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WORK PLAN FOR BIOSLURPING PILOT SCALE TEST AND DESIGN AT NS MAYPORT FL
6/24/1996
BATTELLE

WORK PLAN

for

BIOSLURPING PILOT-SCALE TEST AND DESIGN
at
NAVAL STATION MAYPORT, FLORIDA

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ABBREVIATIONS AND ACRONYMS

bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
gpm	gallon per minute
HASP	Health and Safety Plan
LNAPL	light, nonaqueous-phase liquid
MDL	method detection limit
NA	not applicable
NAVSTA	Naval Station
OWS	oil/water separator
OWTP	Oily Waste Treatment Plant
POC	point of contact
ppmv	part(s) per million by volume
PVC	polyvinyl chloride
scfm	standard cubic foot (feet) per minute
SWMU	Solid Waste Management Unit
TC	thermocouple
TPH	total petroleum hydrocarbons
VOA	volatile organic analysis

Section 1.0: INTRODUCTION

This Test Plan has been written to describe the activities to be conducted as part of the Bioslurping Pilot Scale Test and Design at Solid Waste Management Unit 7 (SWMU-7) at the Oily Waste Treatment Plant (OWTP) Sludge Beds area at Naval Station (NAVSTA) Mayport, Florida. The short-term pilot testing will be used to determine the effectiveness of bioslurping for (1) recovering free-phase light, nonaqueous-phase liquid (LNAPL) and (2) enhancement of natural in situ biodegradation of petroleum contamination in the vadose zone. The purpose of short-term testing is to determine the feasibility of this technology for application in full-scale remediation. If the bioslurping technology is determined to be an effective alternative for SWMU-7, Battelle will develop a conceptual design package for full-scale remediation at the site.

1.1 Bioslurper Pilot Test. The bioslurper field activities at SWMU-7 will consist of a 2-week pilot-scale test to evaluate the recoverability of LNAPL from an existing site recovery well using the bioslurper technology. Battelle will evaluate site-specific data received from the Navy and address site-specific variables before beginning field activities. The field program involves installation and operation of the bioslurping system supported by a wide variety of site characterization, performance monitoring, and chemical analysis activities.

The bioslurper system for the short-term test will be installed on a single well and will be operated for a period of 2-weeks. Baildown tests will be performed and oil/water measurements will be taken to identify a suitable extraction well. Soil gas monitoring points will be installed prior to startup of the bioslurper system. Measurements of the extracted soil gas composition, free product thickness, and groundwater level will be made during the test. In addition, aqueous discharge and vapor discharge samples will be collected throughout bioslurper activities. These data will allow the amounts of extracted free product, groundwater, and soil gas to be quantified over time.

During the operational period, Battelle will be conducting in situ respiration tests to establish vadose zone hydrocarbon biodegradation rates and will perform vacuum radius of influence tests to aid in determining the optimum well spacing for full-scale system design. Detailed procedures for specific field activities are described in the document entitled *Best Practices Manual for Bioslurping* (Battelle, 1995).

1.2 Bioslurper Technology Description. Bioslurping is a technology application that teams vacuum-assisted free-product recovery with bioventing to simultaneously recover free product and remediate the vadose zone. Unlike other LNAPL recovery technologies, bioslurping systems treat two separate geologic media simultaneously. Bioslurping pumps are designed to extract free-phase fuel from the water table and to aerate vadose zone soils through soil gas extraction. The systems also can be designed to achieve hydraulic control as is done with conventional pump-and-treat technology. The bioslurper system withdraws groundwater, free product, and soil gas in one process stream using a single aboveground pump. Groundwater is separated from the free product, treated (when required), and discharged. Free product is recovered and can be recycled. Soil gas vapor is treated (when required) and discharged.

The bioslurper technology is unique because it utilizes elements of two separate remedial technologies, **free-product recovery** and **bioventing/soil vapor extraction**, to address two separate contaminant media.

1.2.1 Free-product recovery is the process of removing free-phase petroleum in liquid form from the capillary fringe. LNAPL recovery generally is accomplished by using either (a) a skimmer pump to pump out any fuel that passively enters a well or (b) a dual-pump recovery system that uses one pump to lower the water table and increase the fuel flow into the well (due to the gravity-induced gradient) and a second pump to skim off the fuel.

1.2.2 Bioventing and soil vapor extraction are forced aeration processes that enhance natural in situ biodegradation of petroleum contamination and removal of VOCs from the vadose zone.

Both technologies, which are described in detail in Section 1.0 of the *Best Practices Manual for Bioslurping*, are widely used in some form. Bioslurping combines elements of each to simultaneously recover free product and aerate vadose zone soils. Conventional LNAPL recovery skimmer systems generally are inefficient for LNAPL recovery because they have little effect on free product outside the recovery well, so efficiency relies on the passive movement of fuel into the recovery well. Dual-pump LNAPL recovery systems increase recovery efficiency by drawing the water table down several feet to create a hydraulic gradient into the well. Although higher recovery rates are achieved, creation and maintenance of the hydraulic gradient can require extraction of large volumes of groundwater that must be treated prior to discharge. In addition, lowering the water table may serve only to trap much of the free product in the newly exposed vadose zone so that it reappears when the water table returns to its normal level.

Bioslurping may improve free-product recovery efficiency without requiring the extraction of large quantities of groundwater. The bioslurper system pulls a vacuum of up to 20 inches of mercury on the recovery well to create a pressure gradient to promote movement of fuel into the well. Bioslurping treats the vadose zone by increasing the oxygen levels in the unsaturated soils through soil gas extraction. The slurping action of the bioslurper system cycles between recovering liquid (free product and/or groundwater) and soil gas. The rate of soil gas extraction depends on the recovery rate of liquid into the well. When free-product removal activities are complete, the bioslurper system is easily converted to a conventional bioventing system to complete remediation of vadose zone soils.

Bioslurping systems are designed to minimize environmental discharges of groundwater and soil gas. As done in bioventing, bioslurper systems can be designed and operated to extract soil gas at a low rate to reduce volatilization of contaminants. In some instances, the volatile discharge from the bioslurper can be kept below treatment action levels without treatment. The slurping action of a bioslurping system greatly reduces the volume of groundwater that must be extracted compared to conventional LNAPL recovery systems, thus greatly reducing groundwater treatment costs. Figure 1 illustrates the differences between conventional dual-pump LNAPL recovery and bioslurping.

Nonaqueous-phase liquids that are less dense than water move downward through the vadose zone and accumulate at and above the water table. Generally, the vertical interval containing the accumulated LNAPL also contains some air and water. Near the top of the LNAPL zone, both water and LNAPL contents are low and most of the pore space is occupied by air. LNAPL contents usually are greatest toward the center of the LNAPL zone and decline to zero at the bottom where the pore space is fully occupied by water.

A significant feature of the slurping process is the induced air flow toward the well, which is believed to increase LNAPL flow to the well. The pressure gradient created in the air phase causes a driving force on the LNAPL that is equivalent to the hydraulic gradient created with the dual-pump recovery system. Also of importance is the fact that the air flow created by the vacuum actually

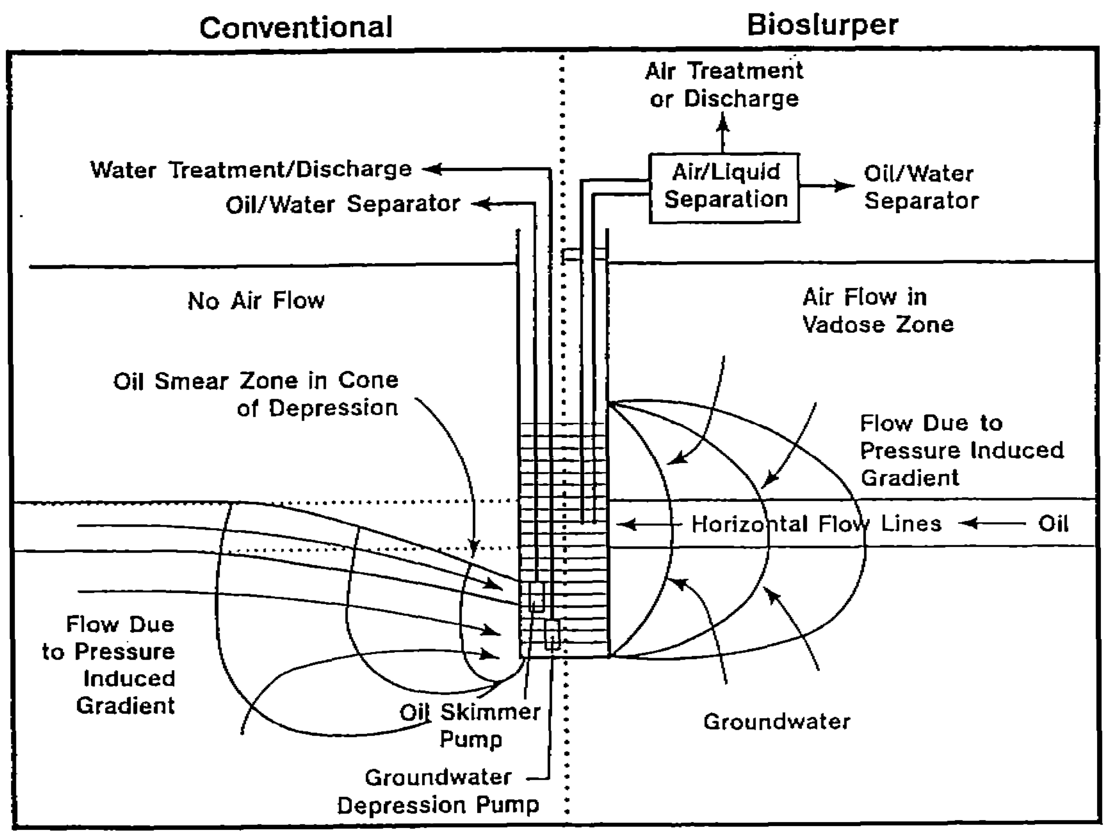

Figure 1. Comparison of Conventional LNAPL Recovery and Bioslurping

enhances the LNAPL content around the well. That is, the LNAPL tends to accumulate around the well. For these reasons, bioslurping has the potential for removing more LNAPL and at greater rates than do other pumping technologies.

The bioslurper system can also be performed in the drawdown mode. This involves extracting groundwater at a rate great enough to lower the water table around the LNAPL collection system to create a cone of depression. This is effective in situations where LNAPL becomes trapped in pockets within the saturated one. The disadvantage of the drawdown recovery system is that greater volumes of groundwater may need to be extracted to maintain the cone of depression. When operating in this mode, the cone of depression should remain above the bottom of the smear zone to prevent the zone from spreading further. This type of technology differs from traditional drawdown recovery technologies in that it is conducted under a vacuum. It differs from the bioslurping mode only in the respect that the drop tube is placed below instead of at the LNAPL/groundwater interface.

