in fact be observed for pump flow rates varying from 5 to 200 mL/min. Pump flow rates above 10 mL/min are generally used in order to minimize errors due to ingress of VOCs via diffusion. Flow rates in excess of 200 mL/min are not recommended for standard 1/4-inch sample tubes unless for short term (e.g. 10 minute) monitoring (21).

*[Note: High sampling flow rates can be used longer term for high boiling materials such as low level, vapor phase polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) in air.]*

10.6.1.2 One and four liter air sample volumes are recommended for this method if consistent with anticipated safe sampling volumes. Adjustments of the flow rates to accommodate low safe sampling volumes should be made by proportionally reducing both rates with the qualification that the lower flow rate result is no less than 300 mL total volume. The 300 mL sample gives adequate detection limits (<0.5 ppb per analyte) with



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full scan mass spectrometry detection for ambient air applications (see Table 4). Sensitivity is generally enhanced at least ten-fold if conventional GC detectors or selected ion monitoring are applied. However; the pump flow rate, sampling time and consequently air volume selected may be varied to suit the requirements of each individual air monitoring exercise.

10.6.1.3 Typical example pump flow rates include:

- 16 mL/min to collect 1 L air samples in 1 hour
- 67 mL/min to collect 4 L air samples in 1 hour
- 10 mL/min to collect 1800 mL air samples over 3 hours
- 40 mL/min to collect 7200 mL air samples over 3 hours

### 10.6.2 Pump Flow Rate Selection

10.6.2.1 The pump flow rate used is dependent upon:

- Safe sampling volume constraints. The flow rate must be adjusted (within the allowed range) to ensure that, for the chosen sample collection time, SSVs are not exceeded for any target analyte
- Time weighted average monitoring requirements. If long-term - 3, 8 or even 24 hour - time weighted average data are required, the pump flow rate must be adjusted to ensure SSVs are not exceeded during the sample collection period.
- GC detection limits. Within the constraints of safe sampling volumes and pump flow rate limits, air volumes selected for trace level (ambient) air monitoring, should be maximized such that the largest possible analyte masses are collected.

10.6.2.2 Typical VOC concentrations and the associated analyte masses retained from a range of different air sample volumes in various atmospheres are presented in Table 4.

## 10.7 Sampling Procedure Verification - Use of Blanks, Distributed Volume Pairs, Back-Up Tubes, and Distributed Volume Sets

### 10.7.1 Field and Laboratory Blanks

10.7.1.1 Laboratory blanks must be identically packed tubes, from the same batch, with similar history and conditioned at the same time as the tubes used for sample collection. At least two are required per monitoring exercise. They must be stored in the laboratory in clean controlled conditions (<4°C) throughout the monitoring program and analyzed at the same time as the samples-- one at the beginning and one at the end of the sequence of runs.

10.7.1.2 Field blanks are the same as laboratory blanks except that they are transported to and from the monitoring site, are uncapped and immediately resealed at the monitoring site, but do not actually have air pumped through them. One field blank tube is taken for every ten sampled tubes on a monitoring exercise and no less than two field blanks should be collected, however small the monitoring study. The field blanks should be distributed evenly throughout the set of sampled tubes to be analyzed. Guidance on acceptable performance criteria for blanks is given in Section 13.

### 10.7.2 Distributed Volume Pairs

10.7.2.1 When monitoring for specific analytes using a validated sorbent tube but in an uncharacterized atmosphere, it is advisable to collect distributed volume tube pairs - e.g. 1 and 4 L samples - in parallel at every monitoring location as described in Section 6. If single tube sampling is used to reduce analysis costs, a reduction in the quality assurance associated with this method has to be assumed.



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10.7.2.2 Back-up tubes (identical to those used for sample collection) should be used to investigate situations in which distributed volume pairs do not agree within acceptable tolerance. To use back-up tubes, a second identical sampling tube is placed in series with a primary (front) tube. The purpose of the backup tube is to capture compounds that pass through the primary tube because of breakthrough. Analysis of the backup tube may indicate unexpected breakthrough or give evidence of channeling of sample through the tube because of loose packing.

10.7.2.3 A significant volume of literature exists on the use of distributed volume sets to determine the occurrence of nonlinearities when different sample volumes are taken from the same sample air mix. Ideally, the quantity of material collected scales linearly with sample volume. If this is not the case, then one of a number of problems has occurred. The 4-tube distributed volume developed by Walling, Bumgardner, and co-workers (32,33) is a method by which sample collection problems can be investigated.

## 10.8 Determining and Validating Safe Sampling Volumes (SSV)

### 10.8.1 Field Test Method for Tube Breakthrough.

10.8.1.1 If SSV information is not readily available for the analytes under test on the sorbent tube selected, or if the safe sampling volumes need validating - the following field experiment may be used. Link at least 12 of the sorbent tubes under test together in series to give 6 pairs of tubes. Use inert, preferably Swagelok®-type 1/4-inch metal unions with PTFE fittings. The sampling end of the back up tube should be connected to the exit end of the front tube in each of the pairs. The tube pairs are then connected to calibrated monitoring pumps and used to simultaneously sample at least 3 different air volumes at pump flow rates between 10 and 200 mL/min with 2 replicates at each air sample volume.

10.8.1.2 The experiment should be carried out in the atmosphere to be monitored and, if possible, under worst-case conditions (i.e., highest natural humidity and highest typical VOC concentrations). The sampling points of all the tube pairs should be placed close together to ensure that, as far as possible, tubes are all sampling the same atmosphere. The sampling location selected should be well ventilated. Both the front and back-up tubes of each tube pair should subsequently be analyzed using thermal desorption - capillary GC.

10.8.1.3 If more than 5% of one or more of the target analytes is observed on any of the back-up tubes, breakthrough is shown to have occurred at that sample volume. For practical purposes, the BV for a given sorbent/analyte combination is usually considered to be the sample volume at which there is 5% breakthrough of that analyte onto the back-up tube. The SSV for that analyte/sorbent combination is then taken as two thirds (~66%) of the BV.

### 10.8.2 Chromatographic Test of Tube Retention Volume for Individual Analytes

10.8.2.1 Inject 0.5 mg of each analyte into a stoppered ~1L volume glass flask fitted with a septum. Check that all the analyte has evaporated.

10.8.2.2 Connect the sample tube under test to a 1/4 inch injection port inside a GC oven. Use 530 $\mu$m, uncoated fused silica capillary tubing, or other appropriate narrow bore tubing, to connect the other end of the sample tube to a FID detector. Use 1/4 inch fittings with graphite ferrules to connect to the sample tube itself.

10.8.2.3 Set a nitrogen carrier gas flow of 50 mL/min through the tube.

10.8.2.4 Inject a 0.1 mL sample of the vapor phase standard onto the tube using a gas syringe. Adjust the GC oven temperature so that the analyte peak elutes on the FID between 1 and 20 minutes.

10.8.2.5 Repeat the experiment 4 or 5 times using different GC oven temperatures. Try to ensure that at each of the GC temperatures selected, the peak elutes within 1-20 minutes.

*[Note: Use the time from injection to peak crest as the retention time. This may have to be measured manually, depending on the type of integrator available.]*



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**10.8.2.6** Inject a sample of methane to measure the delay time of the system and subtract this from the analyte retention times determined.

**10.8.2.7** Use the flow of nitrogen carrier gas and corrected retention times to calculate the analyte retention volumes at different sorbent temperatures.

**10.8.2.8** A graph of $\log_{10}$ retention volume vs. 1/temp(K) should produce a straight line plot which can be readily extrapolated to ambient temperatures. Use this plot to obtain the retention volume.

A SSV for the analyte on that sorbent tube is then derived by halving the calculated retention volume at ambient temperature. When required, this experiment should be carried out for the least well retained compound(s) of interest.

### 10.9 Resealing Sorbent Tubes After Sample Collection

Sampled tubes should be recapped with the metal, Swagelok®-type caps and combined PTFE ferrules, rewrapped in the aluminum foil (if appropriate) and replaced in the storage container immediately after sampling. They should not be removed from the sampling container until they are in the laboratory and about to be analyzed.

### 10.10 Sample Storage

Samples should be refrigerated at <4°C in a clean environment during storage and analyzed within 30 days of sample collection (within one week for limonene, carene, *bis*-chloromethyl ether and labile sulfur or nitrogen-containing volatiles). Samples taken on tubes containing multiple sorbent beds should be analyzed as soon as possible after sampling unless it is know in advance that storage will not cause significant sample recovery errors (see also Section 7.1.3 concerning artifacts).

## 11. Analytical Procedure

### 11.1 Preparation for Sample Analysis

Follow the description given in Compendium Method TO-15 for set up of the GC/MS analytical system including column selection, MS tune requirements, calibration protocols, etc.

### 11.2 Predesorption System Checks and Procedures

The following sample and system integrity checks and procedures must be carried out manually or automatically before thermal desorption:

- Dry purge. Dry purge the batch of sampled, back-up and field blank tubes (do not purge lab blanks).
- Cap. Cap tubes with PTFE 'analytical' caps and place on instrument carousel.
- Leak test the tubes. Each tube must be stringently leak tested at the GC carrier gas pressure, without heat or gas flow applied, before analysis. Tubes which fail the leak test should not be analyzed, but should be resealed and stored intact. On automated systems, the instrument should continue to leak test and analyze subsequent tubes after a given tube has failed. Automated systems should also store a record of which tubes in a sequence have failed the leak test in battery-protected system memory until the error is acknowledged by an operator. These measures prevent sample losses and help ensure data quality.



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- Leak test the sample flow path. All parts of the sample flow path should be stringently leak tested before each analysis without heat or gas flow applied to the sample tube. An automatic sequence of tube desorptions and GC analyses should be halted if any leak is detected in the main sample flow path.
- Purge air. Purge air from the tube and sample flow path at ambient temperature using carrier gas immediately before tube desorption. It helps to dry the sample and prevents analyte and sorbent oxidation thus minimizing artifact formation, ensuring data quality and extending tube lifetimes. The focusing trap should be in-line throughout the carrier gas purge to retain any ultra-volatile analytes "desorbed" from the tube prematurely.
- Check GC/MS analytical system ready status. The "ready" status of the GC, detector(s), data processor and all parts of the analytical system should be automatically checked by the thermal desorption device before each tube desorption. It should not be possible to desorb a tube into the analytical system if it is not ready to accept and analyze samples.
- Internal standard. Introduce a gas phase internal standard onto the sorbent tube or focusing trap before primary (tube) desorption, as an additional check of system integrity (optional).

A series of schematics illustrating these steps is presented in Figure 3, Steps (a) through (f).

## 11.3 Analytical Procedure

### 11.3.1 Steps Required for Reliable Thermal Desorption.

**11.3.1.1** A stepwise summary of the complete thermal desorption procedure is as follows:

- Predesorption system checks (see Section 11.2).
- Introduction of a fixed volume gas phase internal standard (optional) [see Figure 3, Step (d)].
- Desorption of the sorbent tube (typically 200-300°C for 5-15 minutes with a carrier gas flow of 30-100 mL/min - see Table 2) and refocusing of the target analytes on a focusing trap held at near- ambient or subambient temperatures [see Figure 3, Step (e)].

*[Note: Analytes should be desorbed from the tube in "backflush" mode, i.e., with the gas flow in the reverse direction to that of the air flow during sampling].*

- Splitting the sample as it is transferred from the tube to the focusing trap (Optional). This is only required to prevent column or detector overload due to excess water accumulation or during the analysis of high concentration/large volume air samples or when using ultra-sensitive detectors such as the ECD [see Figure 3, Step (e)].
- Rapid desorption of the focusing trap (typically 40 deg/sec. to a top temperature of 250-350°C, with a "hold" time of 1-15 mins at the top temperature and an inert/carrier gas flow of 3-100 mL/min) and transfer of the analytes into the analytical column [see Figure 3, Step (f)].

*[Note: Components should normally be desorbed from the focusing trap in "backflush" mode, i.e., with the gas flow through the 'cold' trap in the reverse direction to that used during analyte focusing.]*

- Splitting the sample as VOCs are transferred from the focusing trap to the analytical column. (Optional). This is only required to prevent column or detector overload due to excess water accumulation or during the analysis of high concentration/large volume air samples or when using ultra-sensitive detectors such as the ECD [See Figure 3, Step (f)].
- Desorbing the focusing trap initiates the GC run. [See Figure 3, Step (f)].



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- All volatiles should be stripped from the sorbent tubes during the thermal desorption process leaving them clean and ready for reuse. The tubes should be resealed to ensure they are kept clean and ready for immediate reuse while the sequence of tube desorptions and analyses is completed.

11.3.2 GC/MS Analytical Procedure

11.3.2.1 Once the GC run has been initiated by desorption of the focusing trap, the chromatographic procedure continues as described in Compendium Method TO-15.

11.3.2.2 The precision of the analytical system should be tested using six standard tubes all loaded with a mid-concentration-range standard. This procedure should be carried out whenever the thermal desorption - GC/MS analytical method is changed and should be repeated once every tenth series of samples run with an analytical method or once every three months, whichever happens first. The report produced from the most recent precision test should be included with the final batch report generated for each series of samples.

## 12. Calibration of Response

Descriptions of how to load tubes from standard atmospheres, concentrated gas phase standards or liquid standards are given in Sections 9.2 and 9.3. Once the tubes are desorbed to the focusing trap and into the analytical GC/MS system the calibration procedure becomes identical to that presented in Section 3 of Compendium Method TO-15. The guidance given in Section 3 of Compendium Method TO-15 concerning multi-level calibration procedures and calibration frequencies should be followed for this Compendium method. It is also advisable to analyze a single level calibrant (i.e. tubes loaded with analyte masses in the mid-range of those expected to be collected during sampling) approximately every tenth sample during an analytical sequence, as a check on system performance. All samples processed that exceed the calibration range will require data qualifiers to be attached to the analytical results.

## 13. Quality Assurance

### 13.1 Validating the Sample Collection Procedure

#### 13.1.1 Blanks.

13.1.1.1 Artifact levels on laboratory and field blanks should be at the low or sub-nanogram level for carbonaceous sorbents and Tenax® and at the double digit ng level for Porapaks®, Chromosorb® Century series sorbents and other porous polymers as described in Section 7.1. If artifact levels are considerably above this, careful attention must be paid to the tube conditioning and storage procedures described in Sections 10.2.1 and 10.2.2. Artifact peaks which are 10% or more of the area of average component peaks should be marked as artifacts in the final data reports. When monitoring unknown atmospheres, special care must be taken to distinguish between sorbent artifacts and analytes, using the MS to identify components which are significant in both blank and sampled tubes.

13.1.1.2 If the same profile/pattern of VOCs is observed on the field blanks as on the sampled tubes and if the level of these components is 5% or more of the sampled volatiles, careful attention must be paid to the method of sealing the tubes and other storage procedures in future studies. If the profile of volatiles on the field blanks matches that of the sampled tubes and if the areas of the peaks on the field blank are 10% or more of sampled tube levels, the sampled tube data are invalidated.



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13.1.2 Routine Checking of Sorbent Tube Safe Sampling Volumes.

13.1.2.1 The SSVs of sorbent tubes should be retested annually or once every 20 uses (whichever happens first) using one of the procedures described in Section 10.8.

13.1.2.2 If the SSV of a tube (i.e., half the RV or two thirds of the BV) falls below the normal air sample collection volume for the analytes in question, the tube should be repacked with fresh adsorbent and reconditioned.

### 13.2 Performance Criteria for the Monitoring Pump

Records of the pump flow rate delivered against the pump flow rate, stroke rate or pressure selected on a pump should be reviewed at least once per three months. If the performance of any pump has been found to have changed significantly over that time; for example if completely different pump settings are required to deliver the same pump flow rate, the pump should be serviced by the manufacturer or their approved agent.

Sampling pump errors can normally be presumed to be in the order of 5% (8). If the pump sampling flow rate measured at the end of sample collection varies more than 10% from that measured at the beginning of sample collection, then that sample is invalidated.

## 14. Performance Criteria for the Solid Adsorbent Sampling of Ambient Air

### 14.1 Introduction

There are four performance criteria which must be met for a system to qualify under Compendium Method TO-17. These criteria closely parallel those of Compendium Method TO-15, *"The Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)"*. These criteria are:

- A method detection limit ≤0.5 ppb.
- Duplicate (analytical) precision within 20% on synthetic samples of a given target gas or vapor in a typical target gas or vapor mix in humidified zero air.
- Agreement within 25% for distributed volume pairs of tubes taken in each sampling set.
- Audit accuracy within 30 percent for concentrations normally expected in contaminated ambient air (0.5 to 25 ppb). Either mass spectrometry as emphasized here, or specific detectors can be used for analysis. Details for the determination of each of the criteria follow.

### 14.2 Method Detection Limit

The procedure chosen to define the method detection limit is that given in the Code of Federal Regulations (40CFR136 Appendix B). The method detection limit is defined for each system by making seven replicate measurements of a concentration of the compound of interest near the expected detection limit (within a factor of five), computing the standard deviation for the seven replicate concentrations, and multiplying this value by 3.14 (the Student's t value for 99 percent confidence for seven values).



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### 14.3 Analytical Precision of Duplicate Pairs

The measure of analytical precision used for this method is the absolute value of the relative difference between two identical samples (same flow rate over the same time period from with a common inlet to the sample volume). The analytical precision is expressed as a percentage as follows:

$$\text{Analytical Precision} = \left(\frac{[|X1 - X2|]}{X}\right) 100$$

where:

X1 = A measurement value taken from one of the two tubes using in sampling.
X2 = A measurement value taken from the second of two tubes using in sampling.
X = Average of X1 and X2.

The analytical precision is a measure of the precision achievable for the entire sampling and analysis procedure including the sampling and thermal desorption process mentioned above and the analytical procedure that is same as the TO-15 analytical finish, although specific detector systems can also be used.

### 14.4 Precision for the Distributed Volume Pair

The measure of precision used for this method is the absolute value of the relative difference between the distributed volume pair expressed as a percentage as follows:

$$\text{percent difference} = \left(\frac{[|X1 - X2|]}{X}\right) 100$$

where:

X1 = One measurement value (e.g., for a defined sample volume of 1 L).
X2 = Duplicate measurement value (e.g., for a defined sample volume of 4 L taken over the same time period as the first sample).
X = Average of the two values.

There are several factors that may affect the precision of the measurement as defined above. In fact any factor that is nonlinear with sample volume may be significant enough to violate the constraint placed on distributed volume pair precision. These factors include artifact formation, compound reactions on the sorbent, breakthrough of target compounds, etc.

### 14.5 Audit Accuracy

A measure of audit accuracy is the degree of agreement with audit standards. Audit accuracy is defined as the relative difference between the measurement result and the nominal concentration of the audit compound:

$$\text{Audit Accuracy, \%} = \left[\frac{(\text{Spiked Value} - \text{Observed Value})}{(\text{Spiked Value})}\right] \times 100$$

The choice of audit standard is left to the analyst.



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TABLE 1. GUIDELINES FOR SORBENT SELECTION

| Sample Tube Sorbent | Approx. Analyte Volatility Range | Max. Temp., (°C) | Specific Surface Area, ($m^2/g$) | Example Analytes |
|---|---|---|---|---|
| CarbotrapC® CarbopackC® Anasorb® GCB2 | n-$C_8$ to n-$C_{20}$ | >400 | 12 | Alkyl benzenes and aliphatics ranging in volatility from n-C6 to n-C . |
| Tenax® TA | bp 100°C to 400°C n-$C_7$ to n-$C_{26}$ | 350 | 35 | Aromatics except benzene, Apolar components (bp>100°C) and less volatile polar components (bp>150°C). |
| Tenax GR | bp 100°C to 450°C n-$C_7$ to n-$C_{30}$ | 350 | 35 | Alkyl benzenes, vapor phase PAHs and PCBs and as above for Tenax TA. |
| Carbotrap® CarbopackB® Anasorb® GCB1 | (n-$C_4$) n-$C_5$ to n-$C_{14}$ | >400 | 100 | Wide range of VOCs inc., ketones, alcohols, and aldehydes (bp>75°C) and all apolar compounds within the volatility range specified. Plus perfluorocarbon tracer gases. |
| Chromosorb® 102 | bp 50°C - 200°C | 250 | 350 | Suits a wide range of VOCs incl. oxygenated compounds and haloforms less volatile than methylene chloride. |
| Chromosorb 106 | bp 50°C - 200°C | 250 | 750 | Suits a wide range of VOCs incl. hydrocarbons from n-C6 to n-C . Also good for volatile oxygenated compounds |
| Porapak Q | bp 50°C - 200°C n-$C_5$ to n-$C_{12}$ | 250 | 550 | Suits a wide range of VOCs including oxygenated compounds. |
| Porapak N | bp 50°C - 150°C n-$C_5$ to n-$C_8$ | 180 | 300 | Specifically selected for volatile nitriles; acrylonitrile, acetonitrile and propionitrile. Also good for pyridine, volatile alcohols from EtOH, MEK, etc. |
| Spherocarb* | -30°C - 150°C $C_3$ to n-$C_8$ | >400 | 1,200 | Good for very volatile compounds such as VCM, ethylene oxide, CS and CH2I . Also good for volatile polars e.g. MeOH, EtOH and acetone. |
| Carbosieve SIII*® Carboxen 1000*® Anasorb® CMS* | -60°C to 80°C | 400 | 800 | Good for ultra volatile compounds such as CC hydrocarbons, volatile haloforms and freons. |
| Zeolite Molecular Sieve 13X** | -60°C to 80°C | 350 | | Used specifically for 1,3- butadiene and nitrous oxide. |
| Coconut Charcoal* (Coconut charcoal is rarely used) | -80°C to 50°C | >400 | >1,000 | Rarely used for thermal desorption because metal content may catalyze analyte degradation. Petroleum charcoal and Anasorb® 747 are used with thermal desportion in the EPA's volatile organic sampling train (VOST), Methods 0030 and 0031. |

* These sorbents exhibit some water retention. Safe sampling volumes should be reduced by a factor of 10 if sampling a high (>90%) relative humidity.
** Significantly hydrophilic. Do not use in high humidity atmospheres unless silicone membrane caps can be fitted for diffusive monitoring purposes.
CarbotrapC™, CarbopackC™, CarbopackB™, Carboxen™ and Carbosieve SIII™ are all trademarks of Supelco, Inc., USA; Tenax® is a trademark of Enka Research Institute; Chromosorb® is a trademark of Manville Corp.; Anasorb® is a trademark of SKC, Inc.; Porapak® is a trademark of Waters Corporation.



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TABLE 2. GUIDELINES FOR SORBENT USE

| Sample Tube Sorbent | Maximum Temp., (°C) | Hydro-phobic (?) | Temp. and Gas Flow for Conditioning | Temp. and Min. Gas Flow for Desorption | Recommended Focusing Trap Packing |
|---|---|---|---|---|---|
| CarbotrapC® CarbopackC® Anasorb® GCB2 | >400 | Yes | 350°C and 100 mL/min | 325°C and 30 mL/min | Tenax® or Carbopack C® |
| Tenax® TA | 350 | Yes | 330°C and 100 mL/min | 300°C and 30 mL/min | Tenax® |
| Tenax GR | 350 | Yes | 330°C and 100 mL/min | 300°C and 30 mL/min | Tenax® |
| Carbotrap® CarbopackB® Anasorb® GCB1 | >400 | Yes | 350°C and 100 mL/min | 325°C and 30 mL/min | Tenax or Carbopack B® |
| Chromosorb® 102 | 250 | Yes | 250°C and 100 mL/min | 225°C and 30 mL/min | Dual-bed CB plus CMS trap or Chrom. 102 |
| Chromosorb 106 | 250 | Yes | 250°C and 100 mL/min | 250°C and 30 mL/min | Dual-bed CB plus CMS trap or Chrom. 106 |
| Porapak Q | 250 | Yes | 250°C and 100 mL/min | 225°C and 30 mL/min | Dual-bed CB plus CMS trap or Porapak Q |
| Porapak N | 180 | Yes | 180°C and 100 mL/min | 180°C and 30 mL/min | Dual-bed CB plus CMS trap or Porapak N |
| Spherocarb* | >400 | No | 400°C and 100 mL/min | 390°C and 30 mL/min | Dual-bed CB plus CMS trap or Spherocarb |
| CMS such as CSIII*® Carboxen 1000*® Anasorb® CMS* | 400 | No | 350°C and 100 mL/min | 325°C and 30 mL/min | Dual-bed CB plus CMS trap or CMS alone |
| Zeolite Molecular Sieve 13X** | 350 | No | 330°C and 100 mL/min | 300°C and 30 mL/min | Dual-bed CB plus CMS trap or CMS alone |
| Tenax / CB : comb. Tube Type 1 (see Sect. 9.1.3) | 350 | Yes | 330°C and 100 mL/min | 300°C and 30 mL/min | Tenax |
| Carb B / CMS* comb. Tube Type 2 (see Sect. 9.1.3) | 400 | No | 350°C and 100 mL/min | 325°C and 30 mL/min | Dual-bed CB plus CMS trap |
| Carb. 300 type*, comb. Tube Type 3 (see Sect. 9.1.3) | 400 | No | 350°C and 100 mL/min | 325°C and 30 mL/min | Dual-bed CB plus CMS trap |

* These sorbents exhibit some water retention. Safe sampling volumes should be reduced by a factor of 10 if sampling a high (>90%) relative humidity.
** Significantly hydrophilic. Do not use in high humidity atmospheres unless silicone membrane caps can be fitted for diffusive monitoring purposes.