Section 2.0: SITE DESCRIPTION

Information presented in this section of the Test Plan summarizes data from the following documents prepared for NAVSTA Mayport by ABB Environmental Services, Inc.: *RCRA Facility Investigation: Group II Solid Waste Management Units* (January 1996), *Corrective Action Program General Information Report* (July 1995), *RFI Report* (June 1995), and Draft Interim Measures Workplan (May 1994). These data are used to provide an overview of the state of contamination identified at NAVSTA Mayport and as engineering reference material for existing wells at the site.

NAVSTA Mayport is located on a peninsula in northeast Florida and lies approximately 12 miles northeast of Jacksonville. The complex is bounded by the Atlantic Ocean to the east and the St. Johns River to the north and west. The area is used primarily for industrial purposes. NAVSTA Mayport, occupying 3,401 acres, has been in existence since 1942. Current activities include support services for surface fleet and aircraft, including ship and aircraft repair and maintenance.

Solid Waste Management Unit 7 (SWMU-7) is made up of the OWTP Sludge Drying Beds (Figure 2). SWMU-7 was constructed in 1979 and consists of four unlined sludge drying beds enclosed by earthen berms. The sludge drying beds received sludge from the OWTP clarifiers and bilge water from receiving tanks 99 and 100. Records indicate that approximately 1,500 gallons of sludge were transferred to the drying beds on the average of twice per week until late 1994. The easternmost drying bed was excavated in 1989, at which time a lined, diked enclosure and three bilge water receiving tanks were constructed. SWMU 6, located directly adjacent to SWMU-7 on the west, served as a waste oil pit and sludge drying bed prior to the installation of SWMU-7 in 1979.

Cleanup criteria at the site according to Florida State regulatory requirements mandate that free-product in excess of 0.1 inch thickness be removed from the water table. Petroleum-contaminated soil and sludge which has the potential to contribute to the presence of LNAPL and contamination of soil and groundwater also must be remediated.

The depth to groundwater at the site is approximately 9 ft below ground surface (bgs) or 7 ft below the sludge drying beds. Tidal influence accounts for a few tenths of a foot variation in the surficial aquifer, however, its influence is negligible at distances greater than 400 ft from the St. James River. Tidal fluctuations could result in smearing of the floating free-phase hydrocarbon or its entrapment beneath the rising water table. Groundwater tends to flow north towards the St. James River at a horizontal rate of 0.19 to 0.24 ft/day (69 to 87 ft/yr). Hydraulic conductivity at the site averages 3.7 ft/day.

Floating free product as LNAPL has been measured at numerous wells existing at the site. The average apparent fuel thickness at these wells is 0.5 ft. Monitoring wells where floating free product has been measured include the following: MPT-8-MW02S, MPT-8-MW03S, MPT-8-MW04S, MPT-8-MW07S, MPT-8-MW11S, MPT-8-MW15S, and MPT-8-TP02 through MPT-8-TP08. The plume is thought to be elliptical in shape (420 $\times$ 280 ft) and is located at a minimum distance of 100 ft from St. John's River (Figure 3). The amount of total recoverable LNAPL has been estimated at approximately 43,000 to 90,000 gallons. Analyses of free product samples indicate that the fuel most closely resembles diesel fuel or mineral spirits and has a specific gravity of 0.8765.

The subsurface at the site is dredged fill material consisting primarily of fine sand with occasional shell fragments. The dredged material has been characterized as undifferentiated post-

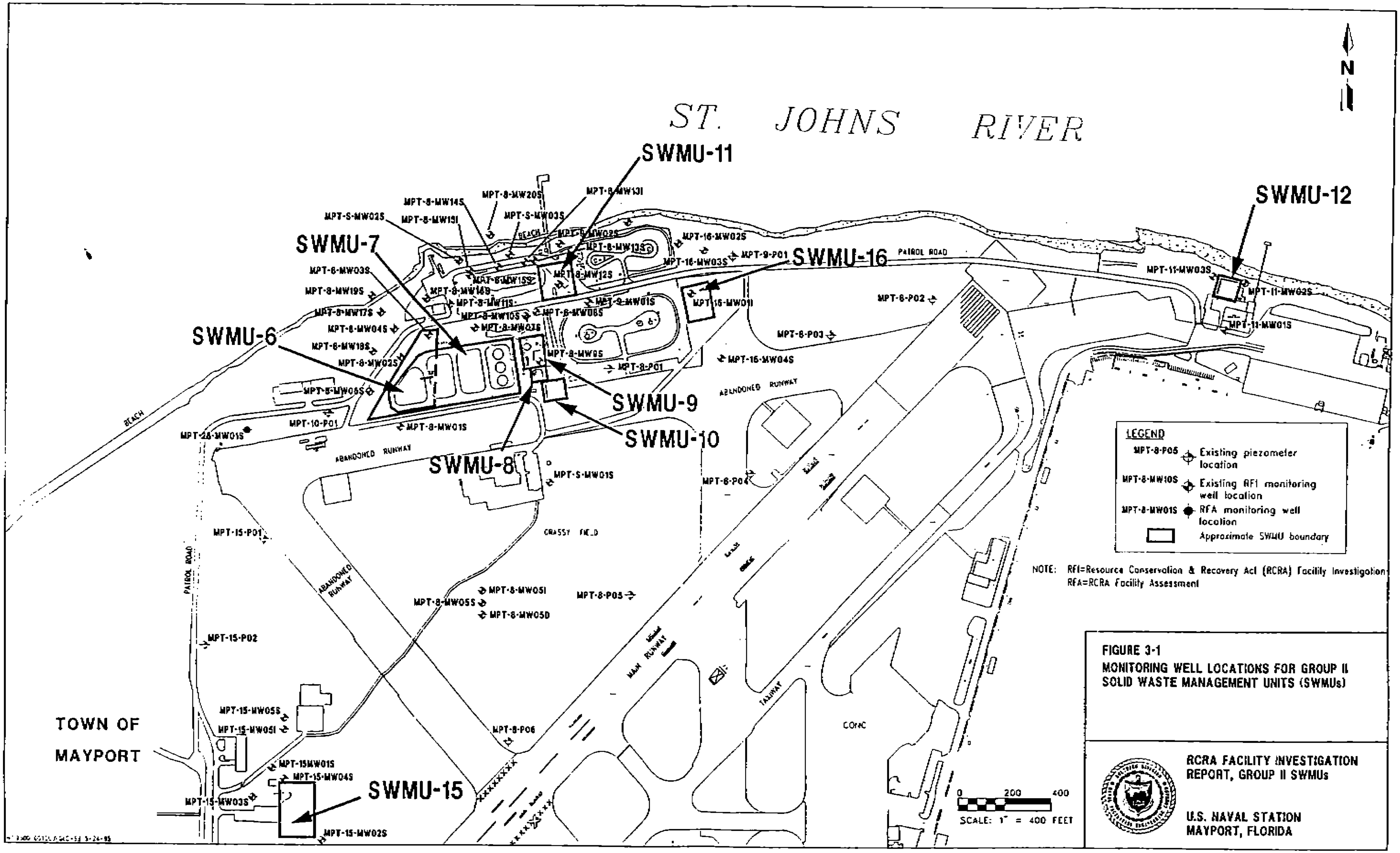

Figure 2. Site Map of Solid Waste Management Units Including Monitoring Well Locations at NAVSTA Mayport, Florida

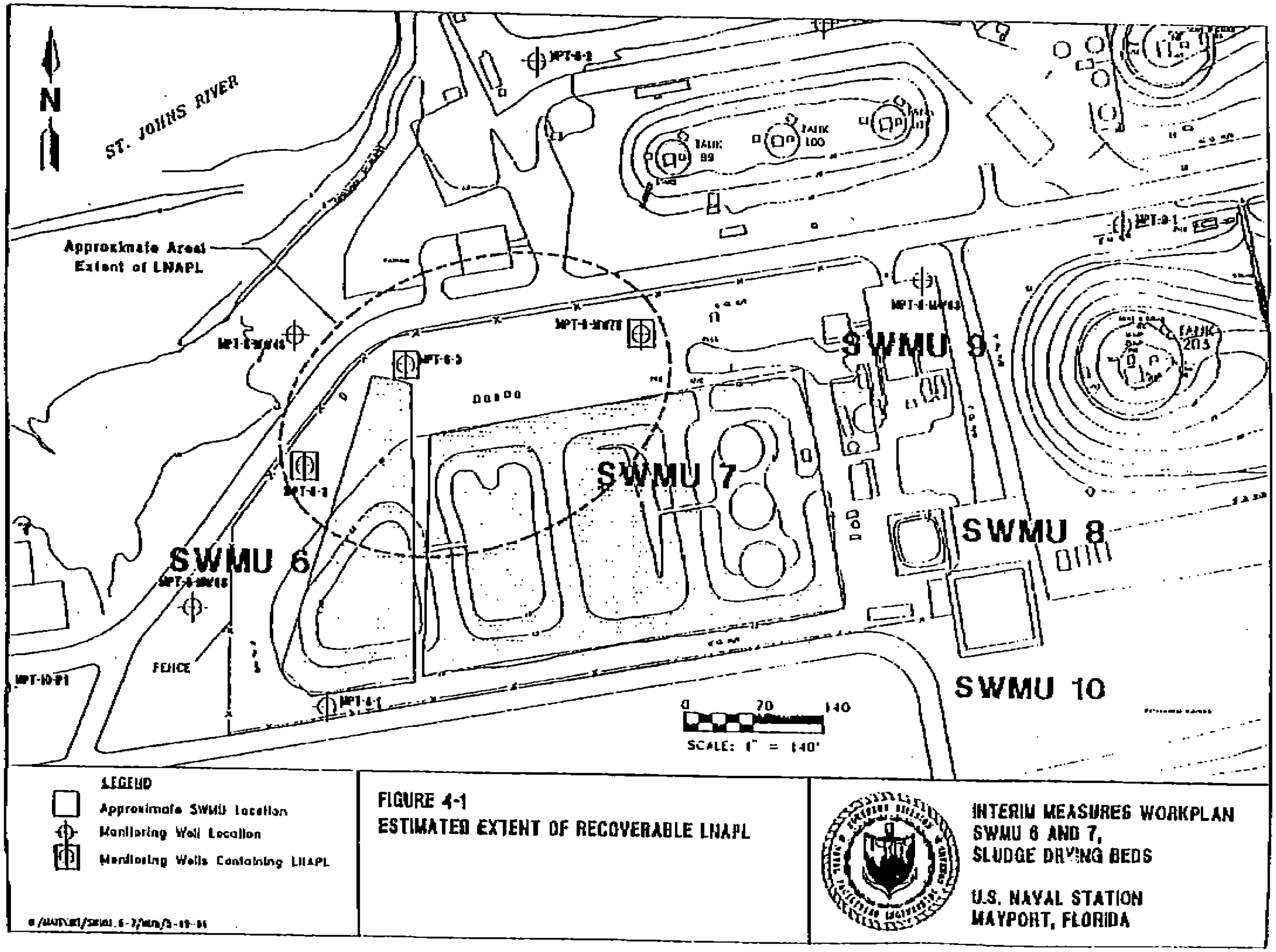

Figure 3. Estimated Location of Free-Product Plume, NAVSTA Mayport, Florida

Hawthorn deposits. No confining unit of sufficient areal extent has been found at the site. A cross section of the area is seen in Figure 4.

Subsurface soil samples were collected during the 1993/1994 sampling events. The highest concentrations of hydrocarbon-related organic compounds were detected in boring MPT08-MW03S. Maximum concentrations of benzene, toluene, and ethylbenzene at this location were 160, 170, and 1,500 μg/L, respectively. The distribution of interpreted hydrocarbons in soil is shown in Figure 5.

Groundwater also was sampled during 1993/1994 sampling events. TPH concentrations ranged from 0.045 to 132 mg/L, with maximum concentrations being detected at MPT-8MW04S. Benzene and ethylbenzene were detected at concentrations of 2 μg/L and 21 μg/L, respectively, but were found only at MPT-8-MW07.

As an interim measure to remove LNAPL from the subsurface, a recovery system is currently operating at the site. The system consists of five sumps containing total fluids pumps which recover LNAPL and water at a rate of approximately 1 gallon per minute (gpm). The collected LNAPL and water are sent through the OWTP process for treatment and disposal. This existing passive recovery system at SWMU-7 will be shut down 1 week prior to initiating the pilot-scale bioslurper test and will not resume operations until completion of testing.

Monitoring wells and piezometers have been installed at various locations on the site (Figure 5). Some wells are screened across the water table and others are screened in the intermediate zone of the surficial aquifer. It is Battelle's intention to use one of the existing wells as the bioslurper extraction well. Based on site data and site logistics, the most likely candidate is MPT-8-MW07S; however, final selection will occur after Battelle has taken initial oil/water measurements and performed baildown testing. Well construction details and soil boring logs of monitoring wells known to have contained free product at one time are found in Appendix A.

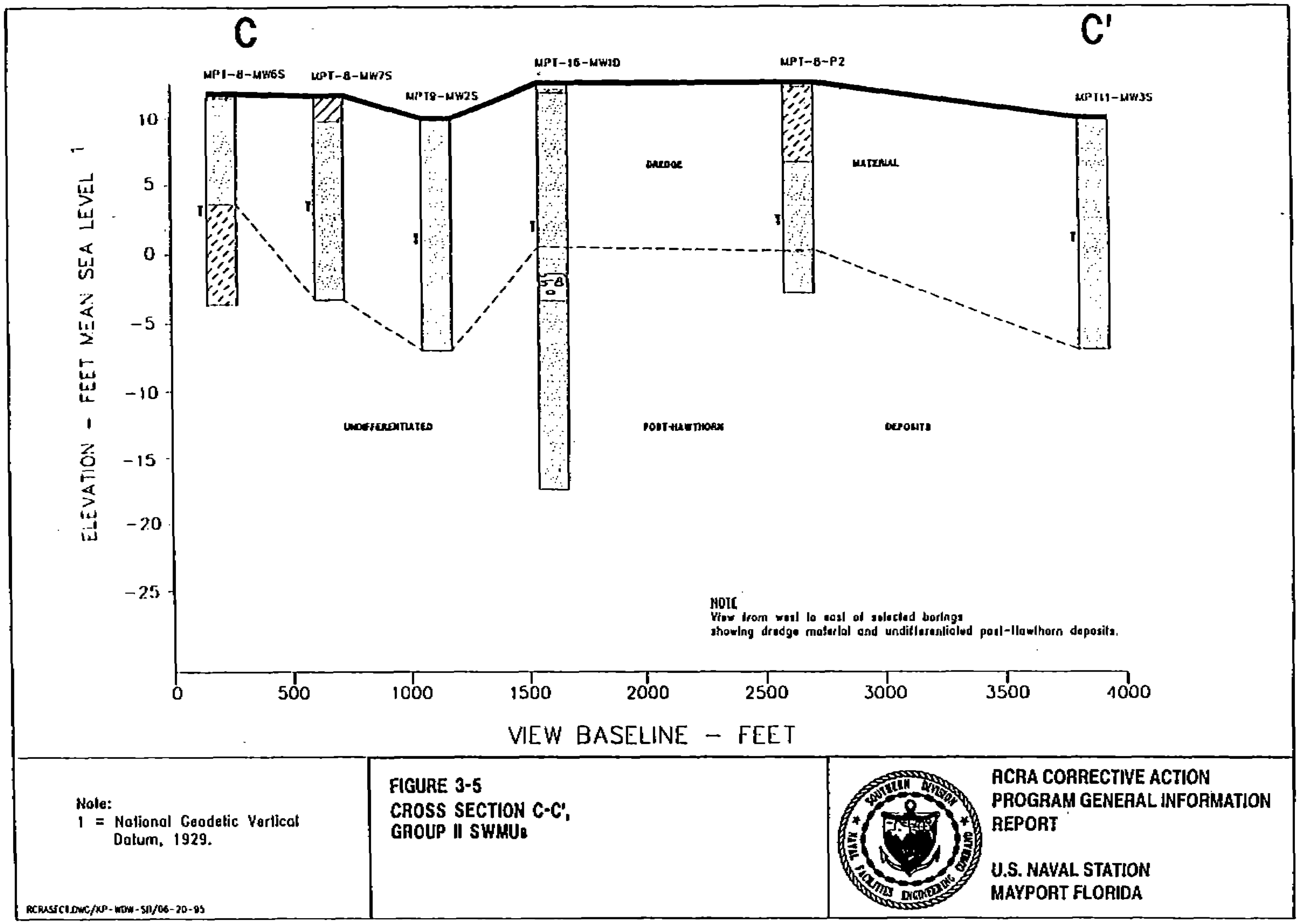

Figure 4. Cross Section of Group II Solid Waste Management Units, NAVSTA Mayport, Florida

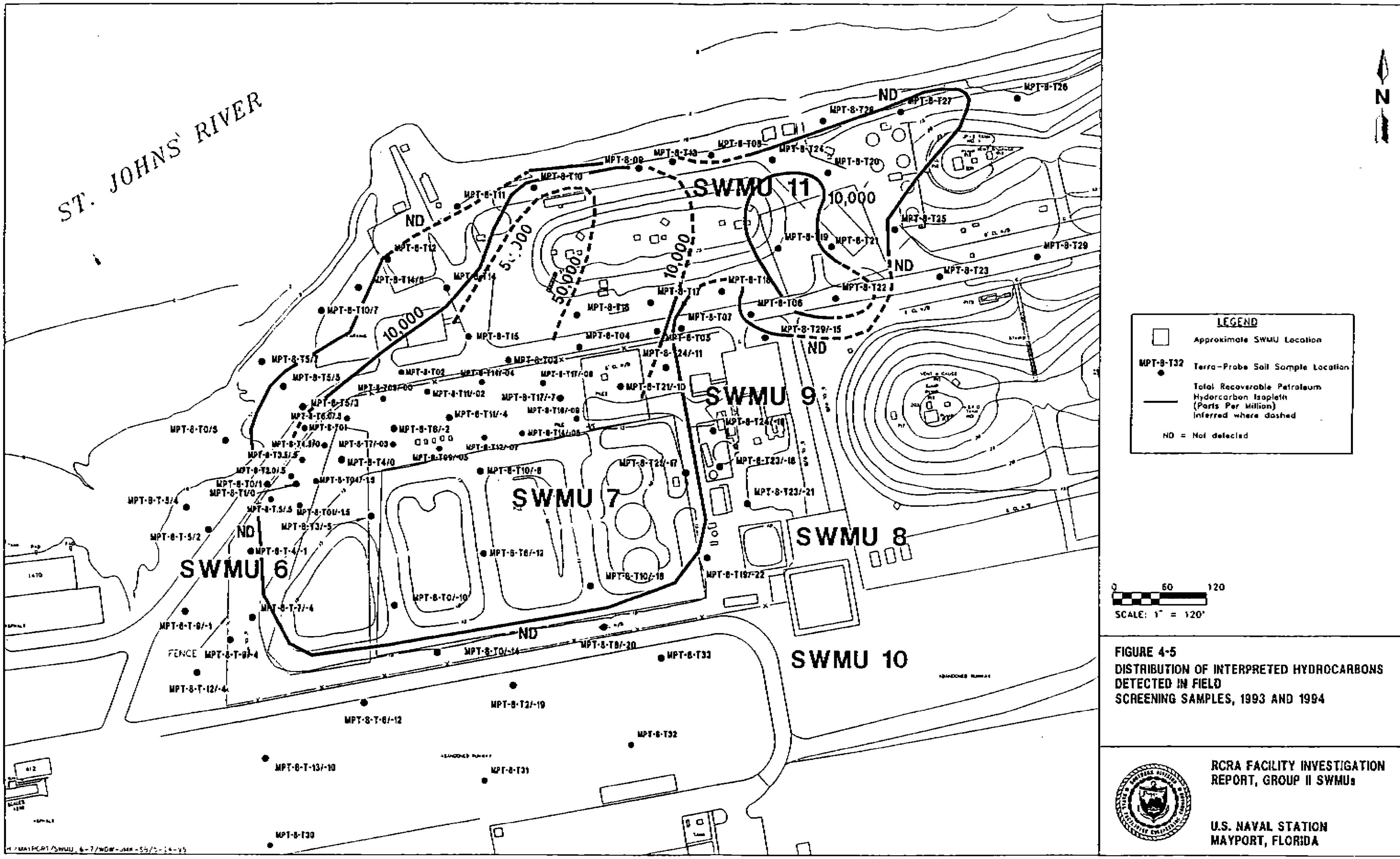

Figure 5. Distribution of Hydrocarbons in Subsurface Soil Samples, NAVSTA Mayport, Florida

Section 3.0: TEST PREPARATION AND SUPPORT ACTIVITIES

3.1 Health and Safety Plan. As a separate deliverable, a site-specific health and safety plan (HASP) and Contractor Quality Control Plan (CQC) for NAVSTA Mayport were prepared. A copy of each will be available on site at all times during the NAVSTA Mayport pilot-scale bioslurper test.

3.2 Application for Required Permits. Based on the discussion with the remedial program manager and the NAVSTA environmental coordinator, permits are not required to conduct the bioslurper short-term pilot-scale test at NAVSTA Mayport. In addition, discussions with the Navy and with local regulatory agencies indicated that an air discharge permit will not be required for operation of the bioslurper system. Additionally, the extracted LNAPL/groundwater will be pumped to the NAVSTA-supplied 40,000-gallon-capacity temporary storage system to be treated subsequently by the NAVSTA OWTP. The Navy has indicated that the aqueous effluent from the OWS can be discharged to the NAVSTA OWTP without a discharge permit requirement.