CB is short for Carbopack B and CMS is short for carbonized molecular sieve.

CarbotrapC™, CarbopackC™, CarbopackB™, Carboxen™ and Carbosieve SIII™ are all trademarks of Supelco, Inc., USA; Tenax® is a trademark of Enka Research Institute; Chromosorb® is a trademark of Manville Corp.; Anasorb® is a trademark of SKC, Inc.; Porapak® is a trademark of Waters Corporation.



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TABLE 3 - LIST OF COMPOUNDS WITH BREAKTHROUGH VOLUMES >5L USING THE AIR TOXICS TUBE STYLE 2 LISTED IN SECTIONS 6.1.2 AND 9.1.3 OF COMPENDIUM METHOD TO-17

*[Note: The following list of compounds was determined to have breakthrough volumes of greater than 5 liters of trace levels in humidified zero air for humidities of 20%, 65% and 90% RH at 25°C. The tests were performed immediately prior to the publication of this document at the Research Triangle Institute, Research Triangle Park, NC as a result of activities leading up to the publication of this document. Compounds with an * were not tested at 90% RH.]*

Halocarbon 114
1,3,5-Trimethylbenzene
Halocarbon 11
1,2,4-Trimethylbenzene
Halocarbon 113
Dichlorobenzenes
1,1-Dichloroethene
1,2,4-Trichlorobenzene
Methylene Chloride
Hexachloro-1,3,-butadiene
1,1 Dichloroethane
*1,3 Butadiene
cis-1,2-Dichloroethene
*Acetonitrile
Chloroform
*Acetone
1,1,1-Trichloroethane
*2-Propanol
Carbon tetrachloride
*Acrylonitrile
Benzene
*Isoprene
1,2-Dichloroethane
*Methyl Acetate
Trichloroethene
*Methyl tert-Butyl Ether
1,2-Dichloropropane
*Methyl Ethyl Ketone
cis-1,3-Dichloropropene
*Ethyl Acrylate
Toluene
*Methyl Acrylate
Trans-1,3-Dichloropropene
*Methyl Isobutyl Ketone
*Furfural
Tetrachloroethene
1,2-Dibromoethane
Chlorobenzene
Ethylbenzene
m-Xylene
p-Xylene
o-Xylene
1,1,2,2-Tetrachloroethane



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TABLE 4. MASS OF AN ANALYTE 'X' COLLECTED FROM 1, 2 OR 10 L AIR SAMPLES AT DIFFERENT ATMOSPHERIC CONCENTRATIONS (ASSUMING 'X' HAS A MOLAR WEIGHT OF 100 g)

| Sample type | Typical concentration | Mass collected in 1 L sample volume | Mass collected in 2 L sample volume | Mass collected in 10 L sample volume |
|---|---|---|---|---|
| Fenceline/severe urban area | 10-250 ppb | 40-1,000 ng | 80 ng-2 μg | 0.4-10μg |
| Indoor air sampling | 1-100 ppb | 4-400 ng | 8-800 ng | 40 ng-4μg |
| Avg. exposure to benzene | ~3 ppb | 11 ng | 22 ng | 110 ng |
| Normal urban area | 1-10 ppb | 4-40 ng | 8-80 ng | 40-400 ng |
| Normal rural area | 0.1-1 ppb | 0.4-4 ng | 0.8-8 ng | 4-40 ng |
| Forested area | 0.25-2.5 ppb | 1-10 ng | 2-20 ng | 10-100 ng |
| Mt. Everest/K2 site | 0.025-7.5 ppb | 0.1-30 ng | 0.2-60 ng | 1-300 ng |
| Arctic on an ultraclean day | 15-50 ppt | 60-200 pg | 0.12-0.4 ng | 0.6-2 ng |



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# COMPENDIUM METHOD TO-17
# FIELD TEST DATA SHEET (FTDS)

## I. GENERAL INFORMATION

PROJECT:_____ DATE(S) SAMPLED:_____
SITE:_____ TIME PERIOD SAMPLED:_____
LOCATION:_____ OPERATOR:_____
INSTRUMENT MODEL NO.:_____ CALIBRATED BY:_____
PUMP SERIAL NO.:_____ RAIN: ____YES _____NO

ADSORBENT CARTRIDGE INFORMATION:

| | Tube 1 | Tube 2 |
|---|---|---|
| Type: | _____ | _____ |
| Adsorbent: | _____ | _____ |
| Serial No.: | _____ | _____ |
| Sample No.: | _____ | _____ |

## II. SAMPLING DATA

| Tube Identification | Sampling Location | Ambient Temp., °F | Ambient Pressure, in Hg | Flow Rate (Q), mL/min | | Sampling Period | | Total Sampling Time, min. | Total Sample Volume, L |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Tube 1 | Tube 2 | Start | Stop | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

## III. FIELD AUDIT

| | Tube 1 | Tube 2 |
|---|---|---|
| Audit Flow Check Within 10% of Set Point (Y/N)? | pre- _____ post- | pre- _____ post- |

CHECKED BY:_____
DATE:_____

Figure 1. Compendium Method TO-17 Field Test Data Sheet.



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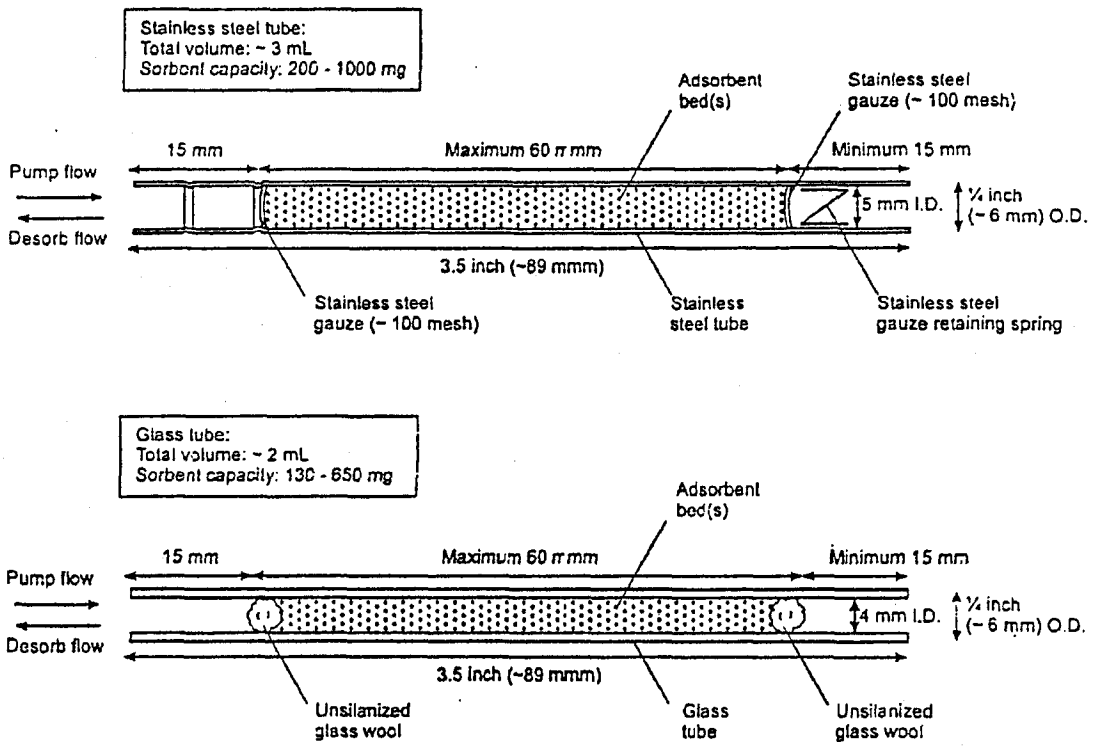


Figure 2. Example of construction of commercially available adsorbent tubes.



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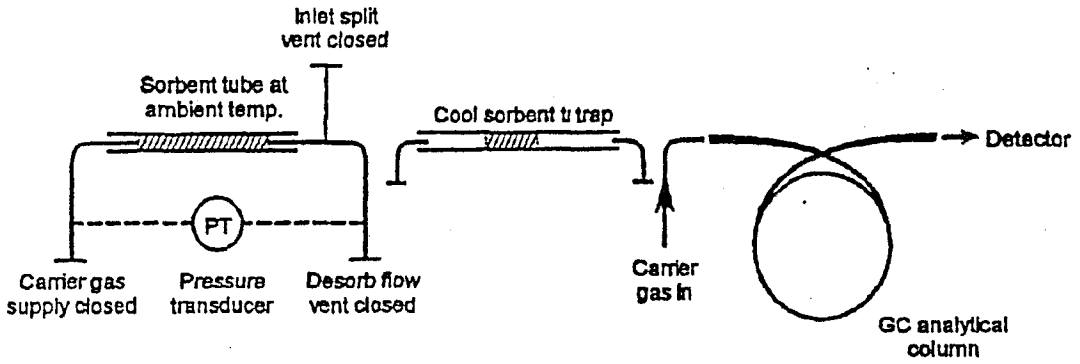
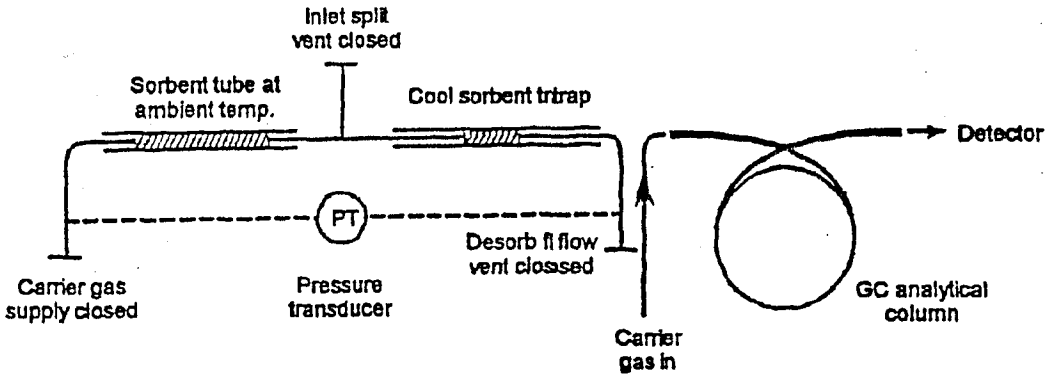



(a) Tube leak check.




(b) Leak check sample flow path.

Figure 3. Sequence of operations to thermally desorb the sample from the sorbent tube and transfer to the gas chromatograph: (a) tube leak test and (b) leak check flow path.



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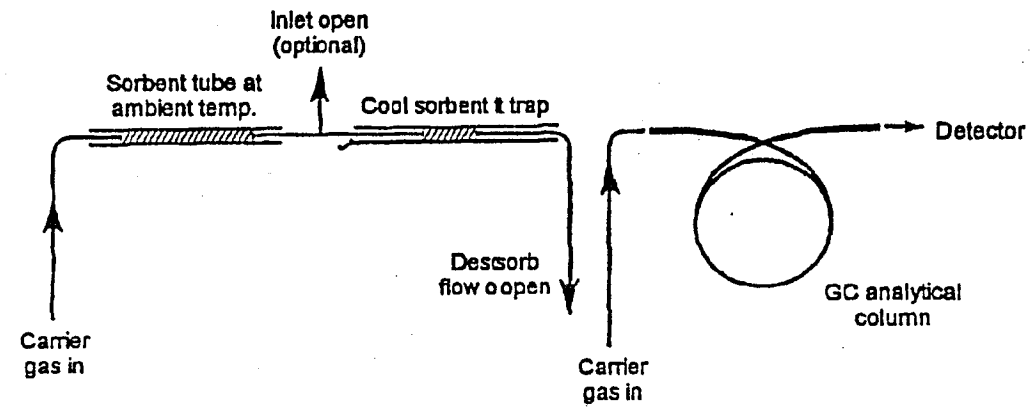
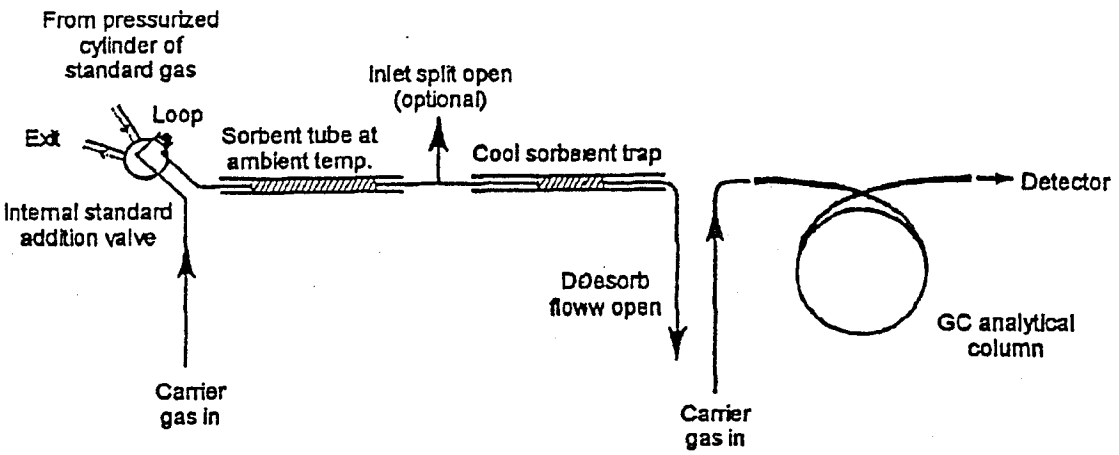



(c) Purge to remove air.




(d) Gas phase internal standard addition to sample tube.

Figure 3 (cont). Sequence of operations to thermally desorb the sample from the sorbent tube and transfer to the gas chromatograph: (c) purge to remove air and (d) gas phase internal standard addition to sample tube.



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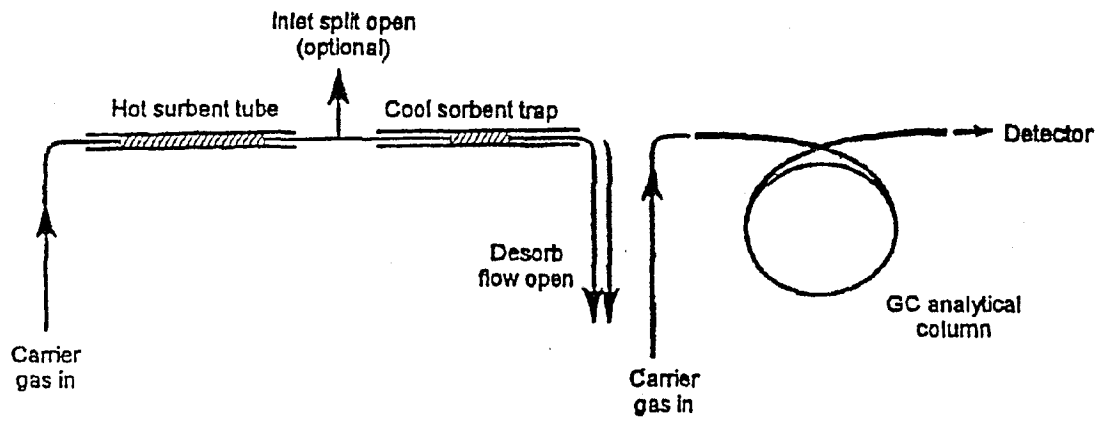
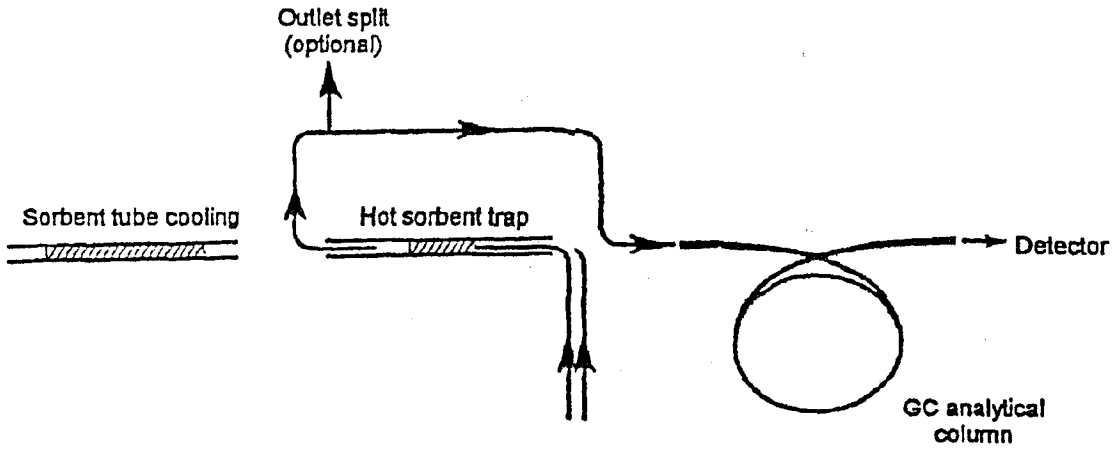



(e) Primary (tube) desorption.




(f) Secondary (trap) desorption.

Figure 3 (cont). Sequence of operations to thermally desorb the sample from the sorbent tube and transfer to the gas chromatograph: (e) primary (tube) desorption and (f) secondary (trap) desorption.



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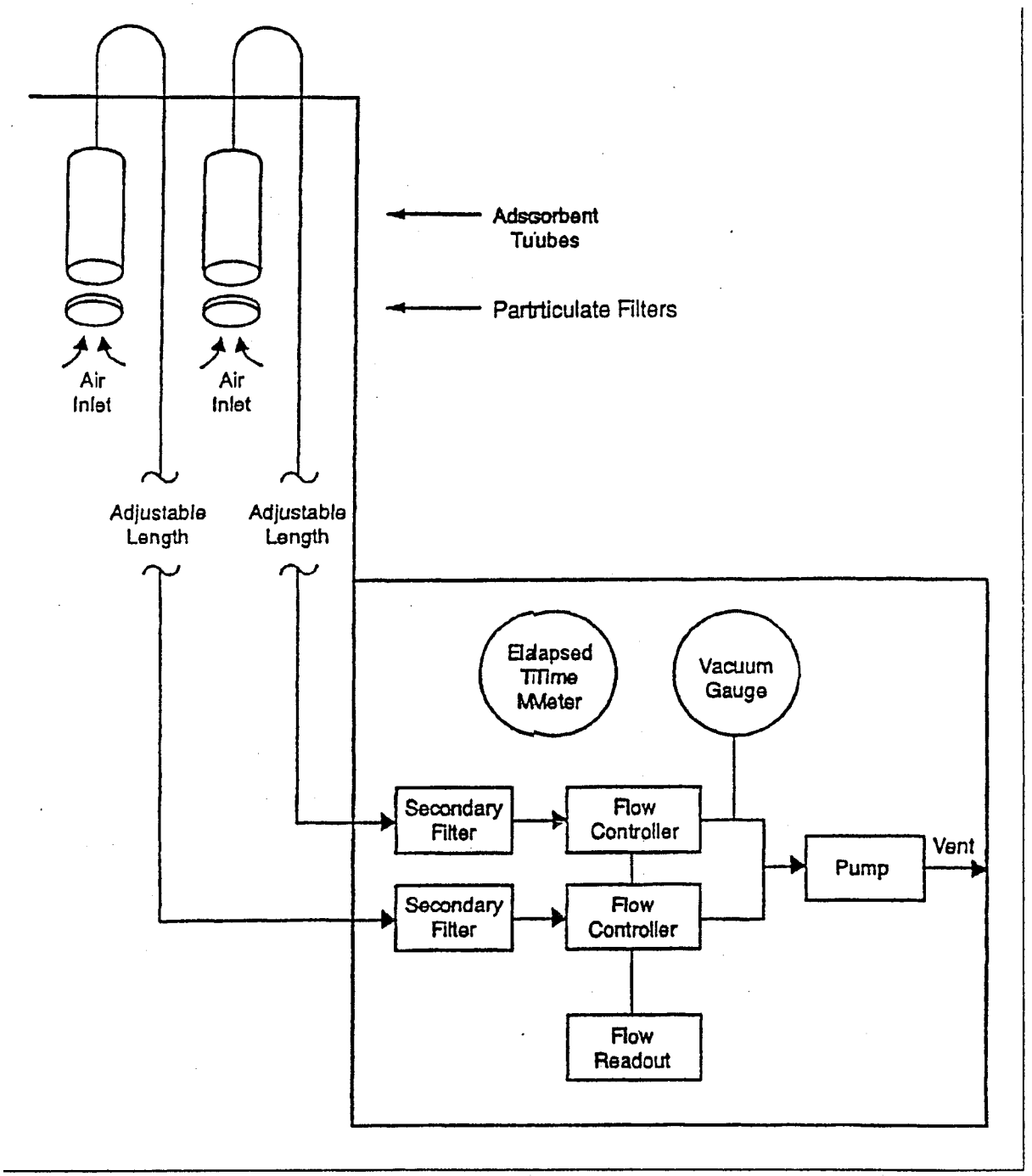


Figure 4. Example of distributive air volume using adsorbent tube technology.



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## APPENDIX 1.

The following list includes safe sampling volume data generated by the UK Health and Safety Executive (4) on single sorbent bed 1/4 inch O.D. stainless steel tubes and compatible with a thermal desorption - capillary GC analytical procedure. It is provided as a resource to readers only. The recommendation for Tube Style 2 is based on the specific tube referenced in Section 6.1.2 and Table 3. Where tubes are not listed with safe sample volumes they have not been tested and their inclusion represents a suggestion only. Application to air sampling is subject to criteria listed in Section 14 of Compendium Method TO-17.