Under the Saint Johns Water Management District, a well installation permit is not required for installing monitoring wells less than 25 ft deep. It is not anticipated that wells will be installed deeper than 12 ft; therefore, it is assumed that conditions do not necessitate the acquisition of a well installation permit.

3.3 Base Support Requirements. The bioslurper field activities are designed to minimize NAVSTA support requirements for conduct of the pilot-scale test. Electrical power required for conducting the tests will be supplied by NAVSTA Mayport. The contractor will coordinate with the NAVSTA point of contact (POC) to obtain access and the necessary clearance to conduct the tests at the candidate test area. The contractor will present a copy of the contract with the Navy in order to obtain temporary NAVSTA passes.

The bioslurper system will generate free product and an aqueous wastestream; the contractor will coordinate the discharge of this material to the NAVSTA OWTP for treatment. Contaminated soil cuttings generated at the site will be spread within the sludge drying beds. Contaminated personal protective equipment, rags, and absorbent pads will be double-bagged and given to the NAVSTA hazardous waste management coordinator for proper disposal.

Section 4.0: SYSTEM COMPONENTS AND EQUIPMENT

4.1 Bioslurper Extraction Wells. Bioslurper extraction wells are used for the extraction of groundwater, free product, and soil gas through the subsurface, creating a pressure/vacuum gradient for enhanced fluid recovery and air permeability testing, and increasing the subsurface oxygen levels for in situ respiration testing. A schematic diagram of a typical bioslurper well is shown in Figure 6. An existing monitoring well with a history of free product contamination will be used as the bioslurper extraction well for the pilot-scale test at NAVSTA Mayport.

The bioslurper well will be chosen based on historical data as well as preliminary site characterization activities performed at the site. The most important criteria for the selection of the bioslurper test well are the presence of floating free product and the high recovery potential of the well. Measurements of LNAPL thickness will be measured with an oil/water interface probe as described in Section 5.2.2 of this document. In addition, past LNAPL thickness measurements will be reviewed. Recovery potential will be determined by baildown testing, as described in Section 5.2.3. In most cases, the well exhibiting the highest rate of LNAPL recovery will be selected for the bioslurper extraction well.

4.2 Soil Gas Monitoring Points.

4.2.1 Locations of Monitoring Points. Three soil gas monitoring points will be used for pressure and soil gas measurements. Monitoring points are best located in a straight line radially out from the bioslurping well at the intervals recommended in Table 1. A general arrangement of the bioslurping well and monitoring points is shown in Figure 7. Deviations from the grid configuration may be dictated by a variety of site-specific conditions including, but not limited to, spatial heterogeneities, obstructions, or the desire to monitor a specific location. The exact locations of the new monitoring points will be determined in the field, based on results of a limited soil gas survey and the location of the bioslurper wells. To the extent possible, the monitoring points should be located in contaminated soils with >1,000 mg/kg of total petroleum hydrocarbons. Monitoring points located in contaminated soil are also important in obtaining meaningful in situ respiration data. Based on Battelle's experience, the monitoring points should be selected to have significant soil gas hydrocarbon concentrations (ideally >10,000 ppmv) and low oxygen concentrations (ideally 5% oxygen or less).

4.2.2 Depth of Monitoring Points. In general, each monitoring point will be screened to at least three depths (Figure 8). The deepest screen should be placed approximately 1 ft above the water table. Consideration should be given to potential seasonal water table fluctuations and soil type in determining the depth. In more-permeable soil the monitoring point can be screened closer to the water table. In less-permeable soil it must be screened further above the water table. The shallowest screen normally should be 3 to 5 ft below land surface. The intermediate screen is placed at a reasonable interval at a depth corresponding to the center to upper quarter of the depth of the vent well screen.

4.2.3 Installation/Construction of Monitoring Points. Soil gas monitoring points will be installed to a depth of approximately 8 ft below ground surface. A manually driven hand auger is the preferred method to advance soil borings; however, site soils may necessitate an alternative method.

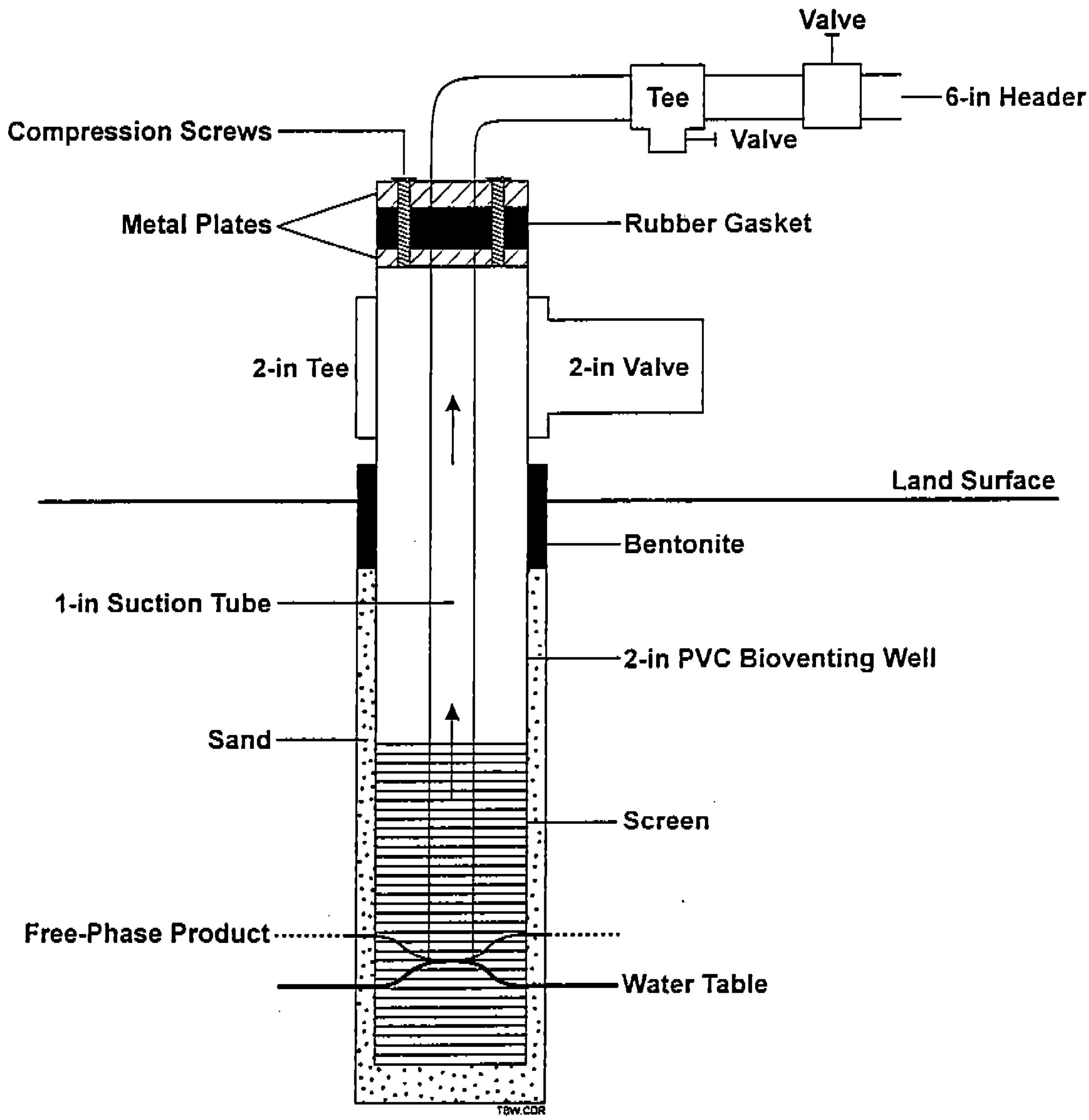

Figure 6. Schematic Diagram of a Typical Bioslurper Well

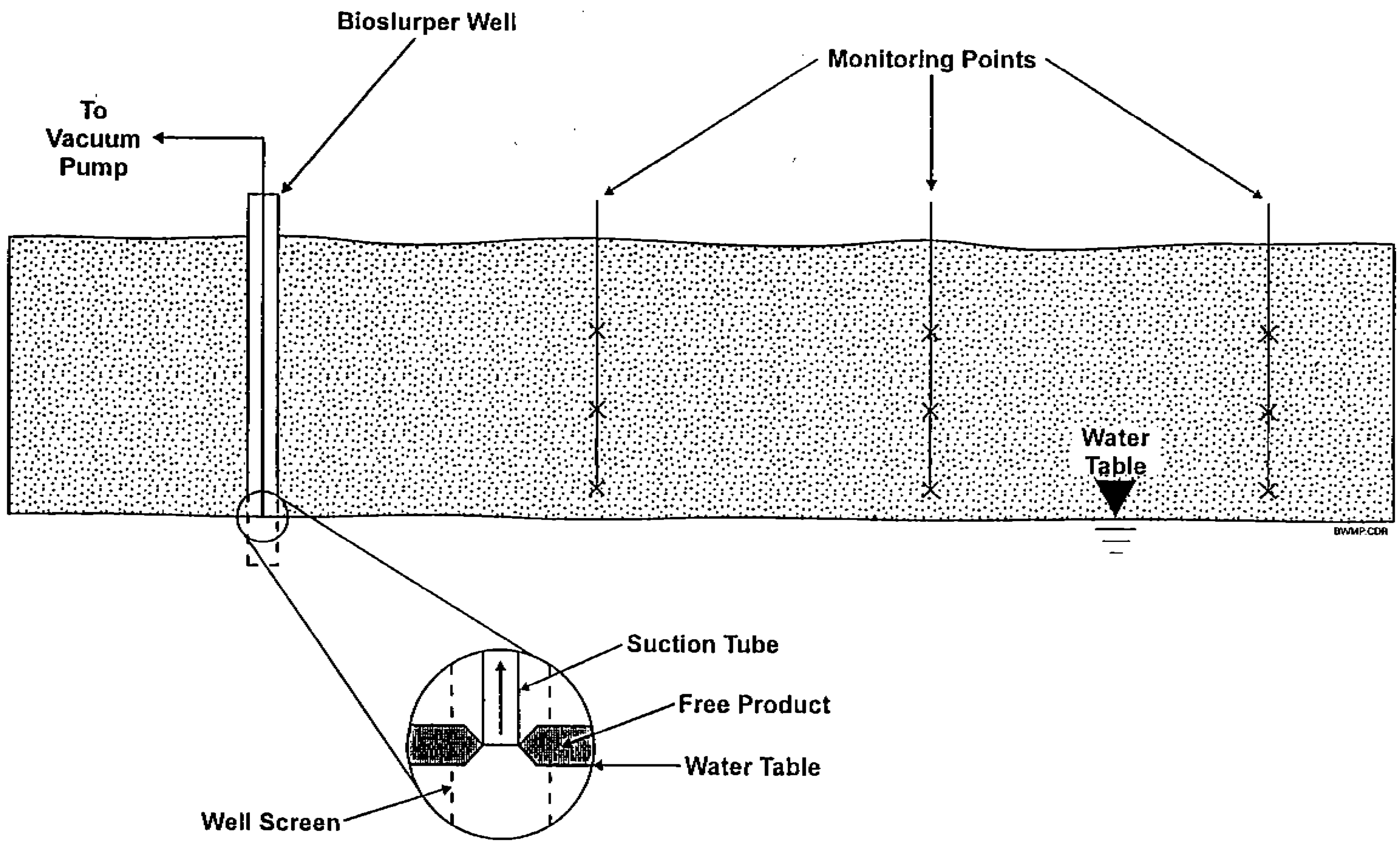

Figure 7. General Arrangement of Bioslurper Well and Monitoring Points

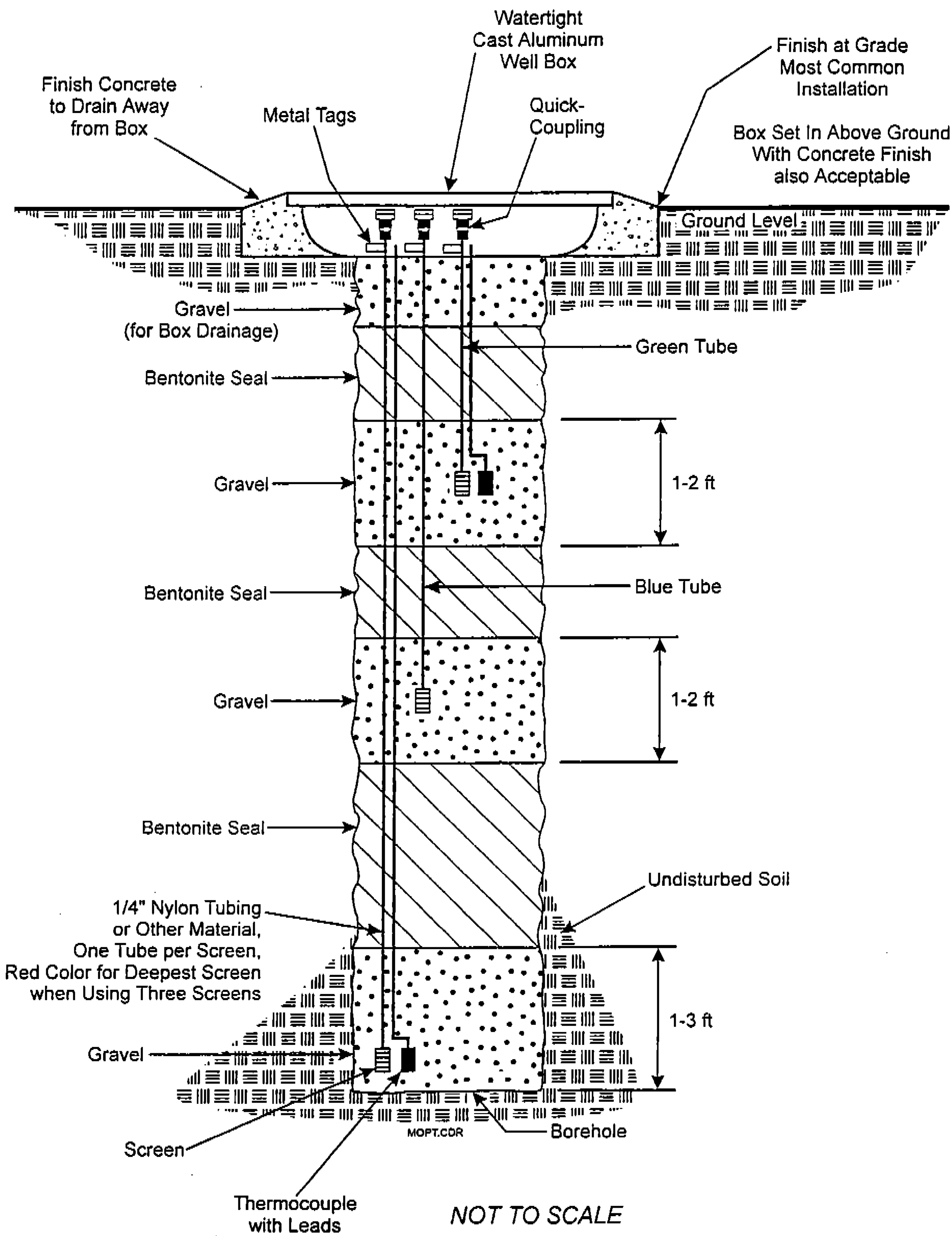

Figure 8. Typical Soil Gas Monitoring Point

Table 1. Recommended Spacing for Monitoring Points

Soil Type	Depth to Top of Bioslurping Well Screen (ft)[1]	Lateral Spacing from Bioslurping Well (ft)[1]
Coarse Sand	5	5-10-20
	10	10-20-40
	>15	20-30-60
Medium Sand	5	10-20-30
	10	15-25-40
	>15	20-40-60
Fine Sand	5	10-20-40
	10	15-30-60
	>15	20-40-80
Silts	5	10-20-40
	10	15-30-60
	>15	20-40-80
Clays	5	10-20-30
	10	10-20-40
	>15	15-30-60

[1] Assuming 10 ft of well screen. If more screen is used, the > 15-ft spacing will be used.

Monitoring point construction varies depending on the depth of drilling and the drilling technique. The monitoring points generally consist of a small-diameter ¼-in. tube to the specified depth with a screen of approximately 6 in. in length and ½ to 1 in. in diameter. In shallow hand-augered installations, rigid tubing (i.e., schedule 80 ¼" PVC) terminating in the center of a gravel or sand pack may be adequate. The gravel or sand pack normally will extend for an interval of 1 to 2 ft with the screen centered. In low-permeability soils, a larger gravel pack may be desirable. In wet soils, a longer gravel pack with the screen near the top may be desirable. A bentonite seal at least 2 ft thick normally is required above and below the gravel pack. Figure 8 shows a typical installation.

Tubes may be used to collect soil gas for carbon dioxide and oxygen analysis in the 0 to 25% range, and for fuel hydrocarbons in the 100-ppmv range or higher. The tubing material must have sufficient strength and be nonreactive. Sorption and gas interaction with the tubing materials have not been significant problems for this application. All tubing from each monitoring point will be finished with quick-connect couplings and will be labeled twice. Each screened depth will be labeled with a name as follows:

[MP] — [Code for Monitoring Point] — [Depth to Center of Screened Interval].

The tubing will be labeled with a metal tag firmly attached or directly by engraving or in waterproof ink. The label will be placed close to the ground so that if the tube is damaged, the label will likely survive. The top of each monitoring point will be labeled to be visible from above. This will be done either by writing in the concrete or with spray paint.

The monitoring points will be finished by placement in a watertight cast aluminum well box. The well box will be placed either aboveground in a concrete pad or at grade, also in concrete. The box will be drained to prevent water accumulation.

4.2.4 Thermocouples. Two thermocouples will be installed in a single monitoring well. These will be installed, as shown in Figure 8, at the depths of the shallowest and the deepest screens. Thermocouples used are type K (or equivalent) and will be connected to a Fluke Model 52 thermocouple thermometer (or equivalent). The thermocouple wires will be labeled using the same system as for the tubing, except that a two-letter abbreviation for thermocouple, TC, is added to the identification label.

4.3 Extraction and Treatment System. The bioslurper system is a trailer mounted unit will consist of an extraction manifold, a liquid ring pump, a gravity oil/water separator (OWS) with 10 gpm flow capacity, a 225-gallon surge tank with an automatic overflow shutoff switch, a pump for directing extracted groundwater and LNAPL to the NAVSTA-supplied 40,000-gallon capacity temporary storage system, and an activated carbon treatment system for off-gas. Figure 9 shows a schematic diagram of bioslurper process flow.

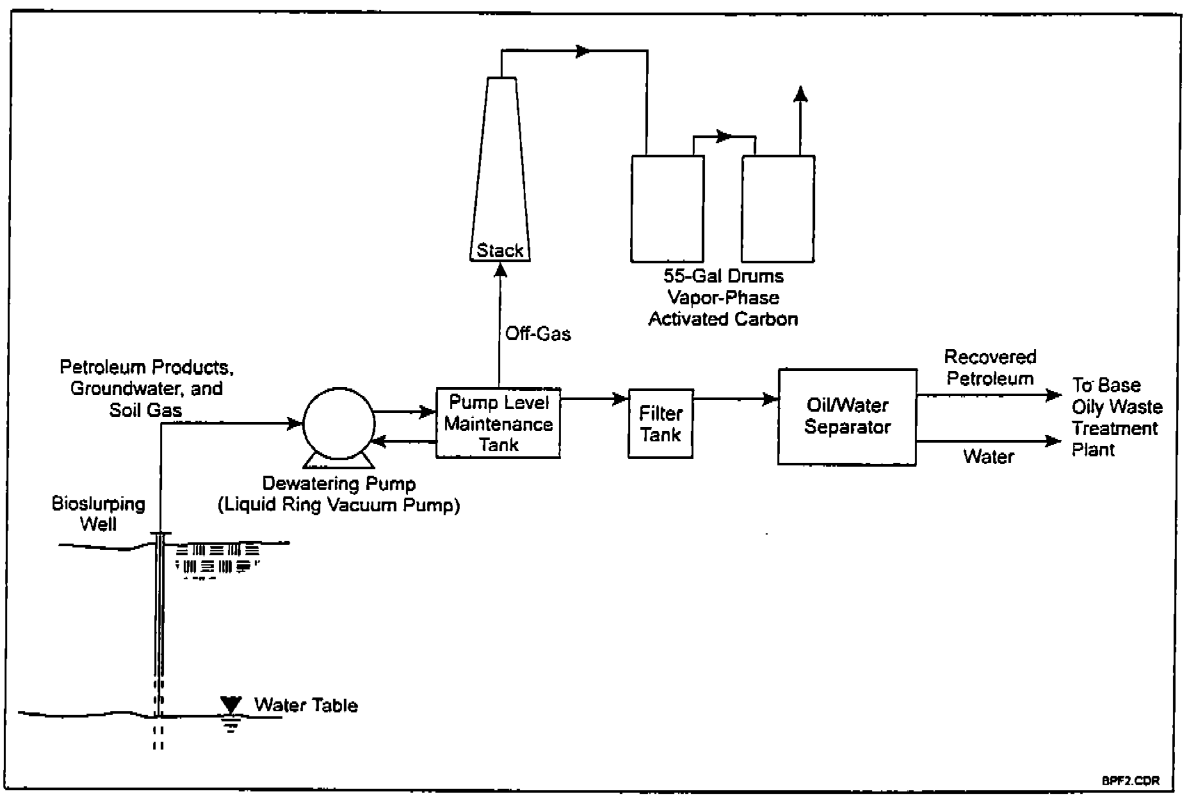

Figure 9. Bioslurper Process Flow

A 7.5-hp Atlantic Fluidics Model A100 liquid ring pump will be used for all pilot testing. LNAPL will be separated from the aqueous phase by passing the liquid discharge stream through a gravity OWS (Megator Corp. Model #S-1-A-1.5, or equivalent). Extracted groundwater will gravity-drain into a 225-gallon surge tank located adjacent to the OWS. This tank will be equipped with a float switch to shut down all power prior to tank overflow. Recovered LNAPL will be removed from the oil/water separator in order to quantify the amount. After the recovered LNAPL has been quantified, it will then be returned to the groundwater effluent discharge stream.