*[Note: Combination tubes 1, 2, and 3 referenced in this Appendix are those adsorbent tubes described in Section 9.1.3.]*

| Compound | Suitable sorbents and SSV's where available |
|---|---|
| **Hydrocarbons** | |
| This procedure is suitable for all aliphatic, aromatic and cyclic hydrocarbons less volatile than ethane and more volatile than n-C20. These include: | |
| n-Butane | CS III, C 1000, Combination Tubes 2 or 3 or Spherocarb (SSV 820L). |
| n-Pentane | CS III, C 1000, Spherocarb (SSV 30,000L), Combination Tubes 2 or 3 or Chromosorb 106 (SSV 5.5L). |
| n-Hexane | Carbopack™ B, Combination Tubes 1, 2, 3 or Chromosorb 106 (SSV 30L). |
| Benzene | Carbopack™ B, Combination Tubes 1, 2, 3 or Chromosorb 106 (SSV 26L) or Tenax (SSV 6L). |
| n-Heptane | Carbopack™ B, Tenax (SSV 17L), Combination Tubes 1, 2, 3 or Chromosorb 106 (SSV 160L). |
| Toluene | Carbopack™ B, Tenax (SSV 38L), Combination Tubes 1, 2, 3 or Chromosorb 106 (SSV 80L). |
| n-Octane | Carbopack™ B, Tenax (SSV 700L) Combination Tubes 1, 2, 3 or Chromosorb 106 (SSV 1000L). |
| Ethylbenzene | Carbopack™ B, Tenax (SSV 180L), Combination Tubes 1, 2, 3 or Chromosorb 106 (SSV 360L). |
| all Xylenes | Carbopack™ B, Tenax (SSV 300L), Combination Tubes 1, 2, 3 or Chromosorb 106 (SSV 770L). |
| n-Nonane | Carbopack™ C/B, Tenax (SSV 700L), Combination Tubes 1, 2 or 3 or Chromosorb 106 (SSV 7000L). |
| Styrene | Carbopack™ C/B, Tenax (SSV 300L) or Combination Tubes 1, 2 or 3. |
| Isopropylbenzene | Carbopack™ C/B, Tenax (SSV 480L) or Combination Tubes 1, 2 or 3. |
| n-Propylbenzene | Carbopack™ C/B, Tenax (SSV 850L) or Combination Tubes 1, 2 or 3. |
| 1-Methyl-3-ethylbenzene | Carbopack™ C/B, Tenax (SSV 1000L) or Combination Tubes 1, 2 or 3. |
| 1-Methyl-4-ethylbenzene | Carbopack™ C/B, Tenax (SSV 1000L) or Combination Tubes 1, 2 or 3. |



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| Compound | Suitable sorbents and SSV's where available |
|---|---|
| 1,3,5-Trimethylbenzene | Carbopack™ C/B, Tenax (SSV 1800L), Combination Tubes 1, 2 or 3 or Chromosorb 106 (SSV 2800). |
| Methylstyrene | Carbopack™ C/B, Tenax (SSV 1200L) or Combination Tubes 1, 2 or 3. |
| Methyl-2-ethylbenzene | Carbopack™ C/B, Tenax (SSV 1000L) or Combination Tubes 1, 2 or 3. |
| 1,2,4-Trimethylbenzene | Carbopack™ C/B, Tenax (SSV 1800L) or Combination Tubes 1, 2 or 3. |
| n-Decane | Carbopack™ C/B, Tenax (SSV 2100L), Combination Tubes 1, 2 or 3 or Chromosorb 106 (SSV 37,000L). |
| 1,2,3-Trimethylbenzene | Carbopack™ C/B, Tenax (SSV 1800L) or Combination Tubes 1, 2 or 3. |
| n-Undecane | Carbopack™ C/B, Tenax (SSV 12,000L) or Combination Tubes 1, 2 or 3. |
| n-Dodecane | Carbopack™ C, Tenax (SSV 63,000L) or Combination Tubes 1 or 3. |

## Halogenated Hydrocarbons including PCBs

This procedure is suitable for all aliphatic, aromatic and cyclic halogenated hydrocarbons more volatile than n-C20. Examples include:

| | |
|---|---|
| Dichloromethane | CS III, C 1000, Spherocarb (SSV 200L) or Combination Tubes 2 or 3. |
| 1,2-Dichloroethane | CS III, C 1000, Spherocarb, Chrom. 106 (SSV 17L), Carbopack™ B, Tenax (SSV 5.4L) or Combination Tubes 1, 2 or 3. |
| 1,1,1-Trichloroethane | Spherocarb (SSV 8,000L), Chrom. 106 (SSV 8L), Carbopack™ B, or Combination Tubes 1, 2 or 3. |
| Carbontetrachloride | Chrom. 106 (SSV 22L), Carbopack™ B, Tenax (SSV 6.2L) or Combination Tubes 1, 2 or 3. |
| Trichloroethylene | Chrom. 106, Carbopack™ B, Tenax (SSV 5.6L) or Combination Tubes 1, 2 or 3. |
| 1,1,2-Trichloroethane | Chrom. 106, Carbopack™ B, Tenax (SSV 34L) or Combination Tubes 1, 2 or 3. |
| Tetrachloroethylene | Chrom. 106, Carbopack™ B, Tenax (SSV 48L) or Combination Tubes 1, 2 or 3. |
| Chlorobenzene | Chrom. 106, Carbopack™ B, Tenax (SSV 26L) or Combination Tubes 1, 2 or 3. |
| 1,1,1,2-Tetrachloroethane | Chrom. 106, Carbopack™ B, Tenax (SSV 78L) or Combination Tubes 1, 2 or 3. |
| 1,1,2,2-Tetrachloroethane | Chrom. 106, Carbopack™ B, Tenax (SSV 170L) or Combination Tubes 1, 2 or 3. |



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| Compound | Suitable sorbents and SSV's where available |
|---|---|

## Alcohols

This procedure is suitable for alcohols more volatile than n-C20 and sufficiently stable to be analyzed by conventional GC techniques. Examples include:

| | |
|---|---|
| Methanol | CSIII, C1000, Spherocarb (SSV 130L) or Combination Tubes 2 or 3. |
| Ethanol | CSIII, C1000, Spherocarb (SSV 3500L) or Combination Tubes 2 or 3. |
| n-Propanol | Porapak N (SSV 20L), Chrom 106 (SSV 8L), Carbopack™ B or Combination Tubes 1, 2 or 3. |
| Isopropanol | Chrom 106 (SSV 44L), Carbopack™ B or Combination Tubes 1, 2 or 3. |
| n-Butanol | Chrom 106 (SSV 50L), Carbopack™ B, Porapak N (SSV 5L), Tenax (SSV 5L) or Combination Tubes 1, 2 or 3. |
| iso-Butanol | Chrom 106 (SSV 30L), Carbopack™ B, Tenax (SSV 2.8L) or Combination Tubes 1, 2 or 3. |
| Octanol | Tenax (SSV 1400L), Carbopack™ C or Combination Tubes 1 or 3. |

## Esters and Gycol Ethers

This procedure is suitable for all esters and glycol ethers more volatile than n-C20 and sufficiently stable to be analyzed by conventional GC techniques. Examples include:

| | |
|---|---|
| Methylacetate | Chromosorb 106 (SSV 2.6L), Carbopack™ B or Combination Tubes 1, 2 or 3. |
| Ethylacetate | Chromosorb 106 (SSV 20L), Carbopack™ B, Tenax (SSV 3.6L) or Combination Tubes 1, 2 or 3. |
| Propylacetate | Chromosorb 106 (SSV 150L), Carbopack™ B, Tenax (SSV 18L) or Combination Tubes 1, 2 or 3. |
| Isopropylacetate | Chromosorb 106 (SSV 75L), Carbopack™ B, Tenax (SSV 6L) or Combination Tubes 1, 2 or 3. |
| Butylacetate | Chromosorb 106 (SSV 730L), Carbopack™ B, Tenax (SSV 85L) or Combination Tubes 1, 2 or 3. |
| Isobutylacetate | Chromosorb 106 (SSV 440L), Carbopack™ B, Tenax (SSV 130L) or Combination Tubes 1, 2 or 3. |
| Methyl-t-butyl ether | Chromosorb 106 (SSV >6L), Carbopack™ B or Combination Tubes 1, 2 or 3. |
| t-Butylacetate | Chromosorb 106 (SSV 160L), Carbopack™ B or Combination Tubes 1, 2 or 3. |
| Methylacrylate | Chromosorb 106, Carbopack™ B, Tenax (SSV 6.5L) or Combination Tubes 1, 2 or 3. |



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| Compound | Suitable sorbents and SSV's where available |
|---|---|
| Ethylacrylate | Chromosorb 106, Carbopack™ B, Tenax (SSV 60L) or Combination Tubes 1, 2 or 3. |
| Methylmethacrylate | Chromosorb 106, Carbopack™ B, Tenax (SSV 27L) or Combination Tubes 1, 2 or 3. |
| Methoxyethanol | Chromosorb 106 (SSV 5L), Carbopack™ B, Tenax (SSV 3L) or Combination Tubes 1, 2 or 3. |
| Ethoxyethanol | Chromosorb 106 (SSV 75L), Carbopack™ B, Tenax (SSV 5L) or Combination Tubes 1, 2 or 3. |
| Butoxyethanol | Chromosorb 106, Carbopack™ B, Tenax (SSV 35L) or Combination Tubes 1, 2 or 3. |
| Methoxypropanol | Chromosorb 106, Carbopack™ B, Tenax (SSV 13L) or Combination Tubes 1, 2 or 3. |
| Methoxyethylacetate | Chromosorb 106 (SSV 860L), Carbopack™ B, Tenax (SSV 8L) or Combination Tubes 1, 2 or 3. |
| Ethoxyethylacetate | Chromosorb 106 (SSV 4000L), Carbopack™ B, Tenax (SSV 15L) or Combination Tubes 1, 2 or 3. |
| Butoxyethylacetate | Chromosorb 106, Carbopack™ B, Tenax (SSV 150L) or Combination Tubes 1, 2 or 3. |

## Aldehydes and Ketones

This procedure is suitable for all aldehydes and ketones more volatile than n-C20 and sufficiently stable to be analyzed using conventional GC techniques. Examples include:

| | |
|---|---|
| Acetone | CSIII, C1000, Spherocarb, Chrom 106 (SSV 1.5L) or Combination Tubes 2 or 3. |
| Methylethylketone (2-butanone) | Chromosorb 106 (SSV 10L), Tenax (SSV 3.2L), Porapak N (SSV 50L) Carbopack™ B or Combination Tubes 1, 2 or 3. |
| n-Butanal | Chromosorb 106, Carbopack™ B, Porapak N (SSV 50L) or Combination Tubes 1, 2 or 3. |
| Methylisobutylketone | Chromosorb 106 (SSV 250L), Tenax (SSV 26L), Carbopack™ B or Combination Tubes 1, 2 or 3. |
| Cyclohexanone | Chromosorb 106, Tenax (SSV 170L), Carbopack™ B or Combination Tubes 1, 2 or 3. |
| 3,5,5-Trimethylcyclohex-2-enone | Tenax (SSV 5600L), Carbopack™ B or Combination Tubes 1 or 3. |
| Furfural | Tenax (SSV 300L), Carbopack™ B or Combination Tubes 1, 2 or 3. |



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| Compound | Suitable sorbents and SSV's where available |
|---|---|

## Miscellaneous VOCs

This procedure is suitable for the analysis of most VOCs in air. It is generally compatible with all organics less volatile than ethane, more volatile than n-C20 and sufficiently stable to be analyzed using conventional GC techniques. Examples include:

| | |
|---|---|
| Acetonitrile | Porapak N (SSV 3.5L), CSIII, C1000 or Combination Tubes 2 or 3. |
| Acrylonitrile | Porapak N (SSV 8L), Carbopack™ B or Combination Tubes 1, 2 or 3. |
| Propionitrile | Porapak N (SSV 11L), Carbopack™ B or Combination Tubes 1, 2 or 3. |
| Maleic anhydride[a] | Tenax (SSV 88L), Chrom. 106, Carbopack™ B or Combination Tubes 1, 2 or 3. |
| Pyridine | Tenax (SSV 8L), Porapak N (SSV 200L) Chrom. 106, Carbopack™ B or Combination Tubes 1, 2 or 3. |
| Aniline | Tenax (SSV 220L), Chrom. 106, Carbopack™ B or Combination Tubes 1, 2 or 3. |
| Nitrobenzene | Tenax (SSV 14,000L) Carbopack™ C or Combination Tubes 1 or 3. |
| Acetic acid | Porapak N (SSV 50L), Carbotrap™ B or Combination Tubes 1, 2 or 3. |
| Phenol | Tenax (SSV 240L) or combination tube 1. |



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APPENDIX 2.

LINEARITY TESTING OF ONE SORBENT TUBE/FOCUSING TUBE COMBINATION

## Introduction

Automated gas chromatographs such as those used at network monitoring stations for hourly updates of volatile organic compounds (VOCs) have a solid adsorbent concentrator for the VOCs. This unit is comparable to the sorbent tubes being discussed in this document. The table below shows the results of sampling a synthetic mixture of the Compendium Method TO-14 target list in humidified zero air (approximately 70% RH at 25°C). Sampling occurred for 6, 12, and 24 min at a rate of 80 mL/min giving a total sampling volume of 480, 960, and 1920 mL. These results are similar to the determination of safe sampling volume and the amount of material collected should be related linearly to the sample period. The results indicate that breakthrough has not occurred to any appreciable extent at a sampling volume of approximately 2 L for the stated experimental conditions. The response measured is the response of chlorine from an atomic emission detector after chromatographic separation. The sorbent tube mix was Carbotrap™ C/Carbotrap™ B/Carboxen™ 1000 and the focusing tube mix was Tenax-TA/Silica Gel/Ambersorb XE-340/Charcoal. The primary tube was 6 mm O.D. with 4 mm I.D., 110 mm in length. The focusing tube was 6 mm O.D., 0.9 mm I.D., 185 mm in length. The packing lengths for the sorbent tube per sorbent type were: 1.27 cm, 2.86 cm, and 3.18 cm, respectively. The packing lengths for the focusing tube per sorbent type were: 5.08 cm, 2.54 cm, and 1.27 cm.

## Linearity test

*[Note: Actual sampling volumes were 490, 980, and 1960 instead of 1/2, 1, and 2L as listed for convenience in the table below. The response is obtained as chlorine response on an atomic emission detector. Compounds corresponding to the numbered compounds in the table are identified on the following page.]*

| Cpd. | 1/2 L | 1 L | 2 L | 2L/1L | 2L/(1/2L) | 1L/(1/2L) | % Diff (2L/0.5L) vs. 4 |
|---|---|---|---|---|---|---|---|
| 1 | 1255.4 | 2402.9 | 5337.2 | 2.22 | 4.25 | 1.91 | -6.28 |
| 2 | 711.82 | 1802.2 | 3087 | 1.71 | 4.34 | 2.53 | -8.42 |
| 3 | 2079.4 | 4853 | 9386 | 1.93 | 4.51 | 2.33 | -12.85 |
| 4 | 978.14 | 2381.3 | 4680.1 | 1.97 | 4.78 | 2.43 | -19.62 |
| 6 | 1155.7 | 2357.1 | 4725.2 | 2.00 | 4.09 | 2.04 | -2.22 |
| 7 | 3072.8 | 6764.4 | 13662 | 2.02 | 4.45 | 2.20 | -11.15 |
| 8 | 2337.3 | 4356.1 | 8697.2 | 2.00 | 3.72 | 1.86 | 6.97 |
| 9 | 3041.7 | 5986.6 | 11525 | 1.93 | 3.79 | 1.97 | 5.28 |
| 10 | 1061.7 | 2183.6 | 4296.5 | 1.97 | 4.05 | 2.06 | -1.17 |
| 11 | 3800.5 | 7726.7 | 15182 | 1.96 | 3.99 | 2.03 | 0.13 |
| 12 | 2386.9 | 4877.5 | 9669 | 1.98 | 4.05 | 2.04 | -1.27 |
| 13 | 2455.4 | 5063.5 | 9986.6 | 1.97 | 4.07 | 2.06 | -1.68 |
| 14 | 3972.6 | 8118.4 | 15985 | 1.97 | 4.02 | 2.04 | -0.60 |
| 15 | 2430.9 | 4947.9 | 9756.1 | 1.97 | 4.01 | 2.04 | -0.33 |
| 16 | 6155.4 | 9247.4 | 16942 | 1.83 | 2.75 | 1.50 | 31.19 |



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| Cpd. | 1/2 L | 1 L | 2 L | 2L/1L | 2L/(1/2L) | 1L/(1/2L) | % Diff (2L/0.5L) vs. 4 |
|---|---|---|---|---|---|---|---|
| 18 | 4270.4 | 9233.8 | 18721 | 2.03 | 4.38 | 2.16 | -9.60 |
| 19 | 2494.8 | 5115.2 | 10087 | 1.97 | 4.04 | 2.05 | -1.08 |
| 20 | 4023.9 | 8379.4 | 16672 | 1.99 | 4.14 | 2.08 | -3.58 |
| 21 | 1086.8 | 2295.4 | 4611.7 | 2.01 | 4.24 | 2.11 | -6.08 |
| 22 | 793.33 | 1670.1 | 3375.2 | 2.02 | 4.25 | 2.11 | -6.36 |
| 23 | 3708.2 | 7679 | 15165 | 1.97 | 4.09 | 2.07 | -2.24 |
| 26 | 5094 | 10582 | 21139 | 2.00 | 4.15 | 2.08 | -3.74 |
| 27 | 1265.1 | 2615.1 | 5136.9 | 1.96 | 4.06 | 2.07 | -1.51 |
| 31 | 4434.9 | 9176.4 | 17975 | 1.96 | 4.05 | 2.07 | -1.33 |
| 36 | 2320.7 | 5015.7 | 9827.3 | 1.96 | 4.23 | 2.16 | -5.87 |
| 37 | 441.17 | 953.09 | 1894 | 1.99 | 4.29 | 2.16 | -7.33 |
| 38 | 1410.7 | 3015 | 5895.2 | 1.96 | 4.18 | 2.14 | -4.47 |
| 39 | 2338.7 | 4974.8 | 9858.8 | 1.98 | 4.22 | 2.13 | -5.39 |
| 40 | 2640.9 | 6269.4 | 12495 | 1.99 | 4.73 | 2.37 | -18.28 |
| 41 | 6796.5 | 14938 | 29274 | 1.96 | 4.31 | 2.20 | -7.68 |

There are no values presented in the above table for hydrocarbons and brominated hydrocarbons (compounds numbered 5, 17, 24, 25, 28, 29, 30, 32, 33, 34, and 35) which do not respond to the chlorine detector used to collect this data.

**Compendium Method TO-14**
**Target Compound List (TCL)**

1. Dichlorodifluoromethane
2. Methyl Chloride
3. 1,2-dichloro-1,1,2,2-tetrafluoroethane
4. Vinyl Chloride
5. Methyl Bromide
6. Ethyl Chloride
7. Trichlorofluoromethane
8. 1,1-dichloroethene
9. Dichloromethane
10. 3-chloropropene
11. 1,1,2-trichloro-1,2,2-trifluoroethane
12. 1,1-dichloroethane
13. Cis-1,2-dichloroethene
14. Trichloromethane
15. 1,2-dichloroethane
16. 1,1,1-trichloroethane
17. Benzene
18. Carbon Tetrachloride
19. 1,2-dichloropropane
20. Trichloroethene
21. Cis-1,3-dichloropropene
22. Trans-1,3-dichloropropene
23. 1,1,2-trichloroethane
24. Toluene
25. 1,2-dibromoethane
26. Tetrachloroethene
27. Chlorobenzene
28. Ethylbenzene
29. m,p-xylene
30. Styrene
31. 1,1,2,2-tetrachloroethane
32. o-xylene
33. 4-ethyltoluene
34. 1,3,5-trimethylbenzene
35. 1,2,4-trimethylbenzene
36. m-dichlorobenzene
37. Benzyl Chloride
38. p-dichlorobenzene
39. o-dichlorobenzene
40. 1,2,4-trichlorobenzene
41. Hexachlorobutadiene



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# APPENDIX C

## FIELD PILOT TESTING FOR REMEDIATION OF DIESEL PLUME AT SITE 3

## FIELD WORK PLAN FOR SAMPLING AND FIELD PILOT TESTING AT SITE 3

## NAVAL FUEL DEPOT POINT MOLATE RICHMOND, CALIFORNIA

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN II)
Northern and Central California, Nevada, and Utah
Contract No. N62474-94-D-7609
Contract Task Order 379

Prepared for

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# FIELD PILOT TESTING FOR REMEDIATION OF DIESEL PLUME AT SITE 3

NAVAL FUEL DEPOT POINT MOLATE
RICHMOND, CALIFORNIA

DS.0379.15002

May 14, 2001

Prepared by

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| bgs | Below ground surface |
| BTEX | Benzene, toluene, ethylbenzene, and xylenes |
| DO | Dissolved oxygen |
| DQO | Data quality objectives |
| EE/CA | Engineering evaluation and cost analysis |
| EPA | U.S. Environmental Protection Agency |
| FID | Flame ionization detector |
| FSP | Field sampling plan |
| HSA | Hollow stem auger |
| IR | Installation Restoration |
| MPE | Multiphase extraction |
| NFD | Naval fuel depot |
| NIOSH | National Institute of Occupational Safety and Health |
| PID | Photoionization detector |
| PVC | Polyvinyl chloride |
| QAPP | Quality assurance project plan |
| QA/QC | Quality assurance and quality control |
| SCFM | Standard cubic feet per minute |
| SVE | Soil vapor extraction |
| TtEMI | Tetra Tech EM Inc. |
| TPH | Total petroleum hydrocarbons |
| VOC | Volatile organic compound |
| ZOI | Zone of influence |

# 1.0 INTRODUCTION

This appendix describes procedures for field pilot testing recommended to be conducted at Installation Restoration (IR) Site 3 at Naval Fuel Depot (NFD) Point Molate in Richmond, California. This appendix includes a description of the objectives and recommended procedures for conducting pilot tests of air sparging, soil vapor extraction (SVE), and multiphase extraction (MPE) within a plume predominantly made up of diesel free product at Site 3. Project background information, data quality objectives (DQOs), and detailed quality assurance and quality control (QA/QC) procedures are presented in the work plan, the field sampling plan (FSP, Appendix A), and the Quality Assurance Project Plan (QAPP, Appendix B).

This testing plan has been developed to evaluate air sparging, SVE, and MPE in the southern portion of the area of Site 3, specifically near monitoring well MW11-54, where monitoring data indicate the presence of free product plume of diesel and bunker fuel (see Plate 2-1 of the work plan). Monitoring data indicate that the plume near well MW11-54 is predominantly diesel fuel. MPE is recommended for consideration within this area as a means to remove free product from the soils at Site 3. Although air sparging and SVE are not recommended as sole remediation technologies for addressing this plume, use of air sparging and SVE will be considered as part of a remediation approach in the Site 3 Engineering Evaluation and Cost Analysis (EE/CA). If used, air sparging/SVE (and possibly biosparging/bioventing) would serve as complementary technologies to a free-product recovery system.

MPE is recommended for testing within the diesel plume area at Site 3 because:

(1) A relatively thick layer of diesel product, as much as 6 feet, occurs periodically at monitoring well MW11-54. MPE may be effective in extracting this free product.

(2) MPE would remove the lighter-end components of diesel in the vapor phase that may contribute to exceeding future action levels for soils and groundwater.

(3) MPE will also promote aerobic biodegradation of moderate to low-volatile components of diesel fuel that exist in site soils and groundwater.

Air sparging is recommended for testing at Site 3 because it has the ability to:

(1) Remove the lighter-end components of diesel, including benzene, toluene, ethylbenzene, and xylenes (BTEX), from saturated soils and groundwater by in situ air stripping

(2) Create conditions favorable for aerobic biodegradation of moderate- to heavy-end diesel components by providing oxygen to the saturated soils and groundwater

If air sparging is technically feasible and is applied at this site, the system would likely result in removal of the volatile components relatively quickly (that is, within 3 to 6 months). After the initial application of air sparging, the system may be converted to biosparging operation. Thus, the sparge system would be operated with the primary intention of supplying air to the saturated zone to the extent that oxygen is not limiting for aerobic biodegradation of hydrocarbons that remain in saturated soils and groundwater. A biosparging system typically operates at lower flow rates than air sparging systems, and may not require the simultaneous operation of an SVE system. As such, operation in biosparge mode requires less money, while providing equivalent remediation benefit, as operation in air sparging mode.

SVE is typically applied in conjunction with air sparging to collect vapors transported to the vadose zone by operation of the air sparging system. Soil vapor extraction will also be effective in removing the lighter-end components of diesel that exist within the site soils. As previously discussed for the sparging application, the SVE system may be reconfigured to operate as a biovent system after the initial phase of operation in which the lighter-end components have been removed from the soils and groundwater during air sparging operation. The objective of the biovent system is to supply oxygen (by way of air injection) to support aerobic biodegradation of moderate- to low-volatility hydrocarbons that remain in site soils. A biovent system typically involves lower flow rates than an SVE configuration, and may be operated in positive pressure mode, thus removing any requirements for discharge vapor treatment. As such, operation in biovent mode may be able to provide the same remediation benefit at a lower cost than would operation in SVE mode after volatile components have been removed from the groundwater and soils.

Section 2.0 of this appendix presents the test objectives. Section 3.0 presents the test approach and procedures. Figures and tables follow the text. Additional discussion on the basis for these tests is presented in Section 5.0 of the field work plan.

## 2.0 TEST OBJECTIVES

The primary objectives of the sparging tests will include:

(1) Evaluation of the effective zone of influence at the test sparge wells (based on pressure and helium tracer testing)

(2) Confirmation of vertical transport of injected air (and thus volatilized contaminants) from the sparge well up into the vadose zone (based on monitoring vadose zone for changes in soil vapor levels of total petroleum hydrocarbons (TPH), and helium during tracer tests)

(3) Collection of sparging air flow and pressure data

The objectives associated with the SVE testing will include:

(1) Evaluation of the effective vacuum zone of influence (ZOI) associated with the test SVE well

(2) Collection of data on the concentrations of TPH and BTEX in the extracted soil vapor

(3) Collection of data on vacuum and soil vapor flow

The primary objectives of the MPE tests will include:

(1) Evaluation of free-product recovery rates at varying vacuum and flow conditions

(2) Evaluation of the effective zone of influence at the test MPE wells, based on groundwater and product level changes combined with vacuum propagation at soil vapor monitoring points

(3) Collection of vapor and aqueous flow data

(4) Collection of data on the concentrations of TPH and BTEX in the extracted soil vapor

Data collected from the sparging, SVE, and MPE testing will be used to assess the technical feasibility of these technologies to remediate diesel TPH contamination at Site 3. If considered technically feasible for Site 3, the data will also be used as part of the EE/CA to estimate the cost of implementing this technology in a full-scale scenario. Additionally, if the technology is selected based on the EE/CA, test results may be used as input for design of the full-scale remediation system.

## 3.0 TESTING APPROACH

Details of the technical approach for pilot testing in the diesel area are presented in the following sections. Table C-1 summarizes the anticipated chronology for testing. The actual chronology for testing may vary depending on actual site conditions and test results.