NAVSTA personnel have indicated that a heavy emulsion forms during pumping operations at SWMU-7. Emulsion can significantly effect the performance of the bioslurper system. To address this concern, a centrifugal separator (CINC, Model V-5) will be installed and operated in addition to the gravity feed OWS. The unit will be placed upstream of the liquid ring pump. It will be tested to determine its ability to break up emulsion and separate the LNAPL and aqueous streams.

The vapor discharge treatment system will consist of two 200-lb gas-phase activated carbon canisters plumbed in series to the bioslurper vapor discharge stack. A pressure gauge is placed on the vapor discharge stack, and vapor sampling ports are placed before, between, and after the two carbon canisters. The discharge line from the second canister is fitted with a pitot tube flow indicator.

4.4 Field Instrumentation.

4.4.1 Oxygen and Carbon Dioxide. Gaseous concentrations of carbon dioxide and oxygen will be analyzed using a GasTech model 3252OX CO_2/O_2 analyzer or equivalent. This meter has oxygen and carbon dioxide ranges from 0 to 25%.

The battery charge level will be checked to ensure proper operation. The air filters will be checked and, if necessary, will be cleaned or replaced before the experiment is started. The instrument will be turned on and equilibrated for at least 30 minutes before conducting calibration or obtaining measurements. The sampling pump of the instrument will be checked to ensure that it is functioning. Low flow of the sampling pump can indicate that the battery level is low or that some fines are trapped in the pump or tubing.

Each day prior to use against the meters will be calibrated purchased carbon dioxide and oxygen calibration standards. These standards will be selected to be in the concentration range of the soil gas to be sampled. Standard gases will be purchased from a specialty gas supplier. To calibrate the instrument with standard gases, a Tedlar™ bag (capacity ~1 L) is filled with the standard gas, and the valve on the bag is closed. The inlet nozzle of the instrument is connected to the Tedlar™ bag, and the valve on the bag is opened. The instrument is then calibrated against the standard gas according to the manufacturer's instructions. Next, the inlet nozzle of the instrument is disconnected from the Tedlar™ bag and the valve on the bag is shut off. The instrument will be rechecked against atmospheric concentration. If recalibration is required, the above steps will be repeated.

4.4.2 Hydrocarbon Concentration. Petroleum hydrocarbon concentrations in soil gas will be analyzed using a GasTech TraceTechtor™ hydrocarbon analyzer (or equivalent) with range settings of 100 ppmv, 1,000 ppmv, and 10,000 ppmv. The analyzer will be calibrated against hexane calibration gas. The oxygen concentration must be above 10% for the TraceTechtor™ analyzer to be accurate. When the oxygen drops below 10%, a dilution fitting must be added to provide adequate oxygen for analysis. The dilution fitting can also be used if hydrocarbon concentrations are greater than 10,000 ppmv.

4.4.3 Helium Monitoring. Helium will be injected into the vadose zone during the respiration test. A Marks Helium Detector Model 9821 or equivalent will be used to monitor helium concentrations in soil gas samples. Calibration of the helium detector follows the same basic procedure described for oxygen calibration, except that the setup for calibration is different.

4.4.4 Pressure/Vacuum Monitoring. Changes in soil gas pressure during air permeability testing will be measured at monitoring points using Magnehelic™ or equivalent gauges. Tygon™ or equivalent tubing will be used to connect the pressure/vacuum gauge to the quick-disconnect fitting on the top of each monitoring point. Similar gauges will be positioned before and after the blower unit to measure pressure/vacuum across the blower and at the head of the bioslurper well.
Pressure/vacuum gauges are available in a variety of pressure/vacuum ranges, and the same gauge can be used to measure either vacuum or pressure simply by switching inlet ports. Gauges are sealed and calibrated at the factory and will be rezeroed before each test. The following pressure ranges (in inches H_2O) typically will be available for this field test:

0-1", 0-5", 0-10", 0-20", 0-50", 0-100", and 0-200"

4.4.5 Airflow. The volume of vapor discharge will be quantified using a pitot tube (Annubar Flow Characteristics Model #HCR-15) flow indicator. The pitot tube is connected to a differential pressure gauge calibrated in inches of H_2O. The flowrate in cubic feet per minute (cfm) is determined by referencing the differential pressure to a flow calibration curve. The volume of vapor discharge will be calculated based on the average flowrate in cfm and the hours of operation.

Section 5.0: PROJECT ACTIVITIES

The field activities discussed in the following section are planned for the bioslurper pilot test at NAVSTA Mayport. Additional details about the activities are presented in the *Best Practices Manual for Bioslurping* (Wickram et al., 1996), and specific sections are referenced where applicable. Table 2 presents the proposed sequence of bioslurper pilot test activities to be conducted at NAVSTA Mayport.

Table 2. Schedule of Bioslurper Field Activities for NAVSTA Mayport

PILOT TEST ACTIVITY
Mobilization

System Installation
  Bioslurper Installation
  Monitoring Point Installation (3-4 points)

Site Characterization
  Soil Gas Survey (Limited)
  LNAPL/Groundwater Interface Monitoring
  Baildown Tests
  Soil Sampling (BTEX, TPH)

Test Startup
  Low-Vacuum Pump Test (4 days)
    Permeability Test
  Mid-Vacuum Pump Test (4 days)
    Permeability Test
  High-Vacuum Pump Test (4 days)
    Permeability Test
  In Situ Respiration Test
    Air/Helium Injection (1 day)
    Monitoring (2 days)

Demobilization

5.1 Mobilization to the Site. Battelle staff will mobilize equipment to the site. At the request of NAVSTA Mayport, equipment will not be shipped to the NAVSTA prior to staff arrival. The exact mobilization date will be confirmed with the NAVSTA POC as far in advance of fieldwork as is possible.

5.2 Site Characterization Tests.

5.2.1 Soil-Gas Survey (Limited). A small-scale soil gas survey will be conducted to identify the best location for installation of the monitoring points. The soil gas survey will be conducted in areas where historical site data indicated the highest contamination levels. Monitoring points will be located in areas that exhibit the following soil gas characteristics:

- Relatively high total petroleum hydrocarbon (TPH) concentrations (10,000 ppmv or greater)
- Relatively low oxygen concentrations (between 0% and 2%)
- Relatively high carbon dioxide concentrations (depending on soil type, between 2% and 10% or greater).

Additional information on the soil gas survey is provided in Section 4.1.2 of the *Best Practices Manual for Bioslurping* (Battelle, 1995).

5.2.2 LNAPL/Groundwater Interface Monitoring. The depth to groundwater and apparent thickness of LNAPL in site wells will be measured using an oil/water interface probe (ORS model #1068013 or equivalent). Product thickness and depth to groundwater at in situ subsurface soil pressures should be monitored at wells adjacent to the bioslurper extraction well during the pilot test. Detailed procedures describing how to install a system to monitor LNAPL thickness and depth to groundwater at in situ soil gas pressures are found in Section 4.1.3 of the *Best Practices Manual for Bioslurping* (Battelle, 1995).

5.2.3 Baildown Tests. After the depth to groundwater and the initial LNAPL thickness have been determined, the rate of LNAPL recovery will be determined via baildown testing. Baildown tests will be conducted at 3 to 4 wells that have historically contained measurable thicknesses of LNAPL to estimate the LNAPL recovery potential at those particular wells. In most cases, the well exhibiting the highest rate of LNAPL recovery will be selected for the bioslurper extraction well.

The baildown tests will be conducted by lowering a bottom-filling bailer into each well to collect any floating LNAPL. The LNAPL will be removed from the well and poured into a graduated cylinder to determine its volume. Efforts will be made to minimize the volume of water removed from the well, and bailing will cease when the measurable thickness in the well cannot be further significantly reduced (confirmed with the oil/water interface probe).

Baildown test wells will be monitored periodically using the oil/water interface probe to determine the rate of LNAPL recovery. Measurements will be taken every hour for 2 hours, then every 2 to 4 hours for a maximum of 24 hours. The time between measurements can be more frequent if LNAPL recovery is rapid or less frequent if recovery is very slow.

5.2.4 Soil Sampling. Four soil samples will be collected from boreholes advanced for monitoring point installation. Samples will be collected with brass sampling sleeves inserted into a manually driven hand auger. Generally, samples will be collected from the capillary fringe over the free product. Following collection of the soil samples, the sleeves will be sealed with inert caps, labeled, reserved in plastic bags, and stored on ice. Chain-of-custody documentation will accompany the samples, which will be shipped on ice via an overnight courier to a qualified laboratory for analyses benzene, toluene, and ethylbenzene, and xylenes (BTEX) and TPH. The analytical methods and relevant sampling information are summarized in Table 3.

5.2.5 Baseline Measurements. Prior to initiating the LNAPL recovery tests, baseline field data must be collected and recorded. These data will include soil gas concentrations (carbon dioxide, oxygen, and TPH), initial soil gas pressures, depth to groundwater, and LNAPL thickness.

Additionally, ambient soil and all atmospheric conditions (e.g., temperature, barometric pressure) will be recorded.

Table 3. Sampling and Analytical Methods

Analysis	Method	MDL*	Container	Sample Size	Preservation	Holding Time
Soil Samples						
BTEX	EPA 624/8240	20 μg/kg	Brass sleeve	100 g	Cool, @ 4°C	14 days
TPH (as gasoline)	EPA Mod. 8015	10 mg/kg	Brass sleeve	100 g	Cool, @ 4°C	14 days
Stack Gas						
BTEX	EPA TO-3 (modified)	0.1 ppmv*	Summa Canister	Both analyses from a common 1-L canister	NA	30 days
TPH	EPA TO-3 (modified)	0.1 ppmv	Summa Canister		NA	30 days
Aqueous Effluent Samples						
BTEX	EPA 624/8240	1 μg/L	Borosilicate glass, VOA vials	Both analyses from a set of 3 × 40 mL vials	HCl to pH <2, @ 4°C	14 days
TPH	EPA Mod. 8015	0.5 mg/L	Borosilicate glass, VOA vials		HCl to pH <2, @ 4°C	14 days

*MDL = method detection limit; NA = not applicable; ppmv = parts per million by volume; and VOA = volatile organic analysis.