### 3.1 INSTALLATION OF THE TEST WELL NETWORK

The location of the pilot test is near monitoring well MW11-54, as presented in Plate 2-1 of the field work plan. The well network for the pilot test will consist of one sparge well, existing monitoring well

MW11-54 as the test SVE and MPE well, and three sets of nested monitoring points. The layout of test wells is presented in Figure C-1.

The sparge well and monitoring points will be installed in borings advanced using standard hollow stem-auger (HSA) drilling techniques. Soil samples will be collected during drilling to log soil lithology and contaminant staining, and to screen soils with a field organic vapor analyzer (photoionization or flame-ioniozation detector [PID or FID]).

The sparge well will be set 8 to 10 feet below the water table, which is anticipated to be at a depth of approximately 23 feet below ground surface (bgs). The sparge well will be constructed using 2-inch diameter flush-thread Schedule 40 polyvinyl chloride (PVC) well screen (0.01-inch slot) and riser. The well screen interval will be 2 feet long. A 2-inch Schedule 80 PVC female adapter will be attached to the top of the sparge well riser. The riser will be plugged using a 2-inch diameter Schedule 80 PVC threaded plug. A sand filter pack will extend from the bottom of the well screen to 6 inches above the top of the well screen. A 2-foot bentonite seal, constructed using bentonite pellets, will be placed on top of the filter pack. The remaining annular space will be filled with a cement grout containing 5 percent powdered bentonite or a Volclay slurry. A tremie pipe will be used to place the filter pack or grout where formation materials of cave or slough. The sparge well will be completed with a traffic-rated, flush mount road box.

Flush-mounted boxes will be anchored in aggregate concrete and will extend approximately 1 inch above the ground surface. The concrete will slope away from the top surface of the box lid. Grout will be added inside the box to ensure that the well annular space is sealed from surface contamination, leaving a minimum of 6 inches of riser exposed above the top of the grout. Construction details for each well will be documented on a monitoring well installation form (see Figure 4-2 of the FSP).

Three sets of monitoring points will be installed in the test area, MP-01, MP-02, and MP-03. Each monitoring point will consist of three separate monitoring screen intervals identified as "S" for shallow, "M" for medium, and "D" for deep. Shallow and medium-depth monitoring points will be used for collecting soil gas samples and monitoring vacuum levels during testing. Medium and deep-depth monitoring points will be used for monitoring depth to water and product during all testing, and for monitoring pressure during the air sparging tests. The medium and deep monitoring points will be constructed using flush thread Schedule 40 PVC 2-inch diameter well screen (4 feet long, 0.02 inch slot) and riser. The shallow monitoring points will be constructed using flush thread Schedule 40 PVC ½-inch diameter well screen (1-foot interval, 0.02 inch slot) and riser. The monitor points will be installed as follows:

- The well screen for the deep monitoring points will be set at the same depth as the sparge well. The filter pack will extend 1 foot above the top of the well screen for the deep monitoring point. Bentonite pellets will be installed above the filter pack to 2.5 feet below the water table. Approximately 6 inches of sand will be set on top of the deep bentonite seal.

- The screen interval for the medium monitoring point will be set at a depth of approximately 2.5 feet below the water table. The filter pack will be extended from the bottom of the medium screen interval to 2.5 feet above the water table. Bentonite pellets will be installed from the top of the filter pack to 6 inches below the set point of the shallow monitoring point screen interval (see next bullet). Six inches of filter pack sand will be set on top of the bentonite seal.

- The screen interval for the shallow monitoring point will be set at a depth of approximately 9.5 feet bgs. The actual set point will depend on soil lithology observed during drilling. Filter pack will be added from the base of the screen interval to approximately 6 inches above the top of the screen interval. A 1.5- to 2-foot bentonite seal will be installed and hydrated on top of the filter pack. The remaining annular space will be filled with cement grout, as described for the sparge well installation.

- All monitoring points will be completed in a flush-mount road box, as described above for the sparge well installation. The monitoring points will be sealed at the top of the casing with compression plugs (for the 2-inch diameter points) or PVC slip caps (for the ½-inch points).

## 3.2 SVE TESTING

Data collected during SVE testing will be used, in conjunction with data obtained during the previous testing, to develop a design ZOI and operating vacuum (or pressure) requirement for SVE wells at Site 3. Total TPH and individual soil gas concentrations of volatile organic compounds will be used to evaluate air emission control technologies and permitting requirements for a potential full-scale remediation system.

Brief SVE tests will be conducted at well MW11-54. Data collected during each test will include:

- Test well air flow rate and vacuum

- Monitoring point vacuum (if applicable)

- Soil gas TPH and VOC concentrations in soil vapor samples collected from the vacuum pump discharge

- Total hydrocarbon concentrations in soil vapor samples collected from monitoring points

- Oxygen and carbon dioxide concentrations in soil vapor samples collected from vacuum pump discharge and monitoring points

A summary of the monitoring and sampling parameters and associated frequencies is presented in Table C-2. Soil vapor samples will be analyzed in the field using a handheld FID. Soil vapor samples will be collected for laboratory analysis during each SVE test. Samples will be analyzed in the laboratory using modified National Institute of Occupational Safety and Health (NIOSH) Method 1550 for TPH concentrations and U.S. Environmental Protection Agency (EPA) Method TO-17 for BTEX and VOCs. A description of soil gas sampling and analysis procedures is presented in the FSP (Appendix A of the field work plan). Laboratory QA/QC considerations are presented in the QAPP (Appendix B of the field work plan).

## 3.3 AIR SPARGING TESTS

Air sparging is being evaluated as a potential remedial alternative for the diesel-contaminated areas at Site 3. Specifically, air sparging may be applicable for addressing elevated levels of VOCs in groundwater, and also for achieving action levels for TPH in saturated soils and groundwater, primarily by biosparging. Testing results for air sparging may be applied to potential designs for full-scale air sparging or biosparging systems. Data from the air sparge testing will be used to estimate an effective ZOI for the test well and to develop a basis for estimating costs associated with a design of a full-scale air sparge system.

Air sparge testing protocol will include injecting air at three different flow rates, as summarized in Table C-1. During each test, the following data will be collected at selected monitoring points:

- Air flow and pressure at air sparge wellheads
- Total hydrocarbon concentrations in soil vapor at vadose-zone monitoring points and SVE discharge (if applicable)
- Oxygen and carbon dioxide concentrations in soil vapor
- Dissolved oxygen (DO) concentrations in groundwater at monitoring wells in test area
- Pressure and depth to groundwater in test area monitoring wells
- Post-test subsurface air pressure bleed from the test air sparge well to monitor for trapped air volume

Monitoring parameters and frequencies are summarized in Table C-2. Air sparge testing is expected to last between 1 and 3 hours per flow rate (that is, 3 to 9 hours total).

## 3.4 AIR SPARGING HELIUM TRACER TESTS

Helium tracer tests are conducted to supplement standard air sparge test results. Helium tracer tests provide definitive data with respect to the effective ZOI observed during testing. The detection of helium in vadose zone monitoring points provides positive indication that air injected at the sparge well is being transported vertically to the vadose zone soils.

Helium tracer tests will be conducted at the end of each air sparge test to provide additional data with respect to the distribution of air flow while sparging. Tracer tests will consist of injecting a known concentration of helium into the test well (5 to 10 percent by volume) for approximately 5 minutes. Actual concentration and duration of helium injections will depend on the ongoing test results. Vadose zone monitoring points and shallow monitoring wells will be used to monitor for helium that makes its way from the air sparge test well up to the vadose zone.

Tracer tests are expected to last between 1 to 3 hours per flow rate tested (2 to 6 hours total). Data from the tests will be used to evaluate whether air sparging will be feasible at the site, estimate an effective ZOI for each well, and develop a basis for estimating full-scale air sparging (or biosparging) implementation costs.

## 3.5 MULTIPHASE EXTRACTION TESTS

Data collected during MPE testing will be used to evaluate the effectiveness of MPE for product recovery. The data will also be used to develop a design ZOI and operating vacuum (or pressure) requirement for MPE wells at Site 3. Total TPH and BTEX concentrations in soil gas will be used to evaluate air emission control technologies and permitting requirements for a potential full-scale MPE system.

Brief MPE tests will be conducted at monitoring well MW11-54. Data collected during each test will include:

- Product extraction and recovery rate
- Product thickness at test well before and after testing
- Air flow rate and vacuum in test wells

- Monitoring point vacuum (if applicable)
- Concentrations of TPH and BTEX in soil vapor samples collected from vacuum pump discharge
- Total hydrocarbon concentrations in soil vapor samples collected from monitoring points
- Groundwater extraction rate

A summary of the monitoring and sampling parameters and associated frequencies is presented in Table C-2. Soil vapor samples will be analyzed in the field using a handheld FID. Soil vapor samples will be collected for laboratory analysis during each MPE test. Samples will be analyzed in the laboratory using modified NIOSH Method 1550 for TPH concentrations and EPA Method TO-2 for BTEX. Soil gas sampling and analysis procedures are described in the FSP (Appendix A of the field work plan). Laboratory QA/QC considerations are presented in the QAPP (Appendix B of the field work plan).

## 4.0 SCHEDULE

The anticipated schedule for field pilot testing is summarized in Figure 12-1 of the work plan. It is anticipated that the air sparging, SVE, and MPE testing will require approximately 6 to 8 days to complete. The schedule may be modified, as required, based on actual test results.

# FIGURES

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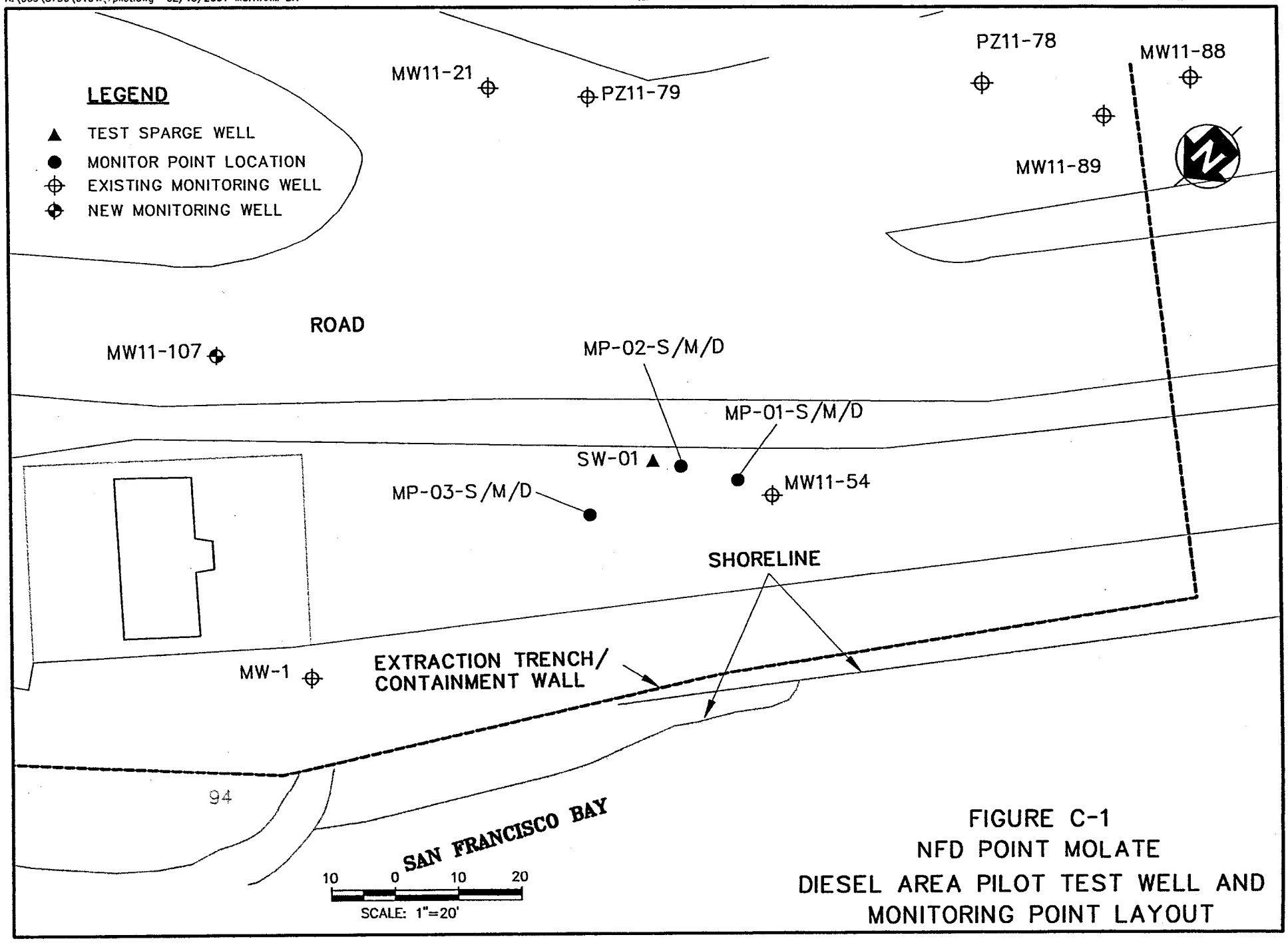


FIGURE C-1
NFD POINT MOLATE
DIESEL AREA PILOT TEST WELL AND
MONITORING POINT LAYOUT

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# TABLES

## TABLE C-1

## NFD POINT MOLATE - RICHMOND, CALIFORNIA
## SITE 3 SAMPLING AND FIELD PILOT TEST TESTING CHRONOLOGY*

| Test/Activity | Description [1,2] | Test Well | Well Screen Interval (feet bgs) | Estimated Duration (hours) |
|---|---|---|---|---|
| **SVE TESTING** | | | | |
| Baseline Monitoring | Field analyses only - groundwater, soil gas | --- | --- | 3 |
| SVE - low flow | Approximately 15 scfm | MW11-54 | 8.6 - 13.6[3] | 2 |
| SVE - high flow | Approximately 25 scfm | MW11-54 | 8.6 - 13.6[3] | 2 |
| **AIR SPARGE TESTING** | | | | |
| Baseline Monitoring | Field analyses only - groundwater, soil gas | --- | --- | 3 |
| Air Sparge - low flow | 1 to 2 scfm, plus Helium tracer test | SW-01 | 21 - 23 | 4 |
| Air Sparge - medium flow | 4 to 6 scfm, plus Helium tracer test | SW-01 | 21 - 23 | 4 |
| Air Sparge - high flow | 8 to 10 scfm, plus Helium tracer test | SW-01 | 21 - 23 | 4 |
| Post-test Monitoring | Vented air from sparge well or monitoring points | As Needed | --- | As Needed |
| **MPE TESTING** | | | | |
| Baseline Monitoring | Field analyses only - groundwater, soil gas | --- | --- | 3 |
| MPE - low flow | Approximately 15 scfm | MW11-54 | 8.6 - 13.6[3] | 2 |
| MPE - high flow | Approximately 25 scfm | MW11-54 | 8.6 - 13.6[3] | 2 |

Notes:

* Estimated schedule

[1] All proposed flow rates are approximate.

[2] Analytical parameters are summarized in Table D-2.

[3] Well screen interval includes only unsaturated portion for well MW11-54, which will be used for MPE testing. Actual screen interval extends to 23 feet bgs.

bgs Below ground surface

MPE Multiphase extraction

scfm Standard cubic feet per minute

SVE Soil vapor extraction

TABLE C-2

NFD POINT MOLATE - RICHMOND, CALIFORNIA
SITE 3 FIELD WORK PLAN
SITE 3 DIESEL AREA FIELD PILOT TESTING MONITORING PARAMETERS

| Description | Monitoring Point | Parameters | Instrument | Laboratory Analysis | Approximate Frequency (min) |
|---|---|---|---|---|---|
| Baseline Monitoring - SVE | Test area soil vapor MPs | Total TPH | FID | - | once |
| | | $O_2/CO_2$ Concentration | Multigas Meter | - | once |
| | Test area groundwater MPs | Water/Product Level[1] | Interface meter | - | once |
| SVE Testing | SVE Discharge | Total TPH | FID | - | 5,10,20,30,45,60,... |
| | | Total TPH | - | NIOSH 1550 | 1 per test |
| | | BTEX | - | EPA Method TO-17 | 1 per test |
| | | $O_2/CO_2$ Concentration | Multigas Meter | - | 5,10,20,30,45,60,... |
| | SVE Wellhead and MPs | Vacuum | Magnehelic Gauge | - | 5,10,20,30,45,60,... |
| | SVE Wellhead | Flow Rate | Anemometer | - | 5,10,20,30,45,60,... |
| | | Inlet Temperature | Temperature Gauge | - | 5,10,20,30,45,60,... |
| Baseline Monitoring - AS | MPs and Test Well | Dissolved $O_2$ | DO Meter | - | once |
| | | Water/Product Level[1] | Interface Meter | - | once |
| | Vadose Zone MPs | $O_2/CO_2$ Concentration | Multigas Meter | - | once |
| | | Helium Concentration | Helium Detector | - | once |
| AS Testing | AS Wellhead | Pressure | Pressure Gauge | - | 5,10,20,30,45,60,... |
| | | Flow Rate | Rotometer | - | 5,10,20,30,45,60,... |
| | | Temperature | Gauge | - | 5,10,20,30,45,60,... |
| | | Post-Test Vent | Rotometer | - | Post-Test |
| | Groundwater MPs | Pressure | Magnehelic Gauge | - | 2, 5,10,20,30,45,60,... |
| | | Water/Product Level[1] | Interface Meter | - | 2, 10, 30, 60,... |
| | | Dissolved $O_2$ | DO Meter | - | Pre/Post Test |
| | Vadose Zone MPs | $O_2/CO_2$ Concentration | Multigas Meter | - | 10,30,60,90,... |
| | | Total TPH | FID | - | 10,30,60,90,... |
| | SVE Discharge | Total TPH | - | NIOSH 1550 | 1 after final AS test |
| | | BTEX | - | EPA Method TO-17 | 1 after final AS test |
| Helium Tracer Testing | Helium Injection Port | Flow Rate | Rotometer | - | 5,10,20,30,45,60,... |
| | | Helium Concentration | Helium Detector | - | 1,5,10,15,20,... |
| | AS Wellhead | Pressure | Gauge | - | 5,10,20,30,45,60,... |
| | | Flow Rate | Rotometer | - | 5,10,20,30,45,60,... |
| | | Vented Flow | Rotometer | - | Post Test |
| | MPs | Helium Concentration | Helium Detector | - | 1,5,10,20,30,45,60,... |
| MPE Testing | MPE Discharge | Total TPH | FID | - | 5,10,20,30,45,60,... |
| | | Total TPH | - | NIOSH 1550 | 1 per test |
| | | BTEX | - | EPA Method TO-17 | 1 per test |
| | MPE Inlet | Liquid/Product extraction rate | Volume Check[2] | | End of test (minimum) |
| | MPE Wellhead and MPs | Vacuum | Magnehelic Gauge | - | 5,10,20,30,45,60,... |
| | MPE Wellhead | Flow Rate[3] | Anemometer | - | 5,10,20,30,45,60,... |
| | | Inlet Temperature | Temperature Gauge | - | 5,10,20,30,45,60,... |
| | Test area groundwater MPs | Water/Product Level[1] | Interface meter | - | 15, 30, 60,... |

Notes:

[1] Water/Product Levels measured only at groundwater monitor wells, sparge well, and monitoring points screened across or below the water table

[2] Measure quantities accumulated periodically during testing by draining the contents of the liquid/vapor separator into a calibrated container.

[3] Vapor flow rate from the well will be monitored at the discharge from the liquid/vapor separator.

AS air sparging
$CO_2$ carbon dioxide
DO dissolved oxygen
FID flame ionization detector
MIN minutes
MP monitoring Point
MPE multiphase extraction
$O_2$ oxygen
scfm standard cubic feet per minute
SVE soil vapor extraction
WL water/product level

# PLATES

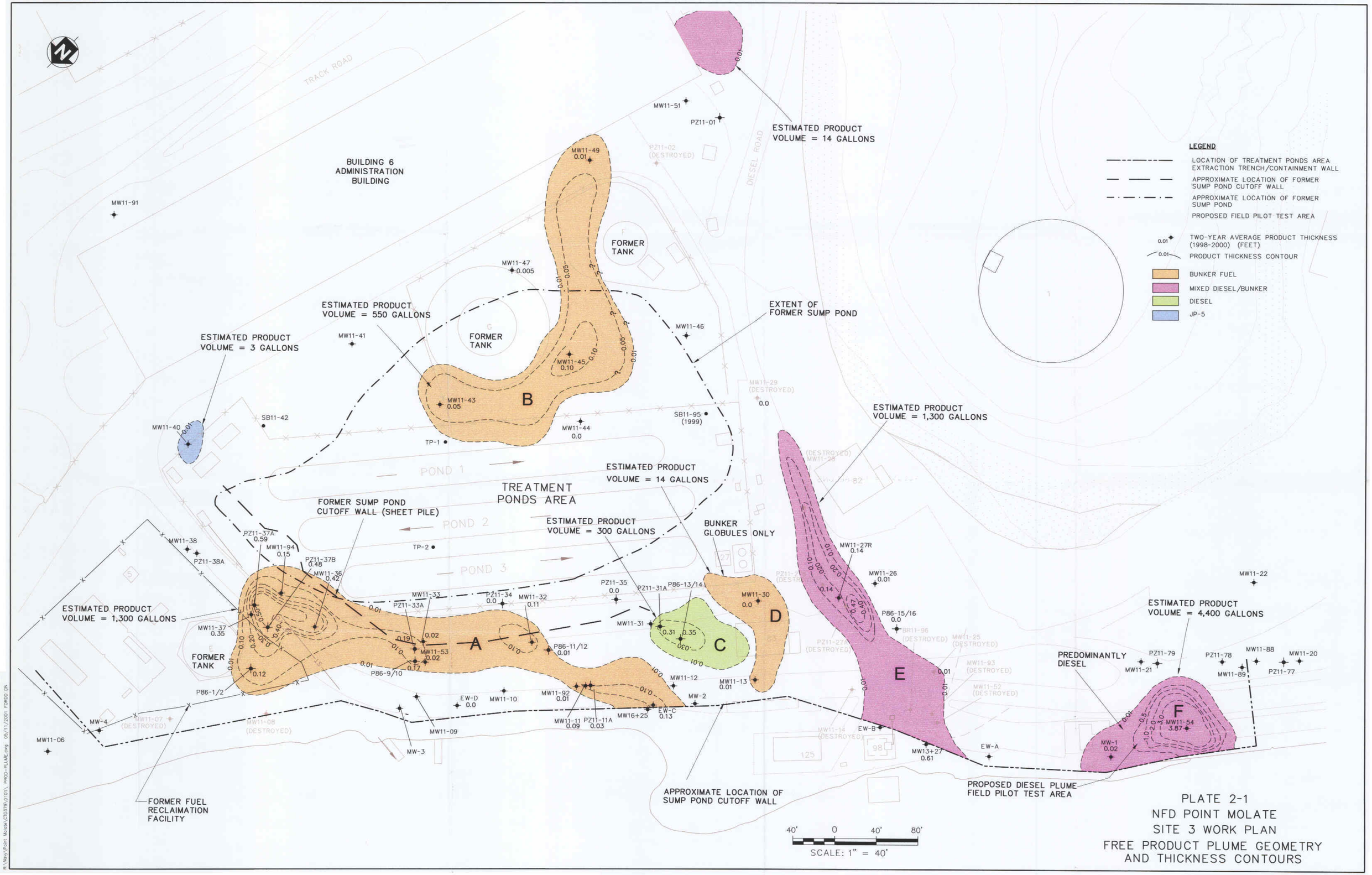



PLATE 2-1
NFD POINT MOLATE
SITE 3 WORK PLAN
FREE PRODUCT PLUME GEOMETRY
AND THICKNESS CONTOURS

DS.0379.15002

## LEGEND

| | |
|---|---|
| (dash-dot line) | LOCATION OF TREATMENT PONDS AREA EXTRACTION TRENCH/CONTAINMENT WALL |
| (dashed line) | APPROXIMATE LOCATION OF FORMER SUMP POND CUTOFF WALL |
| (brown dashed line) | APPROXIMATE LOCATION OF FORMER SUMP POND |
| (yellow area) | AREAS WHERE DISSOLVED COMPOUND CONCENTRATIONS ARE ANTICIPATED TO EXCEED ONE OR MORE GROUNDWATER ACTION LEVEL (BASED ON PRESIDIO FPALDR VALUES) |
| (blue line) | 150' FEET FROM SHORELINE |
| (symbol) | PROPOSED NEW MONITORING WELL LOCATIONS |
| (symbol) | EXISTING MONITORING WELL LOCATIONS |
| (symbol) | EXISTING MONITORING WELL TO BE SAMPLED |
| (blue dot) | GROUNDWATER SAMPLES PREVIOUSLY COLLECTED AND ANALYZED FOR VOAs AT THIS LOCATION |
| FPALDR | FUEL PRODUCT ACTION LEVEL DEVELOPMENT REPORT |
| T,B,V,N | ANALYSES TO BE CONDUCTED AT SAMPLE LOCATION |
| T | TOTAL PETROLEUM HYDROCARBONS (TPH) (GASOLINE, DIESEL, AND RESIDUAL) |
| B | BENZENE, TOLUENE, ETHYLBENZENE, AND XYLENES (BTEX) |
| P | POLYNUCLEAR AROMATIC HYDROCARBONS (PAH) |
| V | VOLATILE ORGANIC COMPOUNDS (VOC) |
| N | NATURAL ATTENUATION PARAMETERS (HETEROTROPHIC PLATE COUNTS, TOTAL KJELDAHL NITROGEN, FERROUS IRON AND ANIONS (NITRATE, ORTHOPHOSPHATE, AND SULFATE)). |
| M | CLP METALS |
| VOA | VOLATILE ORGANIC ANALYSIS |