5.3 Bioslurper System Installation and Operation.

5.3.1 System Setup. Once the well to be used for the bioslurper test installation at NAVSTA Mayport has been identified, the bioslurper pump and support equipment will be installed. A clear, level 20- by 10-ft area near the well selected for bioslurper test installation will be identified to situate the equipment required for bioslurper system operation. Additional information about bioslurper system components can be found in Section 4.0 of this document.

5.3.2 System Shakedown. A brief startup test will be conducted to ensure that all system components are constructed properly and operate safely. All system components will be checked for problems and/or malfunctions. A checklist will be provided to document the system shakedown.

5.3.3 System Startup and Test Operations. After installation is complete and the bioslurper system is confirmed to be operating properly, the two week pilot test will be started. Testing will be conducted to observe the effect of varying system vacuum on LNAPL recovery rates. The sequence of testing involves three 4-day operational periods conducted consecutively at low, medium, and high vacuums. Bioslurping will be conducted at each of these vacuums with drop tube placement at the oil/water interface. Process monitoring will be conducted during each operational mode to evaluate system performance.

The bioslurper system operating parameters that will be measured during operation are vapor discharge, aqueous effluent, LNAPL recovery volume, and groundwater discharge volume. Vapor monitoring will consist of periodic monitoring of TPH using hand-held instruments supplemented by samples collected for detailed laboratory analysis. The off-gas discharge volume will be measured using a calibrated pitot tube. Recovered LNAPL and aqueous discharge volumes will be recorded using in-line flow-totalizing meters. Aqueous effluent also will be collected for analysis of BTEX and TPH. A detailed sampling plan for off-gas discharge and aqueous effluent can be found in Sections 6.1 and 6.2 of this document, respectively.

5.3.4 Soil Gas Profile/Oxygen Radius of Influence Test. Changes in soil gas profiles will be measured before and during the bioslurper pump test. Soil gas will be monitored for concentration of oxygen, carbon dioxide, and TPH using field instruments. These measurements will be used to determine the oxygen radius of influence of the bioslurper.

5.3.5 Soil Gas Permeability Test. Soil gas permeability tests will be conducted concurrently with startup of the bioslurper pump test for each of the three operational periods conducted at low, medium, and high vacuum levels. Soil gas permeability data will support the process of estimating the vadose zone radius of influence of the bioslurper system. Soil gas permeability results also will aid in determining the number of wells required for a full-scale bioslurper system.

5.3.6 In Situ Respiration Test. An in situ respiration test will be conducted after completion of the bioslurper pilot tests. The in situ respiration test will involve injection of an air/helium mixture into selected soil gas monitoring points followed by monitoring changes in concentrations of oxygen, carbon dioxide, TPH, and helium in soil gas at the injection point. Measurement of the soil gas composition typically will be conducted at 2, 4, 6, and 8 hours and then every 4 to 12 hours for about 2 days. Timing of the tests will be adjusted based on the oxygen-use rate. If oxygen depletion occurs rapidly, more frequent monitoring will be required. If oxygen depletion is slow, less frequent readings will be acceptable. The in situ respiration test will be terminated when the oxygen level is about 5%. Results of the in situ respiration test will be used to estimate the biodegradation rate to be reported in mg/kg/day biodegraded. Further information on the procedures and data collection of the in situ respiration test is provided in Section 4.3.3 of the *Best Practices Manual for Bioslurping* (Battelle, 1995).

5.4 Demobilization. Once all necessary tests have been completed at the NAVSTA Mayport site, the equipment will be disassembled by Battelle staff. Battelle staff will be responsible for removal of equipment from the site and shipment to the next destination before they leave NAVSTA Mayport.

Section 6.0: PROCESS AND SITE MONITORING

6.1 Off-Gas Discharge. Process monitoring of off-gas discharge will involve the collection of a total of six off-gas discharge samples for analysis of BTEX and TPH. Two samples will be taken during each of the three vacuum modes of bioslurper operation. Samples will be taken both prior to and following treatment by two 200-lb gas-phase activated carbon canisters.

Soil gas samples will be collected by connecting an evacuated 1-L, Summa polished air-sampling canister to the bioslurper vapor discharge stack. Prior to connecting the canister to the sampling line, a vacuum pump will be used to pull soil gas from the bioslurper stack to ensure that the sample line is flushed with a representative soil gas sample. A minimum of a five-fold flush will be achieved by pumping for 1 minute. Following this flushing process, the evacuated canister is connected to the sampling line, the valve is opened, and a soil gas sample is pulled from the vadose zone. The vacuum is displaced with soil gas until atmospheric pressure is reached. The vacuum/pressure on each canister will be confirmed for each sampling event to ensure that the canister was received in an evacuated state and was completely filled during sampling. The canisters are then tagged with the appropriate sample identification and shipped via overnight courier to the appropriate laboratory for analyses. Chain-of-custody forms will accompany the samples. The analytical method and relevant sampling information are presented in Table 3.

Based on the average concentration of the off-gas samples and the volume of soil gas extracted, the mass loading of hydrocarbons in the vapor phase both before and after treatment will be calculated. Past sites contaminated with similar types of fuels as those found at SWMU-7 have shown average mass loadings of about 7 lb/day TPH and less than 0.01 lb/day benzene without treatment. Vapor discharge rates at NAVSTA Mayport can be expected to be lower as a result of treatment with activated carbon. Discharge rates may also vary depending on concentrations in soil gas and the permeability of the soil.

To ensure the safety and regulatory compliance of the bioslurper system, field soil gas screening instruments will be used to monitor vapor discharge concentration. The volume of vapor discharge will be monitored daily using air flow instruments.

6.2 Aqueous Effluent. Operation of the bioslurper system will generate an aqueous waste discharge that will be passed through an oil/water separator. LNAPL will be removed from the OWS in order to quantify the amount and then returned to the groundwater effluent discharge stream. Extracted groundwater also will be quantified using an in-line flow totalizer meter. Following quantification of extracted LNAPL/groundwater, it is the intention of Battelle to pump aqueous effluent to the base-supplied 40,000-gallon-capacity temporary storage system to subsequently undergo treatment by the NAVSTA Mayport OWTP. It is assumed that a water discharge permit will not be required for the short-term pilot test because all water will be discharged to the OWTP for treatment.

As with the vapor monitoring, process monitoring of aqueous effluent will involve sample collection during each of the three operational modes. A total of six aqueous effluent samples will be collected, with two samples being taken during each of the three vacuum modes. All samples will be collected from the outlet of the OWS. The samples will be held in 40-mL VOA vials. The pH of the aqueous effluent samples will be adjusted to a value of <2 with hydrochloric acid to stabilize the organic species. The vials will be labeled, stored at 4°C, and shipped with the proper chain-of-custody forms via an overnight courier to a qualified laboratory for analyses.

Samples will be analyzed for BTEX and TPH concentrations according to the methods outlined in Table 3.

Section 7.0: FULL-SCALE DESIGN

A full-scale conceptual design package will be developed by Battelle for NAVSTA Mayport if results from the pilot scale test indicate that bioslurping would be an effective remedial technology for the site. Product recovery rates, soil gas permeability test results, and in situ respiration data during pilot-scale testing will be used to establish the bioslurper system configuration for this site.

Battelle's involvement in full-scale bioslurper operation at NAVSTA Mayport would be in design and technical support only. Battelle would design detailed plans for a full-scale system and prepare a cost estimate for activities associated with such a system. Battelle would provide the Navy with a detailed operations and maintenance manual and would provide operations training to Navy personnel. In addition, a Battelle contact would be available to provide technical support during the extended testing activities.

Detailed records of LNAPL recovery, operational time, and other parameters that indicate system performance would be made by Navy personnel during the full-scale bioslurper testing.

Section 8.0: REPORTING

The section describes the reports to be generated. For consistency, the following units will be used:

— English measurements for length, volume, flow, and mass, specifically:

- feet and inches for length
- gallons and ft^3 for volume
- cfh and cfm for flow
- lb for mass

— Metric units for concentrations and rates, specifically:

- mg/L for aqueous concentrations
- mg/kg for soil concentrations
- mg/(kg·day) for hydrocarbon degradation

— Gaseous concentrations and oxygen utilization rates as follows:

- ppmv for hydrocarbons (parts per million, by volume)
- percent (%) for oxygen, carbon dioxide, and He (percent by volume, i.e., L × 100%/L)
- %/hr for oxygen utilization.

To avoid confusion when discussing gases, the term percent (%) will refer only to concentration. Relative changes will be expressed as fractions. For example, if the oxygen concentration changes from 20% to 15%, the change will be referred to as a 5% reduction or a fractional reduction of 0.25, *not* a 25% reduction.

8.1 Monthly Reports. The contractor will provide a written monthly progress report outlining the work accomplished for the month, the problems encountered, approaches to overcome the problems, and expected progress for the following month. Included in this report will be the monthly expenditures and the accumulated expenditures to date.

8.2 Verbal Communication. The contractor will maintain communication with the project officer and the Base POC and will report on field activities and associated problems. Oral reports will be made to either the project officer or Base POC upon request, and at least weekly to the project officer.

Section 9.0: RECORD OF DATA AND QUALITY ASSURANCE

A project record book will be maintained during the field tests to record events pertaining to site activities, including sampling, changes in process conditions (flow, temperature, and pressure), equipment failure, location of the monitoring wells and monitoring points, calibration checks, and data for the respiration/air permeability tests and extended bioslurper tests. The record book will be reviewed by the contractor's project manager.

Quality assurance will be implemented throughout the project through quality planning, quality control, and quality assessment. The field analytical instruments will be calibrated prior to use each day with purchased calibration standards. Field blanks will consist of ambient air drawn through the entire sampling train setup in an uncontaminated area of the field site. Quality assurance activities include a review of all field activities and procedures by the project manager to ensure compliance with this protocol and with the quality guidelines. Monthly reports to the project officer will include any significant quality assurance problems and recommended solutions.

Section 10.0: REFERENCES

ABB Environmental Services, Inc. 1996. *RCRA Facility Investigation: Group II Solid Waste Management Units*, prepared for the Naval Facilities Engineering Command, North Charleston, South Carolina.

ABB Environmental Services, Inc. 1995. *Corrective Action Program General Information Report*, prepared for the Naval Facilities Engineering Command, North Charleston, South Carolina.

ABB Environmental Services, Inc. 1994. Draft Interim Measures Workplan, prepared for the Naval Facilities Engineering Command, North Charleston, South Carolina.