QUALIFIERS:

| | |
|---|---|
| B | COMPOUND WAS FOUND IN THE BLANK AND THE SAMPLE |
| D | SURROGATE OR MATRIX SPIKE RECOVERIES WERE NOT OBTAINED BECAUSE THE EXTRACT WAS DILUTED FOR ANALYSIS; ALSO COMPOUNDS ANALYZED AT A DILUTION WILL BE FLAGGED WITH A D |
| E | CONCENTRATION EXCEEDS THE INSTRUMENT CALIBRATION RANGE AND WAS SUBSEQUENTLY DILUTED |
| J | ESTIMATED DETECTED RESULT |
| a | LABORATORY METHOD BLANK AND COMMON BLANK CONTAMINATION |
| c | CALIBRATION EXCEEDED |
| d | DUPLICATE PRECISION EXCEEDED |
| g | QUANTIFICATION BELOW REPORTING LIMIT |
| h | HOLDING TIME EXCEEDED |

| MW11-49 | |
|---|---|
| SAMPLE DATE | 6/3/92 |
| VOA (ug/L) | |
| Chloroform | 19BJ |

| PZ11-01 | |
|---|---|
| SAMPLE DATE | 6/4/92 |
| VOA (ug/L) | |
| 1,2-Dichloroethene | 5 |
| Benzene | 0.4J |
| Chloroform | 3 |
| Toluene | 0.6J |
| Trichloroethene | 5 |

| MW11-40 | | | | | |
|---|---|---|---|---|---|
| SAMPLE DATE | 6/2/92 | 3/31/94 | 6/22/94 | 9/28/94 | 12/9/94 |
| VOA (ug/L) | | | | | |
| 1,2-Dichloroethene | 1J | ND | ND | ND | ND |
| 2-Hexanone | ND | ND | ND | 29Jc | ND |
| 4-Methyl-2-Pentanone | ND | ND | ND | 19Jc | ND |
| Acetone | ND | ND | ND | 12Jc | ND |
| Benzene | ND | 0.1J | ND | ND | ND |
| Bromodichloromethane | ND | ND | ND | ND | 2J |
| Chloroform | 4 | 6 | 2 | 1J | 13 |
| Xylene | 7 | ND | ND | 0.8J | ND |

| MW11-41 | |
|---|---|
| SAMPLE DATE | 6/2/92 |
| VOA (ug/L) | ND |

| MW11-45 | |
|---|---|
| SAMPLE DATE | 6/3/92 |
| VOA (ug/L) | |
| 1,2-Dichloroethene | 2 |
| Benzene | 1J |
| Chloroform | 1J |
| Toluene | 0.7J |
| Xylene | 1J |

| MW11-44 | |
|---|---|
| SAMPLE DATE | 6/2/92 |
| VOA (ug/L) | |
| 1,1-Dichloroethene | 1J |
| 1,2-Dichloroethene | 710D |
| Benzene | 1J |
| Chlorobenzene | 1J |
| Toluene | 0.5J |
| Tetrachloroethene | 13 |
| Trichloroethene | 520 |
| Vinyl Chloride | 260D |

| MW11-46 | |
|---|---|
| SAMPLE DATE | 6/3/92 |
| VOA (ug/L) | |
| 1,2-Dichloroethene | 2 |
| Chloroform | 3 |

| SB11-95 | |
|---|---|
| SAMPLE DATE | 2/7/99 |
| VOA (ug/L) | ND |

| MW11-38 | |
|---|---|
| SAMPLE DATE | 6/2/92 |
| VOA (ug/L) | ND |

| MW11-37 | |
|---|---|
| SAMPLE DATE | 6/1/92 |
| VOA (ug/L) | |
| Carbon Disulfide | 0.6J |

| MW11-94 | |
|---|---|
| SAMPLE DATE | 2/19/99 |
| VOA (ug/L) | ND |

| MW11-32 | |
|---|---|
| SAMPLE DATE | 5/30/92 |
| VOA (ug/L) | ND |

| MW11-27 | |
|---|---|
| SAMPLE DATE | 6/1/92 |
| VOA (ug/L) | |
| Benzene | 1J |
| Chloroform | 2 |
| Toluene | 1J |
| Xylene | 4 |

| BR11-96 | |
|---|---|
| SAMPLE DATE | 2/25/99 |
| VOA (ug/L) | |
| Acetone | 5 |
| 2-Butanone | 5 |
| Chloroform | 0.6J |
| Vinyl Chloride | 3 |
| Xylene | 1J |

| MW11-21 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SAMPLE DATE | 5/29/92 | 3/29/94 | 6/23/94 | 9/22/94 | 12/16/94 | 10/3/96 | 11/8/97 | 4/7/98 | 1/21/99 |
| VOA (ug/L) | | | | | | | | | |
| 1,2-Dichloroethane | ND | ND | ND | ND | ND | ND | ND | 0.4Jg | ND |
| Acetone | ND | 4 | 14Jc | ND | ND | 5.3J | ND | ND | ND |
| 2-Butanone | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Benzene | 7 | 2J | 4Ja | 10 | 9 | 1.5 | 2 | 5 | 3Jag |
| Chlorobenzene | 2 | ND | ND | ND | ND | ND | ND | ND | ND |
| Chloroform | 1J | ND | ND | ND | ND | ND | ND | ND | ND |
| Chloromethane | ND | ND | ND | ND | ND | ND | ND | 3 | ND |
| Ethylbenzene | 6 | 2J | 0.8 | 2J | 29 | ND | 1J | 21 | 1Jag |
| Toluene | 13 | 6 | 11Ja | 20 | 28 | 2 | 4 | 17 | 7Jag |
| Xylene | 35 | 22B | 36Ja | 64 | 83BE | 3.6 | 11 | 47 | 21Ja |

| PZ11-78 | | | |
|---|---|---|---|
| SAMPLE DATE | 11/8/97 | 4/7/98 | 1/23/99 |
| VOA (ug/L) | | | |
| Benzene | 12 | 0.7 | ND |
| Ethylbenzene | 2 | 1Jg | ND |
| Toluene | 2 | 0.5Jg | ND |
| Trichloroethene | 0.4J | 1Jg | 1Jg |
| Xylene | 5 | 2Jg | ND |

| MW11-88 | |
|---|---|
| SAMPLE DATE | 2/25/99 |
| VOA (ug/L) | |
| Chloromethane | 4Jg |
| Ethylbenzene | 56 |
| Toluene | 4Jg |
| Xylene | 73 |

| MW11-22 | |
|---|---|
| SAMPLE DATE | 5/29/92 |
| VOA (ug/L) | ND |

| MW11-25 | |
|---|---|
| SAMPLE DATE | 5/30/92 |
| VOA (ug/L) | |
| Benzene | 0.8J |
| Toluene | 0.6J |
| Xylene | 4 |

| MW11-52 | |
|---|---|
| SAMPLE DATE | 5/28/92 |
| VOA (ug/L) | |
| 2-Butanone | 27 |
| Benzene | 2J |
| Chlorobenzene | 7J |
| Chloroform | 3J |
| Xylene | 3J |

| MW11-07 | |
|---|---|
| SAMPLE DATE | 5/26/92 |
| VOA (ug/L) | ND |

| MW11-53 | |
|---|---|
| SAMPLE DATE | 6/1/92 |
| VOA (ug/L) | |
| Xylene | 1J |

| MW11-11 | |
|---|---|
| SAMPLE DATE | 5/27/92 |
| VOA (ug/L) | ND |

| MW11-09 | |
|---|---|
| SAMPLE DATE | 5/27/92 |
| VOA (ug/L) | ND |

| MW11-31 | |
|---|---|
| SAMPLE DATE | 6/1/92 |
| VOA (ug/L) | |
| Benzene | 0.8J |
| Chlorobenzene | 2 |
| Ethylbenzene | 1J |
| Toluene | 2 |
| Xylene | 10 |

| MW11-14 | |
|---|---|
| SAMPLE DATE | 5/28/92 |
| VOA (ug/L) | |
| Chlorobenzene | 5J |

| MW11-16 | |
|---|---|
| SAMPLE DATE | 5/28/92 |
| VOA (ug/L) | |
| Chlorobenzene | 5J |
| Xylene | 3J |

| MW11-89 | |
|---|---|
| SAMPLE DATE | 2/25/99 |
| VOA (ug/L) | |
| 2-Hexanone | 3 |
| Trichloroethene | 0.5Jg |

| MW11-92 | | | | |
|---|---|---|---|---|
| SAMPLE DATE | 3/29/94 | 6/22/94 | 9/21/94 | 12/9/94 |
| VOA (ug/L) | | | | |
| 2-Butanone | 3 | ND | ND | ND |
| Benzene | 0.09J | ND | ND | ND |
| Toluene | ND | ND | ND | 0.1J |
| Xylene | ND | 0.4J | ND | ND |

| MW11-08 | | | | | |
|---|---|---|---|---|---|
| SAMPLE DATE | 5/27/92 | 3/22/94 | 6/22/94 | 9/20/94 | 12/9/94 |
| VOA (ug/L) | | | | | |
| Chloroform | 0.2J | ND | ND | ND | 0.2J |
| Trichloroethene | 1J | ND | ND | ND | 1J |

| MW11-13 | | | | | | | |
|---|---|---|---|---|---|---|---|
| SAMPLE DATE | 5/27/92 | 3/25/94 | 6/24/94 | 9/29/94 | 12/12/94 | 11/3/97 | 4/1/98 |
| VOA (ug/L) | | | | | | | |
| 2-Butanone | ND | ND | ND | 41Jcdh | 2 | ND | 23 |
| Benzene | 2J | 2J | 2J | 1 | 0.6J | ND | ND |
| Chlorobenzene | 180 | 93 | 130 | 110Jdh | 27 | 7 | 5 |
| Toluene | ND | ND | ND | ND | 0.2J | ND | ND |
| Xylene | ND | ND | 0.9J | 1 | ND | ND | ND |

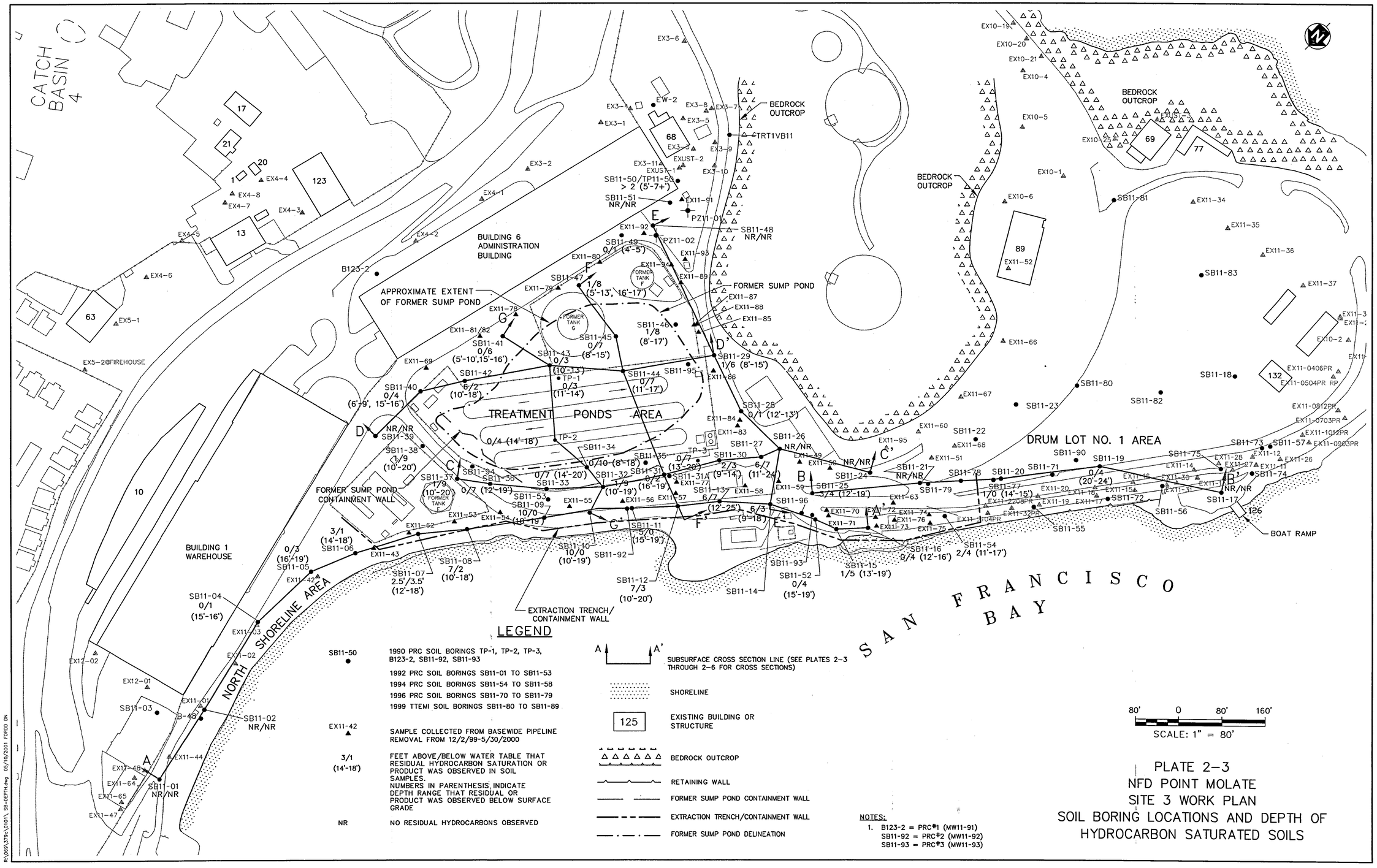
| MW11-93 | | | | | | | |
|---|---|---|---|---|---|---|---|
| SAMPLE DATE | 5/30/92 | 3/30/94 | 6/23/94 | 9/30/94 | 12/18/94 | 11/6/97 | 4/1/98 |
| VOA (ug/L) | | | | | | | |
| Acetone | ND | ND | 18Jc | ND | ND | ND | ND |
| 2-Butanone | ND | 23 | ND | ND | ND | ND | ND |
| Benzene | 2J | 2J | 1J | 1 | 1J | ND | ND |
| Carbon Disulfide | 0.5J | ND | ND | ND | ND | ND | ND |
| Chlorobenzene | ND | ND | ND | 51 | ND | ND | ND |
| Ethylbenzene | ND | 0.6J | 0.7J | ND | 0.4J | ND | ND |
| Toluene | 2 | 1J | 1J | ND | 1J | ND | 2Jg |
| Xylene | 10 | 9 | 10 | 1 | 4 | 5J | 7Jg |

| MW11-54 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SAMPLE DATE | 3/29/94 | 6/24/94 | 9/29/94 | 12/16/94 | 10/3/96 | 11/6/97 | 4/1/98 | 1/19/99 |
| VOA (ug/L) | | | | | | | | |
| 2-Butanone | 26 | 4Jc | ND | 3 | ND | ND | ND | ND |
| Acetone | 32Jc | 22Jc | ND | ND | ND | ND | ND | ND |
| Benzene | 4 | 5Ja | 6 | 28J | ND | ND | ND | 4Jag |
| Ethylbenzene | 2J | 1J | 0.9 | 88 | ND | ND | ND | 1Jag |
| Toluene | 8 | 8Ja | 7 | 6 | ND | ND | 2Jg | 8Jag |
| Xylene | 34B | 27Ja | 22 | 39B | ND | ND | 6Jg | 23 |

| MW11-20 | | | | | | |
|---|---|---|---|---|---|---|
| SAMPLE DATE | 9/22/94 | 12/16/94 | 10/3/96 | 11/7/97 | 4/3/98 | 1/22/99 |
| VOA (ug/L) | | | | | | |
| 1,2-Dichloroethene | 0.3J | ND | ND | 0.4J | ND | ND |
| 4-Methyl-2-Pentanone | ND | ND | ND | ND | 1Jg | ND |
| Benzene | ND | ND | ND | ND | 0.6 | ND |
| Chloromethane | ND | ND | ND | ND | 0.6Jg | ND |
| Ethylbenzene | ND | ND | ND | ND | 2Jg | ND |
| Toluene | ND | 0.2J | ND | ND | 2 | ND |
| Trichloroethene | ND | 6B | ND | ND | 2Jg | ND |
| Xylene | ND | ND | ND | ND | 3 | ND |

# PLATE 2-2
## NFD POINT MOLATE
## SITE 3 WORK PLAN
## HISTORICAL GROUNDWATER DATA AND PROPOSED LOCATIONS FOR NEW MONITORING WELLS AND GROUNDWATER SAMPLING

R:\Navy\Point Molate\CTO379\0101\ mw-voa.dwg 05/11/2001 FORDD DN




## LEGEND

| | |
|---|---|
| SB11-50 ● | 1990 PRC SOIL BORINGS TP-1, TP-2, TP-3, B123-2, SB11-92, SB11-93 |
| | 1992 PRC SOIL BORINGS SB11-01 TO SB11-53 |
| | 1994 PRC SOIL BORINGS SB11-54 TO SB11-58 |
| | 1996 PRC SOIL BORINGS SB11-70 TO SB11-79 |
| | 1999 TTEMI SOIL BORINGS SB11-80 TO SB11-89 |
| EX11-42 ▲ | SAMPLE COLLECTED FROM BASEWIDE PIPELINE REMOVAL FROM 12/2/99-5/30/2000 |
| 3/1 (14'-18') | FEET ABOVE/BELOW WATER TABLE THAT RESIDUAL HYDROCARBON SATURATION OR PRODUCT WAS OBSERVED IN SOIL SAMPLES. NUMBERS IN PARENTHESIS INDICATE DEPTH RANGE THAT RESIDUAL OR PRODUCT WAS OBSERVED BELOW SURFACE GRADE |
| NR | NO RESIDUAL HYDROCARBONS OBSERVED |
| A A' | SUBSURFACE CROSS SECTION LINE (SEE PLATES 2-3 THROUGH 2-6 FOR CROSS SECTIONS) |
| | SHORELINE |
| 125 | EXISTING BUILDING OR STRUCTURE |
| | BEDROCK OUTCROP |
| | RETAINING WALL |
| | FORMER SUMP POND CONTAINMENT WALL |
| | EXTRACTION TRENCH/CONTAINMENT WALL |
| | FORMER SUMP POND DELINEATION |

NOTES:

1. B123-2 = PRC#1 (MW11-91)
   SB11-92 = PRC#2 (MW11-92)
   SB11-93 = PRC#3 (MW11-93)

PLATE 2-3
NFD POINT MOLATE
SITE 3 WORK PLAN
SOIL BORING LOCATIONS AND DEPTH OF HYDROCARBON SATURATED SOILS

R:\069\379s\0101\ SB-DEPTH.dwg 05/10/2001 FORSD DN

DS.0379.15002

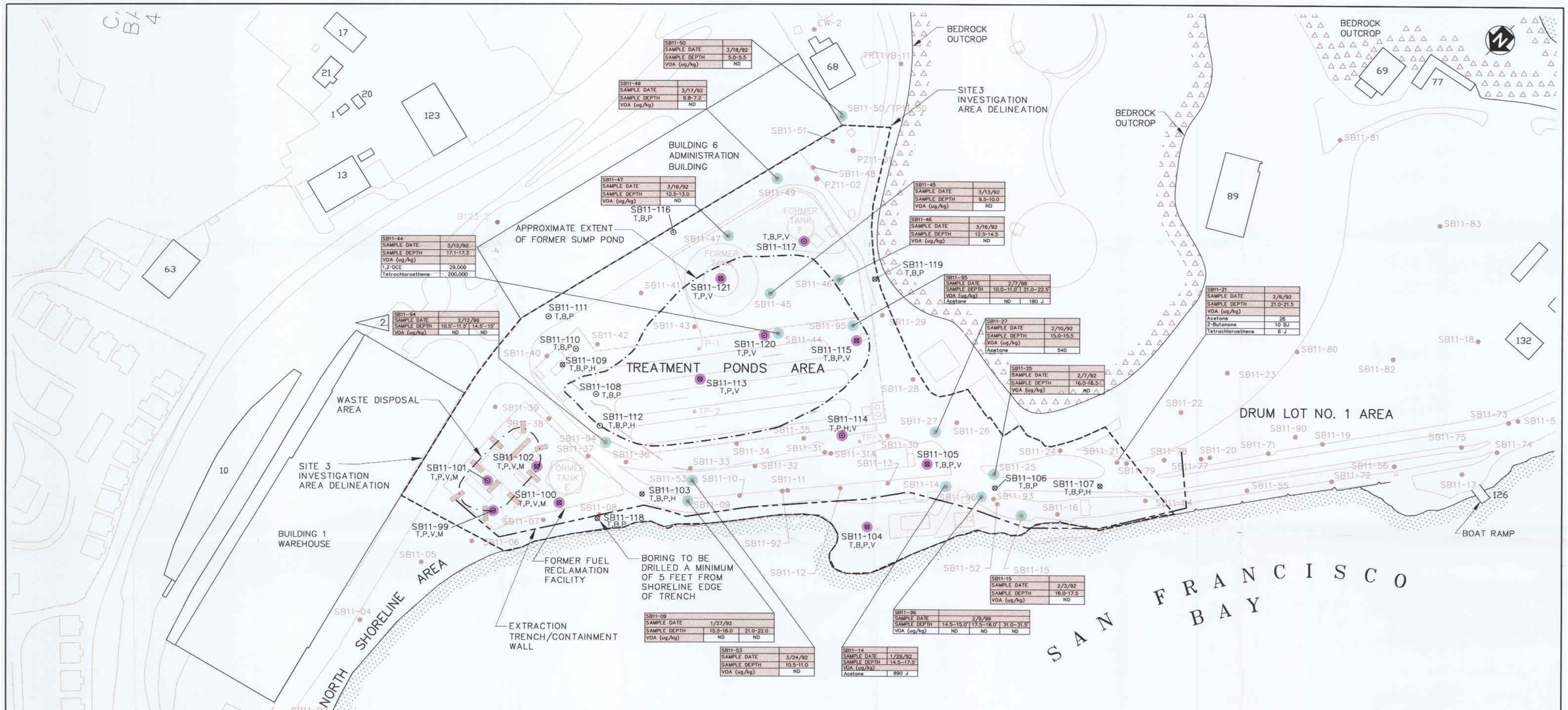
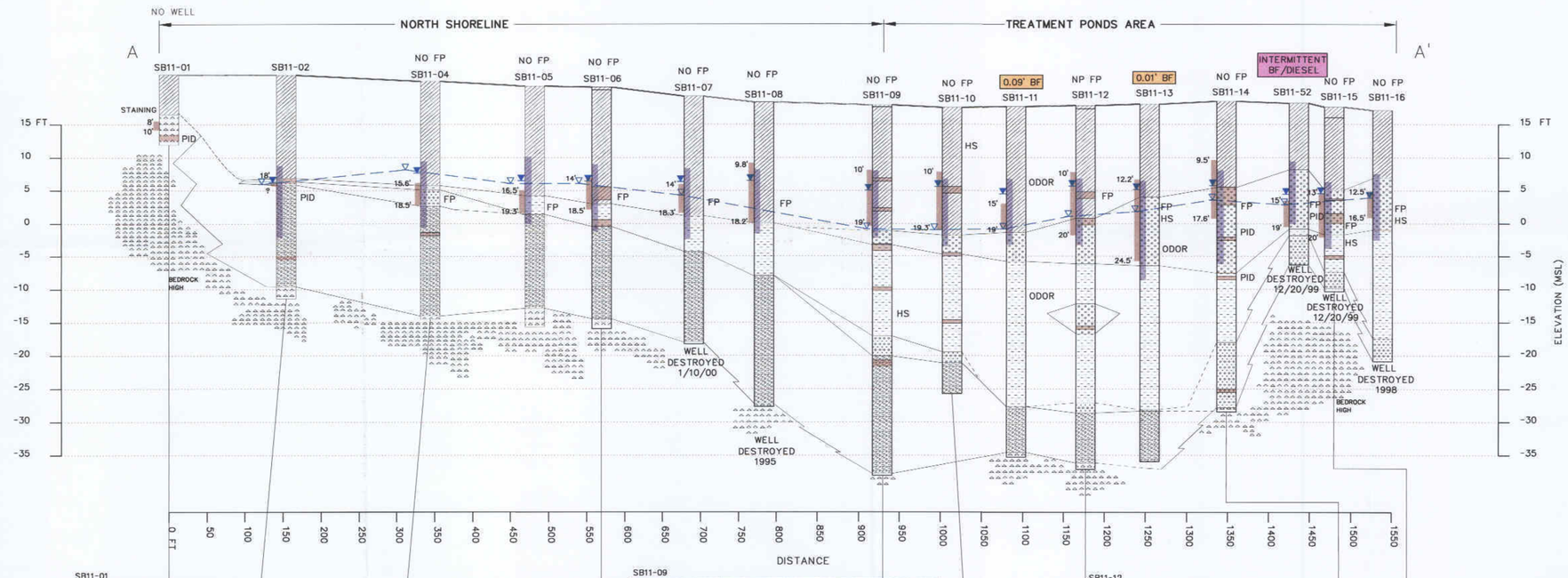



PLATE 2-4
NFD POINT MOLATE
SITE 3 WORK PLAN
HISTORICAL SOIL VOC DATA
AND PROPOSED LOCATIONS
FOR NEW SOIL BORINGS

R:\Navy\Point Molate\CTO379\010\ SOIL-VOC.DWG 05/11/2001 FORD DN

DS.0379.15002




## LEGEND

| | |
|---|---|
| 0.05 BF | BUNKER FUEL FREE PRODUCT |
| 0.2 MIXED | MIXED BUNKER FUEL AND DIESEL FREE PRODUCT |
| <0.05 JP5 | JET FUEL FREE PRODUCT |
| | SAMPLE INTERVAL |
| | FILL |
| | FILL-SILTY; ORGANIC-RICH |
| | ALLUVIUM |
| | PEAT |
| | BAY MUD |
| | REWORKED INTERTIDAL SEDIMENTS |
| | COLLUVIUM |
| | BEDROCK |
| ▼ | WATER LEVEL MEASURED JUNE 17, 1993 |
| ▽ | WATER LEVEL MEASURED APRIL, 1999 |
| | SCREEN INTERVAL OF MONITORING WELL |
| HS | HEADSPACE READING |
| FP | FREE PRODUCT OBSERVED IN SOIL CORE |
| BF | BUNKER FUEL |
| mg/kg | MILLIGRAMS PER KILOGRAM |
| µg/kg | MICROGRAM PER KILOGRAM |
| MSL | MEAN SEA LEVEL |
| PID | PHOTOIONIZATION DETECTOR |
| — ▽ — | APPROXIMATE DEPTH TO WATER TABLE BASED ON ACTIVE GROUNDWATER PUMPING FROM EXTRACTION TRENCH |
| 10' 20' | BORING LOGS INDICATE SOILS ARE RESIDUALLY SATURATED WITH HYDROCARBONS AT INDICATED DEPTH RANGE BELOW SURFACE GRADE |
| - - - - | INFERRED LITHOLOGIC CONTACT |

**SB11-01**

| SAMPLE DATE | 1/21/92 |
|---|---|
| DEPTH | 9.0-10.0 |
| TPH (mg/kg) | |
| Gasoline | 1.1 U |
| Benzene | 0.006 U |
| Toluene | 0.006 U |
| Ethylbenzene | 1.1 U |
| Xylene | 0.006 U |
| Other (Purgeable) | 25 X |
| JP-5 | 2.2 U |
| Diesel | 2.2 U |
| Bunker | 22 U |
| Other (Extractable) | 2.2 U |

**SB11-02**

| SAMPLE DATE | 1/21/92 | 1/22/92 |
|---|---|---|
| DEPTH | 16.0-16.5 | 28.5 |
| TPH (mg/kg) | | |
| Gasoline | 2.4 U | 1.2 U |
| Benzene | 0.012 U | 0.006 U |
| Toluene | 0.012 U | 0.006 U |
| Ethylbenzene | 0.012 U | 0.006 U |
| Xylene | 0.012 U | 0.006 U |
| Other (Purgeable) | 0.012 U | 0.006 U |
| JP-5 | 1.2 U | 60 U |
| Diesel | 1.2 U | 60 U |
| Bunker | 180 | 6400 |
| Other (Extractable) | 47 | 2100 X |

**SB11-04**

| SAMPLE DATE | 1/22/92 |
|---|---|
| DEPTH | 23.5 |
| TPH (mg/kg) | |
| Gasoline | 1.2 U |
| Benzene | 0.006 U |
| Toluene | 0.006 U |
| Ethylbenzene | 0.006 U |
| Xylene | 0.006 U |
| Other (Purgeable) | 72 |
| JP-5 | 12 U |
| Diesel | 12 U |
| Bunker | 2300 X |
| Other (Extractable) | 480 |

**SB11-06**

| SAMPLE DATE | 1/23/92 | |
|---|---|---|
| DEPTH | 15.0-17.0 | 20.0-21.0 |
| TPH (mg/kg) | | |
| Gasoline | ND | ND |
| Benzene | ND | ND |
| Toluene | ND | ND |
| Ethylbenzene | ND | ND |
| Xylene | ND | ND |
| Other (Purgeable) | 92 | 23 |
| JP-5 | ND | ND |
| Diesel | ND | ND |
| Bunker | 5,600 | 690 |
| Motor Oil | ND | NA |
| Other (Extractable) | 1,300 | 170 |
| VOCs (ug/kg) | | |
| All Compounds | NA | NA |
| SVOCs (ug/kg) | | |
| All Compounds | NA | NA |
| Total Metals (mg/kg) | | |
| All Elements | NA | NA |

**SB11-09**

| SAMPLE DATE | 1/23/92 | | | | |
|---|---|---|---|---|---|
| DEPTH | 11.0-11.5 | 15.5-16.0 | 21.0-22.0 | 27.5-28.0 | 37.0-38.0 |
| TPH (mg/kg) | | | | | |
| Gasoline | ND | ND | ND | ND | ND |
| Benzene | ND | ND | ND | ND | ND |
| Toluene | ND | ND | ND | ND | ND |
| Ethylbenzene | ND | 0.019 | ND | ND | ND |
| Xylene | ND | 0.21 | 0.065 | ND | ND |
| Other (Purgeable) | ND | 110 | 48 | ND | ND |
| JP-5 | ND | ND | ND | ND | ND |
| Diesel | ND | ND | ND | ND | ND |
| Bunker | 170 | 5,400 | 2,400 | ND | ND |
| Motor Oil | ND | NA | NA | NA | NA |
| Other (Extractable) | 120 | 1,000 | 470 | 130 | 35 |
| VOCs (ug/kg) | | | | | |
| All Compounds | NA | ND | ND | NA | NA |
| SVOCs (ug/kg) | | | | | |
| Acenaphthene | NA | 290J | ND | NA | NA |
| Pyrene | NA | 650J | 320J | NA | NA |
| Chrysene | NA | ND | 990J | NA | NA |
| Total Metals (mg/kg) | | | | | |
| Aluminum | 14,800 | NA | NA | NA | NA |
| Antimony | ND | NA | NA | NA | NA |
| Arsenic | 1.9 | NA | NA | NA | NA |
| Barium | 87.5 | NA | NA | NA | NA |
| Beryllium | 0.98* | NA | NA | NA | NA |
| Cadmium | ND | NA | NA | NA | NA |
| Chromium | 13 | NA | NA | NA | NA |
| Cobalt | 8.8 | NA | NA | NA | NA |
| Copper | 15.2 | NA | NA | NA | NA |
| Iron | 15,000 | NA | NA | NA | NA |
| Lead | 10.9* | NA | NA | NA | NA |
| Magnesium | 4,000 | NA | NA | NA | NA |
| Manganese | 351N | NA | NA | NA | NA |
| Mercury | NA | NA | NA | NA | NA |
| Nickel | 17.2 | NA | NA | NA | NA |
| Potassium | 3180J | NA | NA | NA | NA |
| Selenium | ND | NA | NA | NA | NA |
| Silver | ND | NA | NA | NA | NA |
| Sodium | ND | NA | NA | NA | NA |
| Thallium | ND | NA | NA | NA | NA |
| Vanadium | 28.1 | NA | NA | NA | NA |
| Zinc | 39.7 | NA | NA | NA | NA |

**SB11-10**

| SAMPLE DATE | 1/27/92 | | |
|---|---|---|---|
| DEPTH | 12.0-13.0 | 22.5-22.5 | 33.5-34.0 |
| TPH (mg/kg) | | | |
| Gasoline | ND | ND | ND |
| Benzene | ND | ND | ND |
| Toluene | ND | ND | ND |
| Ethylbenzene | 0.008 | ND | ND |
| Xylene | ND | ND | ND |
| Other (Purgeable) | 68 | ND | ND |
| JP-5 | ND | ND | ND |
| Diesel | ND | ND | ND |
| Bunker | 9200 X | ND | ND |
| Motor Oil | NA | NA | NA |
| Other (Extractable) | 1700 | 170 | 53 |
| VOCs (ug/kg) | | | |
| All compounds | NA | NA | NA |
| SVOCs (ug/kg) | | | |
| All compounds | NA | NA | NA |
| Total Metals (mg/kg) | | | |
| All elements | NA | NA | NA |

**SB11-12**

| SAMPLE DATE | 1/28/92 | | |
|---|---|---|---|
| DEPTH | 13.0-14.0 | 17.0-18.0 | 33.5-34.0 |
| TPH (mg/kg) | | | |
| Gasoline | ND | ND | ND |
| Benzene | ND | ND | ND |
| Toluene | ND | ND | ND |
| Ethylbenzene | ND | ND | ND |
| Xylene | 0.72 | 0.35 | ND |
| Other (Purgeable) | 140 | 180 | 530 |
| JP-5 | ND | ND | ND |
| Diesel | 2,700 | 12,000 | 740 |
| Bunker | ND | ND | ND |
| Motor Oil | NA | NA | NA |
| Other (Extractable) | 1,300 | 4,500 | 370 |
| VOCs (ug/kg) | | | |
| All Compounds | NA | NA | NA |
| SVOCs (ug/kg) | | | |
| All Compounds | NA | NA | NA |
| Total Metals (mg/kg) | | | |
| All Elements | NA | NA | NA |

**SB11-15**

| SAMPLE DATE | | 2/3/92 | |
|---|---|---|---|
| DEPTH | 13 | 16.0-17.5 | 22.5-23.0 |
| TPH (mg/kg) | | | |
| Gasoline | ND | ND | ND |
| Benzene | ND | ND | ND |
| Toluene | ND | ND | ND |
| Ethylbenzene | ND | ND | ND |
| Xylene | ND | 4.6 | ND |
| Other (Purgeable) | 430J | 880 | ND |
| JP-5 | 1,200 | 1,500 | ND |
| Diesel | 8,800 | 6,400 | ND |
| Bunker | ND | ND | ND |
| Motor Oil | NA | NA | NA |
| Other (Extractable) | 5,100 | 2,400 | 96 |
| VOCs (ug/kg) | | | |
| All Compounds | NA | ND | NA |
| SVOCs (ug/kg) | | | |
| 2-Methylnapthalene | ND | 45,000 | ND |
| Fluorene | ND | 4,500J | ND |
| Phenanthrene | ND | 8,200J | ND |
| Fluoranthene | ND | ND | ND |
| Benzo(a)anthracene | ND | ND | ND |
| Total Metals (mg/kg) | | | |
| All Elements | NA | NA | NA |

**SB11-14**

| SAMPLE DATE | 1/29/92 | | | |
|---|---|---|---|---|
| DEPTH | 14.5-17.5 | 20.5-21.0 | 26.5-27.0 | 43.5-44.0 |
| TPH (mg/kg) | | | | |
| Gasoline | 430 | 37 | ND | ND |
| Benzene | ND | ND | ND | ND |
| Toluene | ND | ND | ND | ND |
| Ethylbenzene | ND | ND | ND | ND |
| Xylene | 0.3 | 0.025 | ND | ND |
| Other (Purgeable) | ND | ND | ND | 15 |
| JP-5 | ND | ND | ND | ND |
| Diesel | 9,200 | 590 | 7.6 | 40 |
| Bunker | ND | ND | ND | ND |
| Motor Oil | NA | NA | NA | NA |
| Other (Extractable) | 1,900 | 200 | 76 | 29 |
| VOCs (ug/kg) | | | | |
| All Compounds | ND | NA | NA | NA |
| SVOCs (ug/kg) | | | | |
| 2-Methylnapthalene | 12,000J | NA | NA | NA |
| Fluorene | 4,300J | NA | NA | NA |
| Phenanthrene | 6,400J | NA | NA | NA |
| Fluoranthene | ND | NA | NA | ND |
| Benzo(a)anthracene | ND | NA | NA | NA |
| Total Metals (mg/kg) | | | | |
| All Elements | NA | NA | NA | NA |

## NOTES

1. CROSS SECTION LOCATIONS ARE PRESENTED ON PLATE 2-3.
2. FREE PRODUCT THICKNESS REPRESENTS APPROXIMATE AVERAGE OVER THE PAST 2 YEARS OF MONITORING.
3. SVOC PHTHALATES, SUCH AS DIETHYLPHTHALATE, DI-N-BUTYLPHTHALATE, AND BUTYLBENZYLPHTHALATE ARE NOT REPORTED AS SVOC DETECTIONS.
4. DATA QUALIFIERS
   NA NOT ANALYZED
   ND NOT DETECTED

   ORGANIC DATA QUALIFIERS

   J VALUE WAS QUANTITATIVELY IDENTIFIED BUT REPORTED AS AN ESTIMATED QUANTITY

   INORGANIC DATA QUALIFIERS

   J VALUE WAS QUANTITATIVELY IDENTIFIED BUT REPORTED AS AN ESTIMATED QUANTITY

   N SPIKED SAMPLE RECOVERY WAS NOT WITHIN CONTROL LIMITS

   U THE ANALYTE WAS ANALYZED FOR, BUT NOT DETECTED

   X THE CHROMATOGRAPHIC RESPONSE DID NOT RESEMBLE A TYPICAL FUEL PATTERN

   * DUPLICATE SAMPLE ANALYSIS NOT WITHIN CONTROL LIMITS
5. VERTICAL TO HORIZONTAL SCALE IS APPROXIMATELY 10:1

# PLATE 2-5
# NFD POINT MOLATE
# SITE 3 WORK PLAN
# CROSS SECTION A-A'

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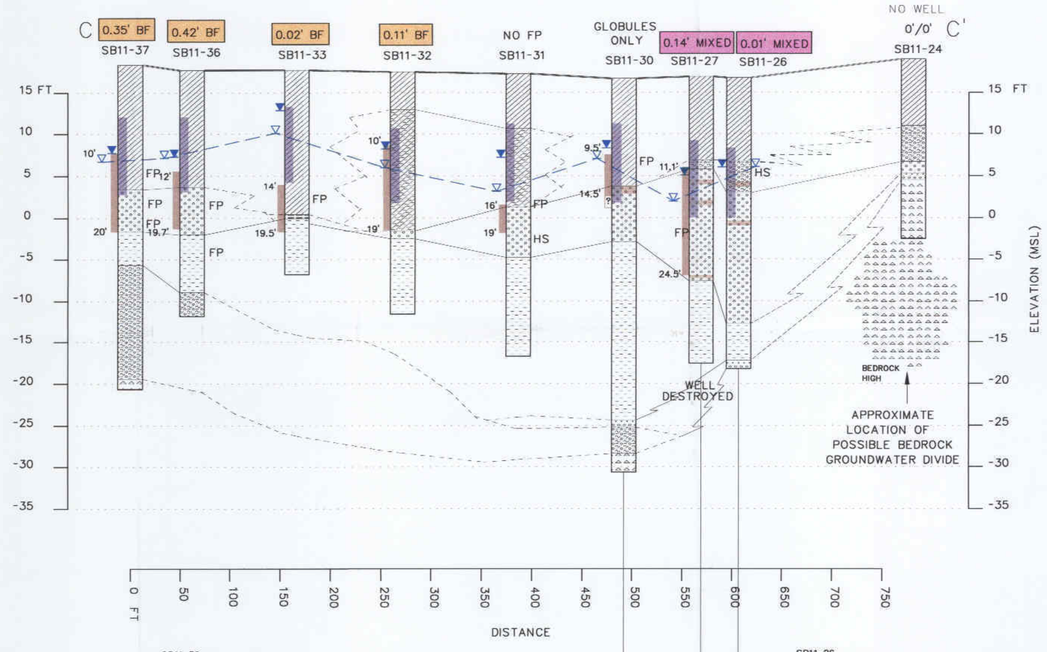
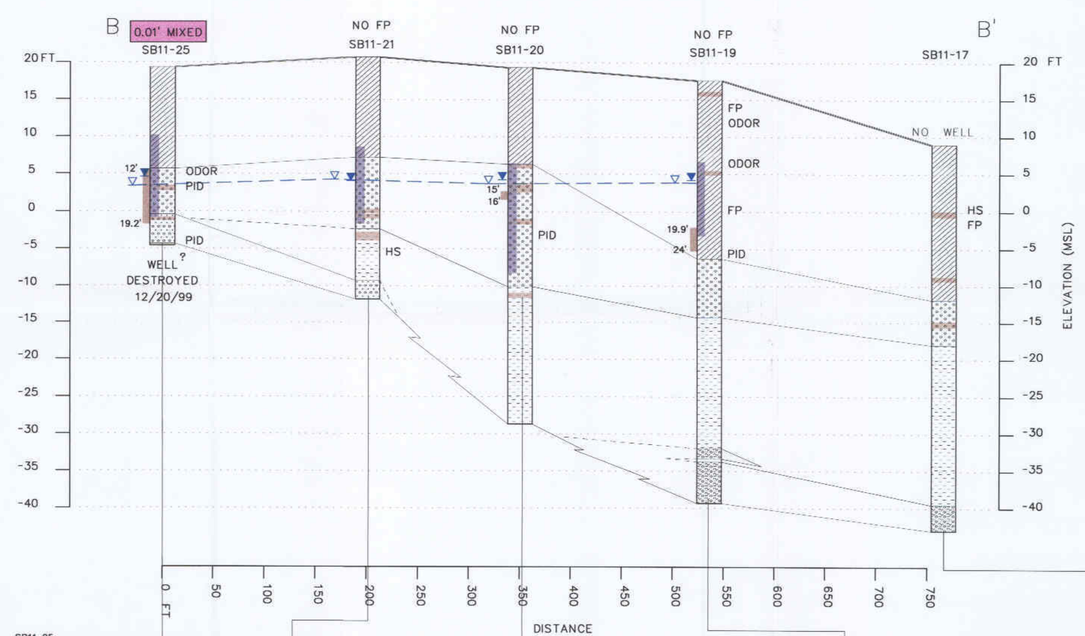
## GEOLOGIC CROSS-SECTION C-C'
## NORTHEAST-SOUTHWEST ALONG POND ROAD




## GEOLOGIC CROSS-SECTION B-B'
## NORTHEAST-SOUTHWEST ALONG SHORELINE NEAR DRUMLOT NO. 1




**SB11-30**

| SAMPLE DATE | 2/12/92 |
|---|---|
| DEPTH | 13.0-13.5' |
| TPH (mg/kg) | |
| Gasoline | 240 |
| Benzene | ND |
| Toluene | 3.2 |
| Ethylbenzene | 1.5 |
| Xylene | 2.5 |
| Other (Purgeable) | ND |
| JP-5 | ND |
| Diesel | 140 |
| Bunker | ND |
| Motor Oil | NA |
| Other (Extractable) | 32 |
| VOCs (ug/kg) | |
| All Compounds | NA |
| SVOCs (ug/kg) | |
| All Compounds | NA |
| Total Metals (mg/kg) | |
| All Elements | NA |

**SB11-27**

| SAMPLE DATE | 2/10/92 | | |
|---|---|---|---|
| DEPTH | 12.5-13.0 | 15.0-15.5 | 25.0-25.2 |
| TPH (mg/kg) | | | |
| Gasoline | ND | ND | ND |
| Benzene | ND | ND | ND |
| Toluene | 0.46 | 0.7 | ND |
| Ethylbenzene | ND | ND | ND |
| Xylene | 5.5 | 4.1 | ND |
| Other (Purgeable) | 1,700 | 1,000 | ND |
| JP-5 | ND | ND | 100 |
| Diesel | 22,000 | 18,000 | ND |
| Bunker | ND | ND | ND |
| Motor Oil | NA | NA | NA |
| Other (Extractable) | 3,500 | ND | 100 |
| VOCs (ug/kg) | | | |
| Acetone | NA | 540 | NA |
| Xylenes (total) | NA | 70 | NA |
| SVOCs (ug/kg) | | | |
| All Compounds | NA | NA | NA |
| Total Metals (mg/kg) | | | |
| Aluminum | NA | 9,820 | NA |
| Antimony | NA | ND | NA |
| Arsenic | NA | 1.9B | NA |
| Barium | NA | 69.4J | NA |
| Beryllium | NA | ND | NA |
| Cadmium | NA | ND | NA |
| Chromium | NA | 15.1 | NA |
| Cobalt | NA | 4.8 | NA |
| Copper | NA | ND | NA |
| Iron | NA | 15,500 | NA |
| Lead | NA | 6.4J-NW | NA |
| Magnesium | NA | 3,720 | NA |
| Manganese | NA | 236 | NA |
| Mercury | NA | NA | NA |
| Nickel | NA | 19.5 | NA |
| Potassium | NA | 2850J | NA |
| Selenium | NA | ND | NA |
| Silver | NA | ND | NA |
| Sodium | NA | ND | NA |
| Thallium | NA | ND | NA |
| Vanadium | NA | 21.9 | NA |
| Zinc | NA | 106E | NA |

**SB11-26**

| SAMPLE DATE | 2/10/92 | |
|---|---|---|
| DEPTH | 13.0-13.5 | 18.0-18.5 |
| TPH (mg/kg) | | |
| Gasoline | ND | ND |
| Benzene | ND | ND |
| Toluene | 0.24 | ND |
| Ethylbenzene | ND | ND |
| Xylene | 0.72 | 0.17 |
| Other (Purgeable) | 410 | 68 |
| JP-5 | ND | ND |
| Diesel | 3,700 | 370 |
| Bunker | ND | ND |
| Motor Oil | NA | NA |
| Other (Extractable) | ND | ND |
| VOCs (ug/kg) | | |
| All Compounds | NA | NA |
| SVOCs (ug/kg) | | |
| All Compounds | NA | NA |
| Total Metals (mg/kg) | | |
| All Elements | NA | NA |

**SB11-25**

| SAMPLE DATE | 2/7/92 | |
|---|---|---|
| DEPTH | 16.0-16.5 | 18.8-19.2 |
| TPH (mg/kg) | | |
| Gasoline | ND | ND |
| Benzene | ND | ND |
| Toluene | ND | ND |
| Ethylbenzene | ND | ND |
| Xylene | 29 | 5.8 |
| Other (Purgeable) | 3,300 | 1,700 |
| JP-5 | ND | ND |
| Diesel | 7,700 | 7,600 |
| Bunker | ND | ND |
| Motor Oil | NA | NA |
| Other (Extractable) | ND | ND |
| VOCs (ug/kg) | | |
| All Compounds | ND | NA |
| SVOCs (ug/kg) | | |
| 2-Methylnaphthalene | 52000J | NA |
| Fluorene | 6800J | NA |
| Phenanthrene | 11000J | NA |
| Total Metals (mg/kg) | | |
| Aluminum | 14,100 | NA |
| Antimony | ND | NA |
| Arsenic | 0.76 | NA |
| Barium | 73.1J | NA |
| Beryllium | ND | NA |
| Cadmium | 0.76 | NA |
| Chromium | 18.1 | NA |
| Cobalt | 9.6 | NA |
| Copper | 28.1 | NA |
| Iron | 20,600 | NA |
| Lead | 11.8J-NW | NA |
| Magnesium | 4,520 | NA |
| Manganese | 272 | NA |
| Mercury | NA | NA |
| Nickel | 28.2 | NA |
| Potassium | 3440J | NA |
| Selenium | 0.47J-BN | NA |
| Silver | ND | NA |
| Sodium | ND | NA |
| Thallium | ND | NA |
| Vanadium | 27.6 | NA |
| Zinc | 62.1E | NA |