Wickram, G.B., J.A. Kittel, R.E. Hoeppel, R. Kratzke, E. Drescher, J.T. Gibbs, M.C. Place, and L.A. Smith. 1996. *Best Practices Manual for Bioslurping*, Technical Memorandum TM-2191-ENV, prepared for the Naval Facilities Engineering Service Center, Port Hueneme, California.

APPENDIX A

Well Construction Details

TITLE: Maypart Naval Station, Mayport, FL	LOG of WELL: MPT-8-MW2S	BORING NO. MPT-8-2
ENT: SOUTHERN DIVISION, NAVFACENGCOM		PROJECT NO: 5097-04

CONTRACTOR: MONITOR TESTING		DATE STARTED: 9/17/87	COMPLTD: 9/17/87
METHOD: H.S.A.	CASE SIZE: 2"	SCREEN INT.: 5-17' ?	PROTECTION LEVEL: D
TOC ELEV.: 14.00 FT.	MONITOR INST.: Hnu	TOT DPTH: 15.0FT.	DPTH TO ▽ 9.50 FT.
LOGGED BY: M. C. Diblin	WELL DEVELOPMENT DATE: 9/17/87		SITE: #8

DEPTH FT.	LABORATORY SAMPLE ID.	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
		SS1	2.0/2'		Sand-fine to medium, tan, few shell fragments, dry, bottom/ tan to grey, many shells		SP	13,20,22,38	
5		SS2	1.7/2'		Sand-same as above, dark brown on the top, light grey at the bottom			17,21,30,56	
	YES	SS3	1.1/2'		Sand-same as above			12,13,20,22	
		SS4	1.1/2'		Sand-fine to medium, grey, shells and fragments, grading to fine sand			8,9,13,19	▽
15		SS5	2.0/2'		Sand-same as abov, light grey, with many shells			4,7,9,13	
20									
25									
30									

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TITLE: Mayport Naval Station, Mayport, Fl.	LOG of WELL: MPT-8-MW3S		BORING NO. MPT-8-3
CLIENT: SOUTHERN DIVISION, NAVFACENGCOM			PROJECT NO: 5087-04
CONTRACTOR: MONITOR TESTING		DATE STARTED: 9/16/87	COMPLTD: 9/16/87
METHOD: H.S.A.	CASE SIZE: 2"	SCREEN INT.: 5-15'	PROTECTION LEVEL: D
TOC ELEV.: 14.10 FT.	MONITOR INST.: Hnu	TOT DPTH: 15.0FT.	DPTH TO ∇ 9.50 FT.
LOGGED BY: M. C. Diblin	WELL DEVELOPMENT DATE: 9/16/87		SITE: #8

DEPTH FT.	LABORATORY SAMPLE ID.	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	SOIL CLASS	BLOWS/6-IN
		SS1	1.4/2'		Sand-fine to medium, light tan, shell fragments, dry	SP	7,13,20,28
5		SS2	1.1/2'		Sand-same as above, interbedded with dark brown shells		13,14,16,7
	YES	SS3	1.6/2'		Sand-same as above, some dark brown		10,10,12,8
					Sand-top (0.5')/ fine, tan, shells, middle (0.5-0.55')/ blue shells bottom/ fine to medium, graded to light grey, shells		
		SS4	1.4/2'		Sand-fine to medium, grey, shells and fragments, grading to fine sand		17,17,15,7
15		SS5	2.0/2'		Sand-same as abov, many shells and fragments		17,21,21,37
20							
25							
30							

WELL DATA

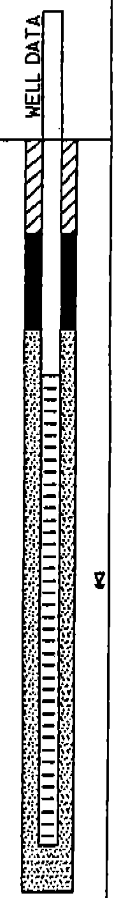

 ABB ENVIRONMENTAL SERVICES, INC.

TITLE: Mayport Naval Station, Mayport, Fl.	**LOG of WELL:** MPT-8-MW4S	**BORING NO.** MPT-8-MW4S
CLIENT: SOUTHERN DIVISION, NAVFACENGCOM		**PROJECT NO:** 7533-84
CONTRACTOR: GROUNDWATER PROTECTION, INC.	**DATE STARTED:** 1/14/93	**COMPLTD:** 1/14/93
METHOD: H.S.A. / **CASE SIZE:** 2"	**SCREEN INT.:** 5-15'	**PROTECTION LEVEL:** D
TOC ELEV.: 11.90 FT. / **MONITOR INST.:** F.I.D.	**TOT DPTH:** 15.5FT.	**DPTH TO ▽** 10.18 FT.
LOGGED BY: Felix Rizk	**WELL DEVELOPMENT DATE:** 1/17/93	**SITE:** #8

DEPTH FT.	LABORATORY SAMPLE ID.	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
0–2	MPT8 MS04-2	X	100%	0.0	ORGANIC SOIL - dark brown, loamy, w/ some shell fragments over SAND - fine, tan, dry (bottom 2")		OL / SP	12,10,14,15*	
4–6 (5)			50%	0.0	ORGANIC SOIL - dark brown, loamy, w/ some shell fragments		OL	2,2,1,2	
6–8			100%	0.0	ORGANIC SOIL -same as above (top 6") over SAND - fine, tan, moist, w/ some fine shell fragments		SP	4,4,6,8	
8–10	MPT8 MS04-6	X	100%	80	SAND - fine, tan, some shells, w/ hydrocarbon odor			12,12,12,20*	▽
15.5					Boring Terminated at 15.5 feet				
					* Use of non-standard 3" split-spoon sampler for sample recovery at these depths is reflected in the higher blow counts				

Depth scale: 5, 15, 20, 25, 30

TITLE: Mayport Naval Station, Mayport, Fl.		**LOG of WELL:** MPT-8-MW7S	**BORING NO.** MPT-8-MW7S
ENT: SOUTHERN DIVISION, NAVFACENGCOM			**PROJECT NO:** 7533-84
CONTRACTOR: GROUNDWATER PROTECTION, INC.		**DATE STARTED:** 1/18/93	**COMPLTD:** 1/18/93
METHOD: H.S.A.	**CASE SIZE:** 2"	**SCREEN INT.:** 5-15'	**PROTECTION LEVEL:** D
TOC ELEV.: 11.73 FT.	**MONITOR INST.:** F.I.D.	**TOT DPTH:** 15.5FT.	**DPTH TO ▽** 8.38 FT.
LOGGED BY: Felix Rizk	**WELL DEVELOPMENT DATE:** 2/1/93		**SITE:** #8

DEPTH FT.	LABORATORY SAMPLE ID.	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
0–2	MPT8 MS07-2	X	100%	0.0	ORGANIC SOIL - dark brown, loamy, w/ some shell fragments		OL	4,8,8,10	
4–6			75%	0.0	SAND - fine, tan, shelly (approx. 30%), moist		SP	4,11,9,15	
7–9	MPT8 MS07-9	X	100%	3000	SAND - medium to fine, dark gray, shelly w/ hydrocarbon odor			21,20,19,25*	▽
15.5					Boring Terminated at 15.5 feet				

Depth scale: 5, 15, 20, 25, 30

*Use of non-standard 3" split-spoon for sample recovery is reflected in the higher blow counts at these depths

TITLE: Naval Station Mayport, Mayport, FL	LOG of WELL: MPT-8-MW11S	BORING NO. MPT-8-MW11S
CLIENT: SOUTHERN DIVISION, NAVFACENGCOM		PROJECT NO: 8533-04

CONTRACTOR: LAYNE ENVIRONMENTAL SERVICES, INC.		DATE STARTED: 07/28/94	COMPLTD: 07/28/94
METHOD: 4.25" HSA	CASE SIZE: 2"	SCREEN INT.: 5-15 FT.	PROTECTION LEVEL: D
TOC ELEV.: 11.48 FT.	MONITOR INST.: FID	TOT DPTH: 15.5FT.	DPTH TO ▽ FT.
LOGGED BY: P. Craine	WELL DEVELOPMENT DATE: 08/05/94		SITE: 8

DEPTH FT.	LABORATORY SAMPLE ID.	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
					Silty Sand-fine to medium, with shell fragments.		SM		
				0				Posthole	
					Silty Sand-fine, gray, with trace of shell fragments.				
5			1/2					11,8,7,8	
10					Silty Sand-fine, tan to gray with shell fragments.				
			0.8/2	250				3,4,6,8	
15				30	Silty Sand-fine to medium, brown to dark gray with trace of shell fragments.			2,1,1,1	
			1/2						
					TOTAL DEPTH OF BORING = 15.5' BLS				
20									

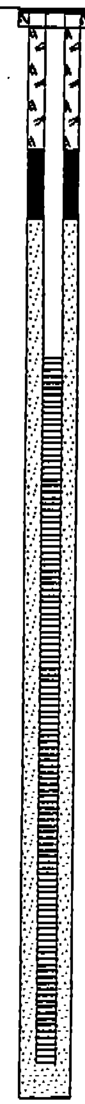

 ABB ENVIRONMENTAL SERVICES, INC.

TITLE: Naval Station Mayport, Mayport, FL.	**LOG of WELL:** MPT-8-MW15S	**BORING NO.** MPT-8-MW15S
CLIENT: SOUTHERN DIVISION, NAVFACENGCOM		**PROJECT NO:** 8533-04
CONTRACTOR: LAYNE ENVIRONMENTAL SERVICES, INC.	**DATE STARTED:** 07/27/94	**COMPLTD:** 07/27/94
METHOD: 4.25" HSA	**CASE SIZE:** 2" / **SCREEN INT.:** 5-15 FT.	**PROTECTION LEVEL:** D
TOC ELEV.: 10.03 FT.	**MONITOR INST.:** FID / **TOT DPTH:** 15.5FT.	**DPTH TO ▽** 8.5 FT.
LOGGED BY: P. Craine	**WELL DEVELOPMENT DATE:** 08/05/94	**SITE:** 8

DEPTH FT.	LABORATORY SAMPLE ID.	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
0–5				0	Silty Sand-fine, dark brown.		SM	Posthole	
5			1.8/2	0	Silty Sand-fine, trace clay, tan to brown.			2,2,4,6	
10			1/2	80	Silty Sand-fine to medium, with shell fragments, gray.			3,5,8,9	
15			1/2	300	Silty Sand-fine, gray.			1,1,1,1	
					TOTAL DEPTH OF BORING = 15.5' BLS				
20									

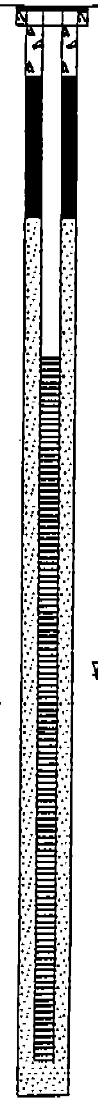

 ABB ENVIRONMENTAL SERVICES, INC.