**SB11-21**

| SAMPLE DATE | 2/6/92 | | |
|---|---|---|---|
| DEPTH | 20.5-21.0 | 21.0-21.5 | 23.5-24.5 |
| TPH (mg/kg) | | | |
| Gasoline | ND | ND | ND |
| Benzene | ND | ND | ND |
| Toluene | ND | 10 | 10 |
| Ethylbenzene | ND | ND | ND |
| Xylene | 9.8 | 0.051 | 10 |
| Other (Purgeable) | 450 | ND | ND |
| JP-5 | 37 | ND | ND |
| Diesel | 230 | ND | ND |
| Bunker | 310 | 10J | 23 |
| Motor Oil | NA | NA | NA |
| Other (Extractable) | ND | ND | ND |
| VOCs (ug/kg) | | | |
| Tetrachloroethene | NA | 6J | NA |
| Toluene | NA | 2J | NA |
| Ethylbenzene | NA | 3J | NA |
| Xylenes (total) | NA | 7J | NA |
| SVOCs (ug/kg) | | | |
| All Compounds | NA | NA | NA |
| Total Metals (mg/kg) | | | |
| All Elements | NA | NA | NA |

**SB11-20**

| SAMPLE DATE | 2/5/92 | | | |
|---|---|---|---|---|
| DEPTH | 13.5 | 15.0-16.0 | 19.6-20.3 | 29.5-30.0 |
| TPH (mg/kg) | | | | |
| Gasoline | ND | ND | 11 | ND |
| Benzene | ND | ND | ND | ND |
| Toluene | 0.05 | ND | 0.037 | 0.12 |
| Ethylbenzene | ND | ND | ND | ND |
| Xylene | 0.69 | 15 | 110 | ND |
| Other (Purgeable) | 87 | 1,000 | ND | ND |
| JP-5 | ND | 30 | ND | ND |
| Diesel | ND | ND | ND | ND |
| Bunker | 45 | 2,700 | 17 | ND |
| Motor Oil | NA | NA | NA | NA |
| Other (Extractable) | ND | ND | ND | ND |
| VOCs (ug/kg) | | | | |
| All Compounds | NA | NA | NA | NA |
| SVOCs (ug/kg) | | | | |
| All Compounds | NA | NA | NA | NA |
| Total Metals (mg/kg) | | | | |
| Aluminum | NA | 11,800 | NA | NA |
| Antimony | NA | ND | NA | NA |
| Arsenic | NA | 1.4 | NA | NA |
| Barium | NA | 76.9J | NA | NA |
| Beryllium | NA | ND | NA | NA |
| Cadmium | NA | ND | NA | NA |
| Chromium | NA | 13.3 | NA | NA |
| Cobalt | NA | 9.6 | NA | NA |
| Copper | NA | ND | NA | NA |
| Iron | NA | 13,900 | NA | NA |
| Lead | NA | 12.7J-NW | NA | NA |
| Magnesium | NA | 3,190 | NA | NA |
| Manganese | NA | 236 | NA | NA |
| Mercury | NA | 0.15J | NA | NA |
| Nickel | NA | 20.1 | NA | NA |
| Potassium | NA | 3010J | NA | NA |
| Selenium | NA | 0.66J | NA | NA |
| Silver | NA | 0.71J | NA | NA |
| Sodium | NA | ND | NA | NA |
| Thallium | NA | ND | NA | NA |
| Vanadium | NA | 23.1 | NA | NA |
| Zinc | NA | 45.6J | NA | NA |

**SB11-19**

| SAMPLE DATE | 2/4/92 | 2/5/92 |
|---|---|---|
| DEPTH | 1.5-2.0 | 12.0-12.5 |
| TPH (mg/kg) | | |
| Gasoline | ND | ND |
| Benzene | ND | ND |
| Toluene | 0.013 | ND |
| Ethylbenzene | ND | ND |
| Xylene | 0.015 | 19 |
| Other (Purgeable) | ND | 2,300 |
| JP-5 | ND | 610 |
| Diesel | ND | 1,900 |
| Bunker | ND | ND |
| Motor Oil | NA | NA |
| Other (Extractable) | 340 | 760 |
| VOCs (ug/kg) | | |
| All Compounds | NA | NA |
| SVOCs (ug/kg) | | |
| All Compounds | NA | NA |
| Total Metals (mg/kg) | | |
| All Elements | NA | NA |

**SB11-17**

| SAMPLE DATE | 2/4/92 | | |
|---|---|---|---|
| DEPTH | 9.0-9.5 | 17.5 | 23.5-24.0 |
| TPH (mg/kg) | | | |
| Gasoline | ND | ND | ND |
| Benzene | ND | ND | ND |
| Toluene | ND | ND | ND |
| Ethylbenzene | ND | ND | ND |
| Xylene | ND | ND | ND |
| Other (Purgeable) | 410 | ND | ND |
| JP-5 | ND | ND | ND |
| Diesel | ND | ND | ND |
| Bunker | ND | ND | ND |
| Motor Oil | NA | NA | NA |
| Other (Extractable) | ND | ND | ND |
| VOCs (ug/kg) | | | |
| All Compounds | NA | NA | NA |
| SVOCs (ug/kg) | | | |
| All Compounds | NA | NA | NA |
| Total Metals (mg/kg) | | | |
| Aluminum | 13,700 | NA | NA |
| Antimony | 9.2N.J | NA | NA |
| Arsenic | 5.5 | NA | NA |
| Barium | 96.2 | NA | NA |
| Beryllium | 0.72+ | NA | NA |
| Cadmium | ND | NA | NA |
| Chromium | 21.4 | NA | NA |
| Cobalt | 8.5 | NA | NA |
| Copper | 34.9 | NA | NA |
| Iron | 27,600 | NA | NA |
| Lead | 58.7+* | NA | NA |
| Magnesium | 6,060 | NA | NA |
| Manganese | 303N | NA | NA |
| Mercury | NA | NA | NA |
| Nickel | 28.6 | NA | NA |
| Potassium | 3510J | NA | NA |
| Selenium | ND | NA | NA |
| Silver | ND | NA | NA |
| Sodium | 2520J | NA | NA |
| Thallium | ND | NA | NA |
| Vanadium | 31 | NA | NA |
| Zinc | 122 | NA | NA |

## LEGEND

- 0.05 BF — BUNKER FUEL FREE PRODUCT
- 0.2 MIXED — MIXED BUNKER FUEL AND DIESEL FREE PRODUCT
- <0.05 JP5 — JET FUEL FREE PRODUCT
- SAMPLE INTERVAL
- FILL
- FILL-SILTY; ORGANIC-RICH
- ALLUVIUM
- PEAT
- BAY MUD
- REWORKED INTERTIDAL SEDIMENTS
- COLLUVIUM
- BEDROCK
- HS — HEADSPACE READING
- FP — FREE PRODUCT OBSERVED IN SOIL CORE
- BF — BUNKER FUEL
- mg/kg — MILLIGRAMS PER KILOGRAM
- µg/kg — MICROGRAM PER KILOGRAM
- MSL — MEAN SEA LEVEL
- PID — PHOTOIONIZATION DETECTOR
- WATER LEVEL MEASURED JUNE 17, 1993
- WATER LEVEL MEASURED APRIL, 1999
- SCREEN INTERVAL OF MONITOR WELL
- INFERRED LITHOLOGIC CONTACT
- APPROXIMATE DEPTH TO WATER TABLE BASED ON ACTIVE GROUNDWATER PUMPING FROM EXTRACTION TRENCH /CONTAINMENT WALL
- 10' / 20' — BORING LOGS INDICATE SOILS ARE RESIDUALLY SATURATED WITH HYDROCARBONS AT INDICATED DEPTH RANGE BELOW SURFACE GRADE

## NOTES

1. CROSS SECTION LOCATIONS ARE PRESENTED ON PLATE 2-3.
2. FREE PRODUCT THICKNESS REPRESENTS APPROXIMATE AVERAGE OVER THE PAST 2 YEARS OF MONITORING.
3. SVOC PHTHALATES, SUCH AS DIETHYLPHTHALATE, DI-N-BUTYLPHTHALATE, AND BUTYLBENZYLPHTHALATE, ARE NOT REPORTED AS SVOC DETECTIONS.
4. DATA QUALIFIERS
   NA NOT ANALYZED
   ND NOT DETECTED

   ORGANIC DATA QUALIFIERS

   J VALUE WAS QUANTITATIVELY IDENTIFIED BUT REPORTED AS AN ESTIMATED QUANTITY

   INORGANIC DATA QUALIFIERS

   B VALUE WAS LESS THAN THE CONTRACT REQUIRED DETECTION LIMIT (CRDL) BUT GREATER THAN THE INSTRUMENT DETECTION LIMIT (IDL)

   E VALUE WAS ESTIMATED BECAUSE OF INTERFERENCE

   J VALUE WAS QUANTITATIVELY IDENTIFIED BUT REPORTED AS AN ESTIMATED QUANTITY

   J-B VALUE WAS ESTIMATED SINCE IT WAS LESS THAN THE CONTRACT REQUIRED DETECTION LIMIT (CRDL) BUT GREATER THAN THE INSTRUMENT DETECTION LIMIT (IDL)

   J-N VALUE WAS ESTIMATED BECAUSE MATRIX SPIKE RECOVERIES WERE OUT OF QC LIMITS
5. VERTICAL TO HORIZONTAL SCALE IS APPROXIMATELY 10:1

INORGANIC DATA QUALIFIERS (CONTINUED)

J-W VALUE WAS ESTIMATED BECAUSE GRAPHITE FURNACE ATOMIC ABSORPTION QC LIMITS WERE EXCEEDED

J-* VALUE WAS ESTIMATED BECAUSE PRECISION OF LABORATORY DUPLICATE SAMPLES WERE OUT OF QC LIMITS

N SPIKED SAMPLE RECOVERY WAS NOT WITHIN CONTROL LIMITS

* DUPLICATE SAMPLE ANALYSIS NOT WITHIN CONTROL LIMITS

+ CORRELATION COEFFICIENT FOR THE MATRIX SPIKE ANALYSIS WAS LESS THAN 0.995

PLATE 2-6
NFD POINT MOLATE
SITE 3 WORK PLAN
CROSS SECTIONS B-B' AND C-C'

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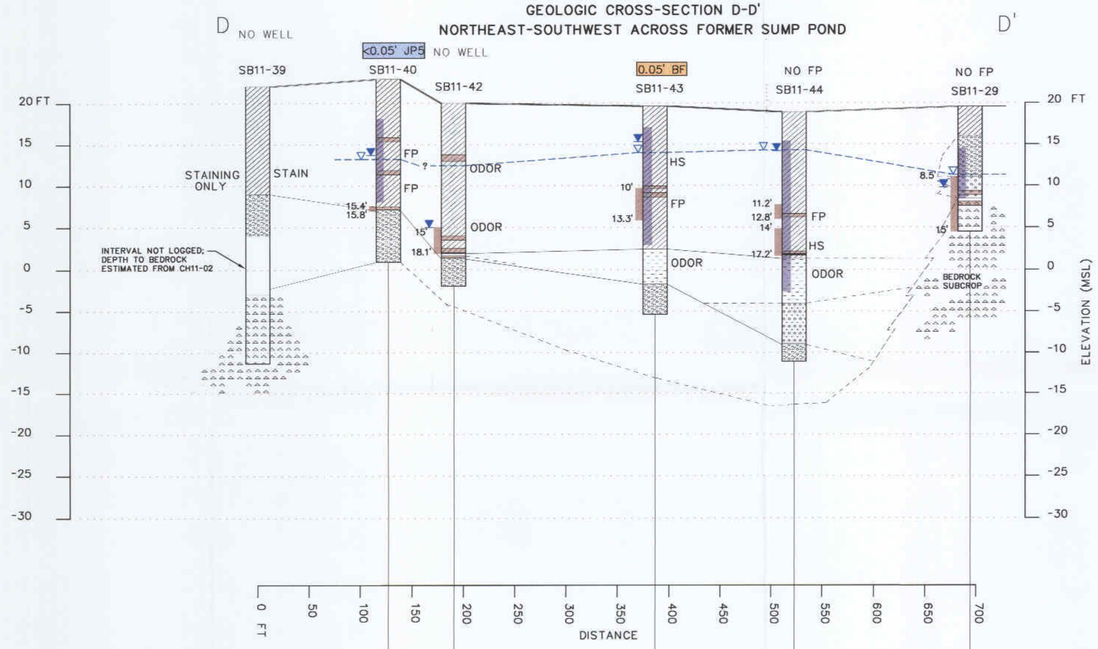
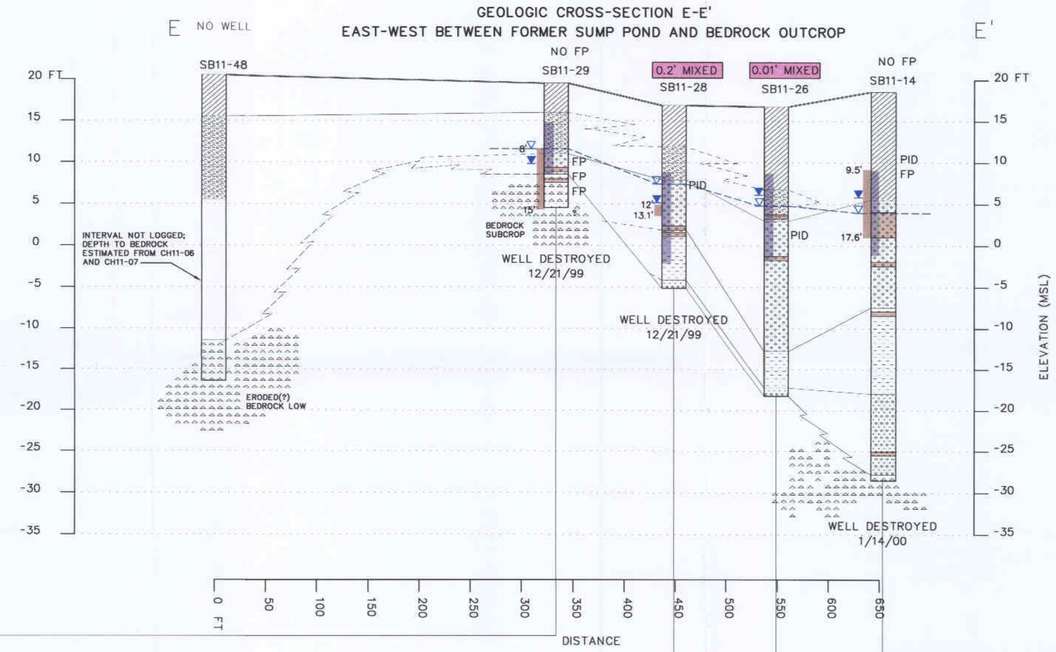
## GEOLOGIC CROSS-SECTION D-D'
## NORTHEAST-SOUTHWEST ACROSS FORMER SUMP POND




## GEOLOGIC CROSS-SECTION E-E'
## EAST-WEST BETWEEN FORMER SUMP POND AND BEDROCK OUTCROP




**SB11-40**

| SAMPLE DATE | 2/21/92 | | |
|---|---|---|---|
| DEPTH | 7.0-7.5 | 11.0-11.5 | 15.4-15.7 |
| TPH (mg/kg) | | | |
| Gasoline | ND | ND | ND |
| Benzene | ND | ND | ND |
| Toluene | ND | ND | ND |
| Ethylbenzene | ND | ND | ND |
| Xylene | ND | ND | ND |
| Other (Purgeable) | 300 | ND | 150 |
| JP-5 | ND | ND | ND |
| Diesel | ND | ND | ND |
| Bunker | 13,000 | 72 | 8,500 |
| Motor Oil | NA | NA | NA |
| Other (Extractable) | ND | ND | ND |
| VOCs (ug/kg) | | | |
| All Compounds | NA | NA | NA |
| SVOCs (ug/kg) | | | |
| All Compounds | NA | NA | NA |
| Total Metals (mg/kg) | | | |
| Aluminum | NA | NA | NA |
| Antimony | NA | NA | NA |
| Arsenic | NA | NA | NA |
| Barium | NA | NA | NA |
| Beryllium | NA | NA | NA |
| Cadmium | NA | NA | NA |
| Chromium | NA | NA | NA |
| Cobalt | NA | NA | NA |
| Copper | NA | NA | NA |
| Iron | NA | NA | NA |
| Lead | 11.8J* | NA | NA |
| Magnesium | NA | NA | NA |
| Manganese | NA | NA | NA |
| Mercury | NA | NA | NA |
| Molybdenum | NA | NA | NA |
| Nickel | NA | NA | NA |
| Potassium | NA | NA | NA |
| Selenium | NA | NA | NA |
| Silver | NA | NA | NA |
| Sodium | NA | NA | NA |
| Thallium | NA | NA | NA |
| Vanadium | NA | NA | NA |
| Zinc | NA | NA | NA |

**SB11-43**

| SAMPLE DATE | 3/11/92 | |
|---|---|---|
| DEPTH | 9.7-10.0 | 10.5-11.0 |
| TPH (mg/kg) | | |
| Gasoline | ND | ND |
| Benzene | ND | 0.180 |
| Toluene | 0.043 | 0.044 |
| Ethylbenzene | ND | 0.031 |
| Xylene | 0.098 | 0.13 |
| Other (Purgeable) | 60 | 50 |
| JP-5 | ND | ND |
| Diesel | ND | ND |
| Bunker | 9,500 | 15,000 |
| Motor Oil | 2,400 | 17,000 |
| Other (Extractable) | ND | ND |
| VOCs (ug/kg) | | |
| All Compounds | NA | NA |
| SVOCs (ug/kg) | | |
| All Compounds | NA | NA |
| Total Metals (mg/kg) | | |
| Aluminum | NA | 20,800 |
| Antimony | NA | ND |
| Arsenic | NA | 15.25 |
| Barium | NA | 70.9 |
| Beryllium | NA | 0.64* |
| Cadmium | NA | ND |
| Chromium | NA | 70.6 |
| Cobalt | NA | 17.2 |
| Copper | NA | 155 |
| Iron | NA | 31,000 |
| Lead | NA | 37.95* |
| Magnesium | NA | 10,700 |
| Manganese | NA | 510N |
| Mercury | NA | NA |
| Molybdenum | NA | NA |
| Nickel | NA | 81.3 |
| Potassium | NA | 2540J |
| Selenium | NA | ND |
| Silver | NA | ND |
| Sodium | NA | 2590J |
| Thallium | NA | ND |
| Vanadium | NA | 68.3 |
| Zinc | NA | 191 |

**SB11-29**

| SAMPLE DATE | 3/12/92 | |
|---|---|---|
| DEPTH | 10.2-10.7 | 11.5-12.0 |
| TPH (mg/kg) | | |
| Gasoline | ND | ND |
| Benzene | ND | ND |
| Toluene | ND | 0.023 |
| Ethylbenzene | ND | 0.250 |
| Xylene | 4.1 | 1.2 |
| Other (Purgeable) | 1,500 | 360 |
| JP-5 | 15,000 | 5,800 |
| Diesel | ND | ND |
| Bunker | ND | 16,000 |
| Motor Oil | NA | NA |
| Other (Extractable) | 25,000 | ND |
| VOCs (ug/kg) | | |
| All Compounds | NA | NA |
| SVOCs (ug/kg) | | |
| All Compounds | NA | NA |
| Total Metals (mg/kg) | | |
| All Elements | NA | NA |

**SB11-44**

| SAMPLE DATE | 3/12/92 | | |
|---|---|---|---|
| DEPTH | 12.3-12.7 | 16.8-17.2 | 17.1-17.3 |
| TPH (mg/kg) | | | |
| Gasoline | ND | ND | NA |
| Benzene | ND | ND | NA |
| Toluene | 0.22 | ND | NA |
| Ethylbenzene | 0.051 | 0.31 | NA |
| Xylene | 0.44 | 1.9 | NA |
| Other (Purgeable) | 170 | 380 | NA |
| JP-5 | ND | ND | NA |
| Diesel | ND | ND | NA |
| Bunker | 2,900 | 15,000 | NA |
| Motor Oil | 2,200 | 5,700 | NA |
| Other (Extractable) | ND | ND | NA |
| VOCs (ug/kg) | | | |
| 1,2-Dichloroethene (total) | NA | NA | 29,000 |
| Tetrachloroethene | NA | NA | 200,000 |
| SVOCs (ug/kg) | | | |
| 2-Methylnaphthalene | NA | NA | 5200J |
| Phenanthrene | NA | NA | 6900J |
| Pyrene | NA | NA | 1900J |
| Total Metals (mg/kg) | | | |
| Aluminum | NA | NA | 17,300 |
| Antimony | NA | NA | ND |
| Arsenic | NA | NA | 2.4 |
| Barium | NA | NA | 207J |
| Beryllium | NA | NA | ND |
| Cadmium | NA | NA | ND |
| Chromium | NA | NA | 76.8 |
| Cobalt | NA | NA | 7.7 |
| Copper | NA | NA | 26 |
| Iron | NA | NA | 22,700 |
| Lead | NA | NA | 19.8J-NW |
| Magnesium | NA | NA | 4,720 |
| Manganese | NA | NA | 256 |
| Mercury | NA | NA | 0.13J |
| Molybdenum | NA | NA | NA |
| Nickel | NA | NA | 25.8 |
| Potassium | NA | NA | 2560J |
| Selenium | NA | NA | ND |
| Silver | NA | NA | ND |
| Sodium | NA | NA | 1400J |
| Thallium | NA | NA | ND |
| Vanadium | NA | NA | 40.1 |
| Zinc | NA | NA | 60.7E |

**SB11-42**

| SAMPLE DATE | 3/11/92 | | | |
|---|---|---|---|---|
| DEPTH | 6.2-7.0 | 16.0-16.5 | 17.5-18.0 | 18.4-18.6 |
| TPH (mg/kg) | | | | |
| Gasoline | ND | ND | ND | ND |
| Benzene | 0.015 | ND | ND | ND |
| Toluene | ND | ND | ND | ND |
| Ethylbenzene | 0.18 | ND | ND | ND |
| Xylene | 0.22 | 0.047 | ND | ND |
| Other (Purgeable) | 160 | 93 | 14 | ND |
| JP-5 | ND | ND | ND | ND |
| Diesel | ND | ND | ND | ND |
| Bunker | 11,000 | 54,000 | 330 | 64 |
| Motor Oil | 2,900 | ND | 300 | ND |
| Other (Extractable) | ND | ND | ND | ND |
| VOCs (ug/kg) | | | | |
| All Compounds | NA | NA | NA | NA |
| SVOCs (ug/kg) | | | | |
| All Compounds | NA | NA | NA | NA |
| Total Metals (mg/kg) | | | | |
| All Elements | NA | NA | NA | NA |

**SB11-28**

| SAMPLE DATE | 2/11/92 | |
|---|---|---|
| DEPTH | 14.5-15.0 | 15.3-15.8 |
| TPH (mg/kg) | | |
| Gasoline | ND | ND |
| Benzene | ND | ND |
| Toluene | 0.049 | ND |
| Ethylbenzene | ND | ND |
| Xylene | 0.38 | ND |
| Other (Purgeable) | 160 | ND |
| JP-5 | ND | ND |
| Diesel | 5,400 | ND |
| Bunker | ND | ND |
| Motor Oil | ND | NA |
| Other (Extractable) | ND | 25 |
| VOCs (ug/kg) | | |
| All Compounds | NA | NA |
| SVOCs (ug/kg) | | |
| All Compounds | NA | NA |
| Total Metals (mg/kg) | | |
| All Elements | NA | NA |

**SB11-14**

| SAMPLE DATE | 1/29/92 | | | |
|---|---|---|---|---|
| DEPTH | 14.5-17.5 | 20.5-21.0 | 26.5-27.0 | 43.5-44.0 |
| TPH (mg/kg) | | | | |
| Gasoline | 430 | 37 | ND | ND |
| Benzene | ND | ND | ND | ND |
| Toluene | ND | ND | ND | ND |
| Ethylbenzene | ND | ND | ND | ND |
| Xylene | 0.3 | 0.025 | ND | ND |
| Other (Purgeable) | ND | ND | ND | 15 |
| JP-5 | ND | ND | ND | ND |
| Diesel | 9,200 | 590 | 7.6 | 40 |
| Bunker | ND | ND | ND | ND |
| Motor Oil | NA | NA | NA | NA |
| Other (Extractable) | 1,900 | 200 | 76 | 29 |
| VOCs (ug/kg) | | | | |
| All Compounds | ND | NA | NA | NA |
| SVOCs (ug/kg) | | | | |
| 2-Methylnaphthalene | 12000J | NA | NA | NA |
| Fluorene | 4300J | NA | NA | NA |
| Phenanthrene | 6400J | NA | NA | NA |
| Fluoranthene | 1,700 | NA | NA | NA |
| Benzo(a)anthracene | 1,500 | NA | NA | NA |
| Total Metals (mg/kg) | | | | |
| All Elements | NA | NA | NA | NA |

**SB11-26**

| SAMPLE DATE | 2/10/92 | |
|---|---|---|
| DEPTH | 13.0-13.5 | 18.0-18.5 |
| TPH (mg/kg) | | |
| Gasoline | ND | ND |
| Benzene | ND | ND |
| Toluene | 0.24 | ND |
| Ethylbenzene | ND | ND |
| Xylene | 0.72 | 0.17 |
| Other (Purgeable) | 410 | 68 |
| JP-5 | ND | ND |
| Diesel | 3,700 | 370 |
| Bunker | ND | ND |
| Motor Oil | NA | NA |
| Other (Extractable) | ND | ND |
| VOCs (ug/kg) | | |
| All Compounds | NA | NA |
| SVOCs (ug/kg) | | |
| All Compounds | NA | NA |
| Total Metals (mg/kg) | | |
| All Elements | NA | NA |

## LEGEND

- 0.05 BF — BUNKER FUEL FREE PRODUCT
- 0.2 MIXED — MIXED BUNKER FUEL AND DIESEL FREE PRODUCT
- <0.05 JP5 — JET FUEL FREE PRODUCT
- SAMPLE INTERVAL
- FILL
- FILL-SILTY; ORGANIC-RICH
- ALLUVIUM
- PEAT
- BAY MUD
- REWORKED INTERTIDAL SEDIMENTS
- COLLUVIUM
- BEDROCK
- WATER LEVEL MEASURED JUNE 17, 1993
- WATER LEVEL MEASURED APRIL, 1999
- SCREEN INTERVAL OF MONITOR WELL
- APPROXIMATE DEPTH TO WATER TABLE BASED ON ACTIVE GROUNDWATER PUMPING FROM EXTRACTION TRENCH/CONTAINMENT WALL
- 10' / 20' — BORING LOGS INDICATE SOILS ARE RESIDUALLY SATURATED WITH HYDROCARBONS AT INDICATED DEPTH RANGE BELOW SURFACE GRADE
- INFERRED LITHOLOGIC CONTACT
- HS — HEADSPACE READING
- FP — FREE PRODUCT OBSERVED IN SOIL CORE
- BF — BUNKER FUEL

mg/kg MILLIGRAMS PER KILOGRAM
µg/kg MICROGRAM PER KILOGRAM
MSL MEAN SEA LEVEL
PID PHOTOIONIZATION DETECTOR

### NOTES

1. CROSS SECTION LOCATIONS ARE PRESENTED ON PLATE 2-3.
2. FREE PRODUCT THICKNESS REPRESENTS APPROXIMATE AVERAGE OVER THE PAST 2 YEARS OF MONITORING.
3. SVOC PHTHALATES, SUCH AS DIETHYLPHTHALATE, DI-N-BUTYLPHTHALATE, AND BUTYLBENZYLPHTHALATE, ARE NOT REPORTED AS SVOC DETECTIONS.
4. DATA QUALIFIERS
   NA NOT ANALYZED
   ND NOT DETECTED

   ORGANIC DATA QUALIFIERS

   J VALUE WAS QUANTITATIVELY IDENTIFIED BUT REPORTED AS AN ESTIMATED QUANTITY

   INORGANIC DATA QUALIFIERS

   E VALUE WAS ESTIMATED BECAUSE OF INTERFERENCE

   J VALUE WAS QUANTITATIVELY IDENTIFIED BUT REPORTED AS AN ESTIMATED QUANTITY

   J-* VALUE WAS ESTIMATED BECAUSE PRECISION OF LABORATORY DUPLICATE SAMPLES WERE OUT OF QC LIMITS

   J-N VALUE WAS ESTIMATED BECAUSE MATRIX SPIKE RECOVERIES WERE OUT OF QC LIMITS

   J-W VALUE WAS ESTIMATED BECAUSE GRAPHITE FURNACE ATOMIC ABSORPTION QC LIMITS WERE EXCEEDED

   N SPIKED SAMPLE RECOVERY WAS NOT WITHIN CONTROL LIMITS

   S REPORTED VALUE WAS DETERMINED BY THE METHOD OF STANDARD ADDITIONS (MSA)

   W POST-DIGESTION SPIKE RECOVERY OF THE FURNACE ATOMIC ABSORPTION ANALYSIS (FAAA) WAS OUT OF CONTROL LIMITS, AND THE SAMPLE ABSORBANCE WAS LESS THAN 50 PERCENT OF THE SPIKED ABSORBANCE

   * DUPLICATE SAMPLE ANALYSIS NOT WITHIN CONTROL LIMITS
5. VERTICAL TO HORIZONTAL SCALE IS APPROXIMATELY 10:1

PLATE 2-7
NFD POINT MOLATE
SITE 3 WORK PLAN
CROSS SECTIONS D-D' AND E-E'

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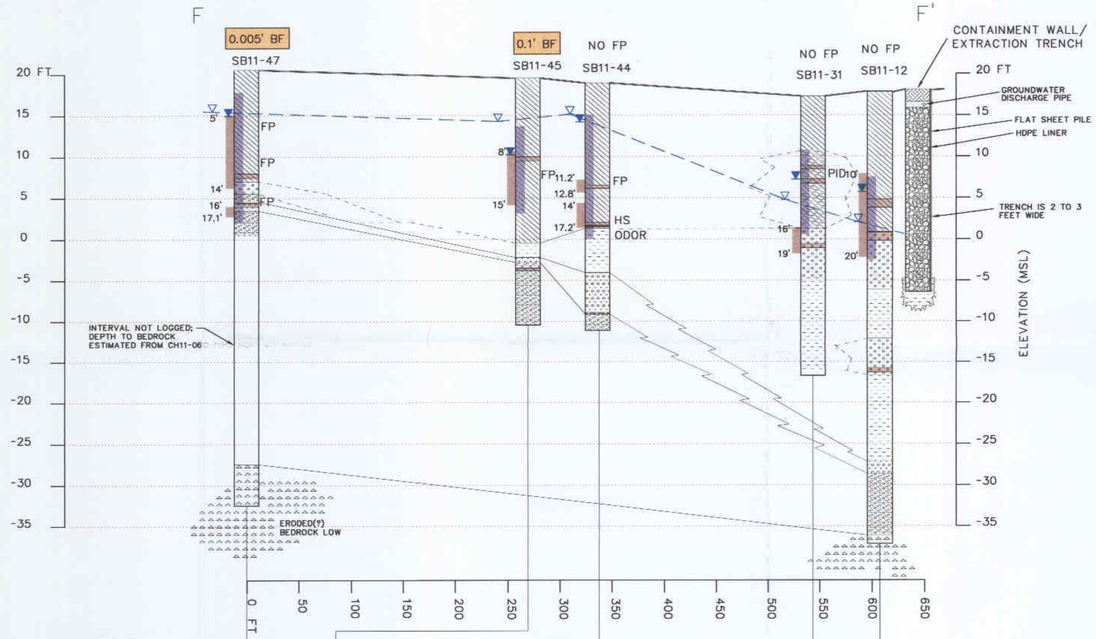
## GEOLOGIC CROSS-SECTION F-F'
## EAST-WEST ACROSS FORMER SUMP POND




| SB11-47 | | |
|---|---|---|
| SAMPLE DATE | 3/16/92 | |
| DEPTH | 12.5-13.0 | 16.0-16.5 |
| TPH (mg/kg) | | |
| Gasoline | ND | ND |
| Benzene | ND | ND |
| Toluene | ND | ND |
| Ethylbenzene | 0.084 | ND |
| Xylene | 0.47 | ND |
| Other (Purgeable) | 200 | 33 |
| JP-5 | ND | ND |
| Diesel | ND | ND |
| Bunker | 83,000 | ND |
| Motor Oil | 19,000 | ND |
| Other (Extractable) | ND | 590 |
| VOCs (ug/kg) | | |
| All Compounds | NA | NA |
| SVOCs (ug/kg) | | |
| 2-Methylnaphthalene | 36,000 | NA |
| Phenanthrene | 25,000 | NA |
| Pyrene | 9200J | NA |
| Total Metals (mg/kg) | | |
| All Elements | NA | NA |

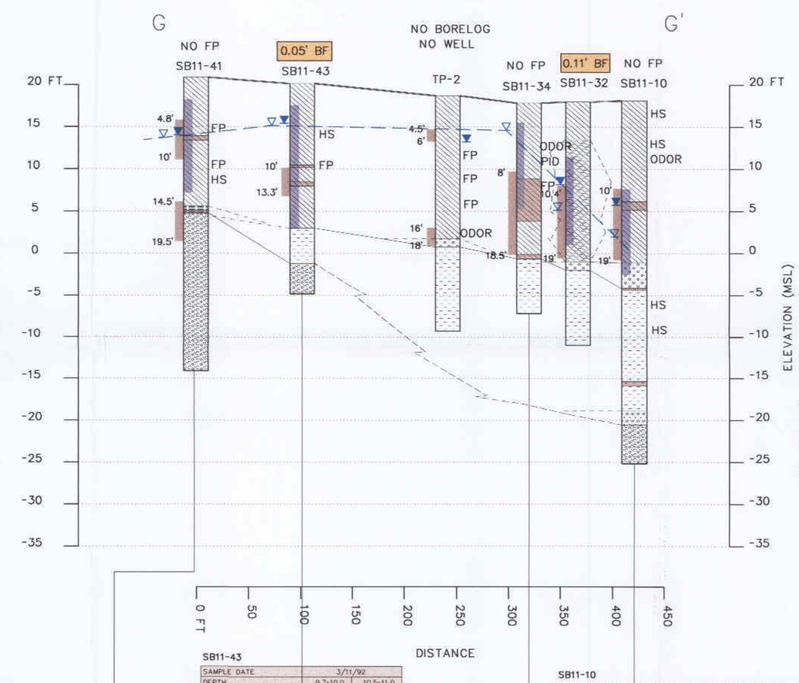
| SB11-44 | | | |
|---|---|---|---|
| SAMPLE DATE | 3/12/92 | | |
| DEPTH | 12.3-12.7 | 16.8-17.2 | 17.1-17.3 |
| TPH (mg/kg) | | | |
| Gasoline | ND | ND | NA |
| Benzene | ND | ND | NA |
| Toluene | 0.22 | ND | NA |
| Ethylbenzene | 0.051 | 0.31 | NA |
| Xylene | 0.44 | 1.9 | NA |
| Other (Purgeable) | 120 | 380 | NA |
| JP-5 | ND | ND | NA |
| Diesel | ND | ND | NA |
| Bunker | 2,900 | 15,000 | NA |
| Motor Oil | 2,200 | 5,700 | NA |
| Other (Extractable) | ND | ND | NA |
| VOCs (ug/kg) | | | |
| 1,2-Dichloroethene (total) | NA | NA | 29,000 |
| Tetrachloroethene | NA | NA | 200,000 |
| SVOCs (ug/kg) | | | |
| 2-Methylnaphthalene | NA | NA | 5200J |
| Phenanthrene | NA | NA | 6900J |
| Pyrene | NA | NA | 1900J |
| Total Metals (mg/kg) | | | |
| Aluminum | NA | NA | 17,300 |
| Antimony | NA | NA | ND |
| Arsenic | NA | NA | 2.4 |
| Barium | NA | NA | 207J |
| Beryllium | NA | NA | ND |
| Cadmium | NA | NA | ND |
| Chromium | NA | NA | 26.8 |
| Cobalt | NA | NA | 7.7 |
| Copper | NA | NA | 26 |
| Iron | NA | NA | 22,700 |
| Lead | NA | NA | 19.8J-NW |
| Magnesium | NA | NA | 4,720 |
| Manganese | NA | NA | 256 |
| Mercury | NA | NA | 0.13J |
| Molybdenum | NA | NA | NA |
| Nickel | NA | NA | 25.8 |
| Potassium | NA | NA | 2560J |
| Selenium | NA | NA | ND |
| Silver | NA | NA | ND |
| Sodium | NA | NA | 1400J |
| Thallium | NA | NA | ND |
| Vanadium | NA | NA | 40.1 |
| Zinc | NA | NA | 60.7E |

| SB11-12 | | | |
|---|---|---|---|
| SAMPLE DATE | 1/28/92 | | |
| DEPTH | 13.0-14.0 | 17.0-18.0 | 33.5-34.0 |
| TPH (mg/kg) | | | |
| Gasoline | ND | ND | ND |
| Benzene | ND | ND | ND |
| Toluene | ND | ND | ND |
| Ethylbenzene | ND | ND | ND |
| Xylene | .72 | .35 | ND |
| Other (Purgeable) | 140 | 180 | 530 |
| JP-5 | ND | ND | ND |
| Diesel | 2,700 | 12,000 | 740 |
| Bunker | ND | ND | ND |
| Motor Oil | NA | NA | NA |
| Other (Extractable) | 1,300 | 4,500 | 370 |
| VOCs (ug/kg) | | | |
| All Compounds | NA | NA | NA |
| SVOCs (ug/kg) | | | |
| All Compounds | NA | NA | NA |
| Total Metals (mg/kg) | | | |
| All Elements | NA | NA | NA |

| SB11-45 | | | |
|---|---|---|---|
| SAMPLE DATE | 3/13/92 | | |
| DEPTH | 9.5-10.0 | 18.5-19.5 | 22.9-23.2 |
| TPH (mg/kg) | | | |
| Gasoline | ND | ND | ND |
| Benzene | ND | ND | ND |
| Toluene | 0.110J | ND | ND |
| Ethylbenzene | ND | ND | ND |
| Xylene | 1.4J | .023 | ND |
| Other (Purgeable) | 400 | 570 | ND |
| JP-5 | ND | ND | ND |
| Diesel | ND | ND | ND |
| Bunker | 74,000 | 66,000 | ND |
| Motor Oil | 9,200 | 7,800 | ND |
| Other (Extractable) | ND | ND | 23 |
| VOCs (ug/kg) | | | |
| All Compounds | ND | NA | NA |
| SVOCs (ug/kg) | | | |
| 2-Methylnaphthalene | 45,000 | NA | NA |
| Phenanthrene | 18,000 | NA | NA |
| Fluoranthene | 1900J | NA | NA |
| Benzo(a)anthracene | 2600J | NA | NA |
| Pyrene | 5200J | NA | NA |
| Total Metals (mg/kg) | | | |
| Aluminum | 13,400 | NA | NA |
| Antimony | ND | NA | NA |
| Arsenic | 0.88 | NA | NA |
| Barium | 132J | NA | NA |
| Beryllium | ND | NA | NA |
| Cadmium | ND | NA | NA |
| Chromium | 14.8 | NA | NA |
| Cobalt | 6.8B | NA | NA |
| Copper | ND | NA | NA |
| Iron | 14,200 | NA | NA |
| Lead | 10.7J-NW | NA | NA |
| Magnesium | 3,140 | NA | NA |
| Manganese | 225 | NA | NA |
| Mercury | ND | NA | NA |
| Nickel | 20.9 | NA | NA |
| Potassium | 3520J | NA | NA |
| Selenium | ND | NA | NA |
| Silver | 1.1BN | NA | NA |
| Sodium | ND | NA | NA |
| Thallium | ND | NA | NA |
| Vanadium | 27.8 | NA | NA |
| Zinc | 45.7E | NA | NA |

| SB11-31 | | |
|---|---|---|
| SAMPLE DATE | 2/12/92 | |
| DEPTH | 8.4-8.8 | 17.8-18.3 |
| TPH (mg/kg) | | |
| Gasoline | ND | ND |
| Benzene | ND | ND |
| Toluene | 1.1 | ND |
| Ethylbenzene | 0.35 | ND |
| Xylene | 0.81 | 0.23 |
| Other (Purgeable) | 73 | 240 |
| JP-5 | ND | ND |
| Diesel | ND | ND |
| Bunker | ND | 39,000 |
| Motor Oil | NA | NA |
| Other (Extractable) | 1,800 | ND |
| VOCs (ug/kg) | | |
| All Compounds | NA | NA |
| SVOCs (ug/kg) | | |
| All Compounds | NA | NA |
| Total Metals (mg/kg) | | |
| Aluminum | NA | 12,700 |
| Antimony | NA | ND |
| Arsenic | NA | 5.2 |
| Barium | NA | 68.9J |
| Beryllium | NA | ND |
| Cadmium | NA | 1.4 |
| Chromium | NA | 14.5 |
| Cobalt | NA | 8.3 |
| Copper | NA | ND |
| Iron | NA | 16,500 |
| Lead | NA | 7.3J-N |
| Magnesium | NA | 4,020 |
| Manganese | NA | 277 |
| Mercury | NA | 0.13J |
| Nickel | NA | 22.6 |
| Potassium | NA | 3260J |
| Selenium | NA | ND |
| Silver | NA | ND |
| Sodium | NA | ND |
| Thallium | NA | ND |
| Vanadium | NA | 24.9 |
| Zinc | NA | 41.1E |

## GEOLOGIC CROSS-SECTION G-G'
## EAST-WEST ACROSS FORMER SUMP POND




| SB11-41 | | |
|---|---|---|
| SAMPLE DATE | 2/21/92 | |
| DEPTH | 7.0-7.5 | 15.8-16.1 |
| TPH (mg/kg) | | |
| Gasoline | ND | ND |
| Benzene | ND | ND |
| Toluene | ND | ND |
| Ethylbenzene | ND | ND |
| Xylene | ND | ND |
| Other (Purgeable) | 61 | 87 |
| JP-5 | ND | ND |
| Diesel | ND | ND |
| Bunker | 9,000 | 21,000 |
| Motor Oil | NA | NA |
| Other (Extractable) | ND | ND |
| VOCs (ug/kg) | | |
| All Compounds | NA | NA |
| SVOCs (ug/kg) | | |
| All Compounds | NA | NA |
| Total Metals (mg/kg) | | |
| All Elements | NA | NA |

| SB11-43 | | |
|---|---|---|
| SAMPLE DATE | 3/11/92 | |
| DEPTH | 9.7-10.0 | 10.5-11.0 |
| TPH (mg/kg) | | |
| Gasoline | ND | ND |
| Benzene | ND | 0.18 |
| Toluene | 0.043 | 0.044 |
| Ethylbenzene | ND | 0.031 |
| Xylene | 0.098 | 0.13 |
| Other (Purgeable) | 60 | 50 |
| JP-5 | ND | ND |
| Diesel | ND | ND |
| Bunker | 9,500 | 15,000 |
| Motor Oil | 2,400 | 17,000 |
| Other (Extractable) | ND | ND |
| VOCs (ug/kg) | | |
| All Compounds | NA | NA |
| SVOCs (ug/kg) | | |
| All Compounds | NA | NA |
| Total Metals (mg/kg) | | |
| Aluminum | NA | 20,800 |
| Antimony | NA | ND |
| Arsenic | NA | 15.25 |
| Barium | NA | 70.9 |
| Beryllium | NA | 0.64+ |
| Cadmium | NA | ND |
| Chromium | NA | 70.6 |
| Cobalt | NA | 17.2 |
| Copper | NA | 155 |
| Iron | NA | 31,000 |
| Lead | NA | 37.95+ |
| Magnesium | NA | 10,700 |
| Manganese | NA | 510N |
| Mercury | NA | NA |
| Nickel | NA | 81.3 |
| Potassium | NA | 2540J |
| Selenium | NA | ND |
| Silver | NA | ND |
| Sodium | NA | 2590J |
| Thallium | NA | ND |
| Vanadium | NA | 69.3 |
| Zinc | NA | 191 |

| SB11-10 | | | |
|---|---|---|---|
| SAMPLE DATE | 1/27/92 | | |
| DEPTH | 12.0-13.0 | 22.3-22.5 | 33.5-34.0 |
| TPH (mg/kg) | | | |
| Gasoline | ND | ND | ND |
| Benzene | ND | ND | ND |
| Toluene | ND | ND | ND |
| Ethylbenzene | .008 | ND | ND |
| Xylene | ND | ND | ND |
| Other (Purgeable) | 68 | ND | ND |
| JP-5 | ND | ND | ND |
| Diesel | ND | ND | ND |
| Bunker | 9,200 | ND | 26 |
| Motor Oil | NA | NA | NA |
| Other (Extractable) | 1,700 | 170 | 53 |
| VOCs (ug/kg) | | | |
| All Compounds | NA | NA | NA |
| SVOCs (ug/kg) | | | |
| All Compounds | NA | NA | NA |
| Total Metals (mg/kg) | | | |
| All Elements | NA | NA | NA |

| SB11-34 | | |
|---|---|---|
| SAMPLE DATE | 2/17/92 | |
| DEPTH | 9.0-14.0 | 18.0-18.5 |
| TPH (mg/kg) | | |
| Gasoline | ND | ND |
| Benzene | ND | ND |
| Toluene | ND | ND |
| Ethylbenzene | ND | ND |
| Xylene | 0.10 | ND |
| Other (Purgeable) | 110 | ND |
| JP-5 | ND | ND |
| Diesel | ND | ND |
| Bunker | 5,800 | 310 |
| Motor Oil | NA | NA |
| Other (Extractable) | ND | 120 |
| VOCs (ug/kg) | | |
| All Compounds | NA | NA |
| SVOCs (ug/kg) | | |
| All Compounds | NA | NA |
| Total Metals (mg/kg) | | |
| Lead | ND | NA |

## NOTES:

1. FREE PRODUCT THICKNESS REPRESENTS APPROXIMATE AVERAGE OVER THE PAST 2 YEARS OF MONITORING.
2. SVOC PHTHALATES, SUCH AS DIETHYLPHTHALATE, DI-N-BUTYLPHTHALATE, AND BUTYLBENZYLPHTHALATE, ARE NOT REPORTED AS SVOC DETECTIONS.
3. LINE OF SECTIONS SHOWN ON PLATE 2-3.
4. DATA QUALIFIERS

   NA NOT ANALYZED
   ND NOT DETECTED

   ORGANIC DATA QUALIFIERS

   J VALUE WAS QUANTITATIVELY IDENTIFIED BUT REPORTED AS AN ESTIMATED QUANTITY

   INORGANIC DATA QUALIFIERS

   B VALUE WAS LESS THAN THE CONTRACT REQUIRED DETECTION LIMIT (CRDL) BUT GREATER THAN THE INSTRUMENT DETECTION LIMIT (IDL)

   E VALUE WAS ESTIMATED BECAUSE OF INTERFERENCE

   J VALUE WAS QUANTITATIVELY IDENTIFIED BUT REPORTED AS AN ESTIMATED QUANTITY

   J-N VALUE WAS ESTIMATED BECAUSE MATRIX SPIKE RECOVERIES WERE OUT OF QC LIMITS

   J-W VALUE WAS ESTIMATED BECAUSE GRAPHITE FURNACE ATOMIC ABSORPTION QC LIMITS WERE EXCEEDED

   J-+ VALUE WAS ESTIMATED BECAUSE PRECISION OF LABORATORY DUPLICATE SAMPLES WAS OUT OF QC LIMITS

   N SPIKED SAMPLE RECOVERY WAS NOT WITHIN CONTROL LIMITS

   S REPORTED VALUE WAS DETERMINED BY THE METHOD OF STANDARD ADDITIONS (MSA)

   X THE CHROMATOGRAPHIC RESPONSE DID NOT RESEMBLE A TYPICAL FUEL PATTERN

   * DUPLICATE SAMPLE ANALYSIS NOT WITHIN CONTROL LIMITS

   + CORRELATION COEFFICIENT FOR THE MSA WAS LESS THAN 0.995

## LEGEND

- 0.05 BF — BUNKER FUEL FREE PRODUCT
- 0.2 MIXED — MIXED BUNKER FUEL AND DIESEL FREE PRODUCT
- <0.05 JP5 — JET FUEL FREE PRODUCT
- SAMPLE INTERVAL
- FILL
- FILL-SILTY; ORGANIC-RICH
- ALLUVIUM
- PEAT
- BAY MUD
- REWORKED INTERTIDAL SEDIMENTS
- COLLUVIUM
- BEDROCK
- COMPACTED BACKFILL
- PIPE BEDDING
- PERMEABLE FILL
- WATER LEVEL MEASURED JUNE 17, 1993
- WATER LEVEL MEASURED APRIL 1999
- SCREEN INTERVAL OF MONITOR WELL
- HS — HEADSPACE READING
- FP — FREE PRODUCT OBSERVED IN SOIL CORE
- BF — BUNKER FUEL
- HDPE — HIGH DENSITY POLYEHTYLENE
- mg/kg — MILLIGRAMS PER KILOGRAM
- µg/kg — MICROGRAM PER KILOGRAM
- MSL — MEAN SEA LEVEL
- PID — PHOTOIONIZATION DETECTOR
- APPROXIMATE DEPTH TO WATER TABLE BASED ON ACTIVE GROUNDWATER PUMPING FROM EXTRACTION TRENCH/CONTAINMENT WALL
- 10' / 20' — BORING LOGS INDICATE SOILS ARE RESIDUALLY SATURATED WITH HYDROCARBONS AT INDICATED DEPTH RANGE BELOW SURFACE GRADE
- INFERRED LITHOLOGIC CONTACT

# PLATE 2-8
# NFD POINT MOLATE
# SITE 3 WORK PLAN
# CROSS SECTIONS F-F' AND G-G'

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