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TREATABILITY STUDY WORK PLAN NUMBER 2 DATA COLLECTION PLAN FOR ASSESSING AIR SPARGING OPERABLE UNIT 4 (OU4) NTC ORLAND FL

4/1/1998

ABB ENVIRONMENTAL SERVICES, INC

TREATABILITY STUDY WORK PLAN NO.2
DATA COLLECTION PLAN FOR ASSESSING AIR SPARGING
OPERABLE UNIT 4

NAVAL TRAINING CENTER, AREA C
ORLANDO, FLORIDA

UNIT IDENTIFICATION CODE: N65298
CONTRACT NO.: N62467-89-D-0317/135

APRIL 1998

SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
NORTH CHARLESTON, SOUTH CAROLINA
29419-9010

PRINTED ON RECYCLED PAPER

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ORLANDO, FLORIDA

Unit Identification Code: N65298

Contract No.: N62467-89-D-0317/135

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Barbara Nwokike, Code 1873, Engineer-in-Charge

April 1998

CERTIFICATION OF TECHNICAL
DATA CONFORMITY (MAY 1987)

The Contractor, ABB Environmental Services, Inc. (ABB-ES), hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. N62467-89-D-0317/135 are complete and accurate and comply with all requirements of this contract.

DATE: April 27, 1998

NAME AND TITLE OF CERTIFYING OFFICIAL: John Kaiser
Task Order Manager

NAME AND TITLE OF CERTIFYING OFFICIAL: Mark Salvetti
Project Technical Lead

(DFAR 252.227-7036)

NTC-OU4.WP2
SAS.04.98

This work plan was prepared to present the technical approach for evaluating air sparging as a potential source area and groundwater remedial alternative at Operable Unit 4 at the Naval Training Center, Orlando, Florida. The engineering evaluation and professional opinions rendered in this document were conducted or developed in accordance with commonly accepted procedures consistent with applicable standards of practice.

Willard A. Murray, P.E.

4/29/98

Senior Consulting Engineer
Professional Engineer No. PE039866
Expires February 28, 1999

FOREWORD

To meet its mission objectives, the U.S. Navy performs a variety of operations, some requiring the use, handling, storage, or disposal of hazardous materials. Through accidental spills and leaks and conventional methods of past disposal, hazardous materials may have entered the environment in ways unacceptable by today's standards. With growing knowledge of the long-term effects of hazardous materials on the environment, the Department of Defense (DOD) initiated various programs to investigate and remediate conditions related to suspected past releases of hazardous materials at their facilities. Two of these programs are the Installation Restoration (IR) program and the Base Realignment and Closure (BRAC) program.

The IR program complies with the Base Closure and Realignment Act of 1988 (Public Law 100-526,102 Statute 2623) and the Defense Base Closure and Realignment Act of 1990 (Public Law 101-510, 104 Statute [1808]), which require the DOD to observe pertinent environmental legal provisions of the Comprehensive Environmental Response, Compensation, and Liability Act, Executive Order 12580, and the statutory provisions of the Defense Environmental Restoration Program, the National Environmental Policy Act, and any other applicable statutes that protect natural and cultural resources.

Originally, the Navy's part of this program was called the Naval Assessment and Control of Installation Pollutants (NACIP) program. Early reports reflect the NACIP process and terminology. The Navy eventually adopted the program structure and terminology of the standard IR program.

The IR program is conducted in several stages as follows:

- Preliminary Assessment (PA),
- A Site Inspection (SI) (formerly the PA and SI steps were called the Initial Assessment Study under the NACIP program),
- Remedial Investigation and Feasibility Study, and
- Remedial Design and Remedial Action.

The goal of the BRAC program is to expedite and improve environmental response actions to facilitate the disposal and reuse of a BRAC installation while protecting human health and the environment.

The Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), the U.S. Environmental Protection Agency, and the Florida Department of Environmental Protection collectively coordinate the cleanup activities through the BRAC cleanup team, called the Orlando Partnering Team, in Orlando. This team approach is intended to foster partnering, accelerate the environmental cleanup process, and expedite timely, cost-effective, and environmentally responsible disposal and reuse decisions.

Questions regarding the BRAC program at Naval Training Center, Orlando should be addressed to the SOUTHNAVFACENGCOM BRAC Environmental Coordinator, Mr. Wayne Hansel, Code 18B7, at (407) 646-5294 or SOUTHNAVFACENGCOM Engineer-in-Charge, Ms. Barbara Nwokike, Code 1873, at (803) 820-5566.

EXECUTIVE SUMMARY

Operable Unit (OU) 4 is composed of Study Areas 12, 13, and 14 at Area C. Building 1100, located in Study Area 13, was constructed in 1943 and was used as a laundry and dry-cleaning facility, serving the entire military base.

A plume of chlorinated solvent contaminated groundwater originating from the area around Building 1100 and migrating into the adjacent Lake Druid was identified during site investigations conducted at OU 4. Volatile organic compounds (VOCs) detected in groundwater and surface water from Lake Druid included tetrachloroethene (PCE), trichloroethene (TCE), *cis*-1,2-dichloroethene (DCE), *trans*-1,2-DCE, 1,1-DCE, and vinyl chloride. Source areas appear to be multiple and are likely located adjacent to and beneath Building 1100. An Interim Remedial Action, consisting of two recirculation wells, has been implemented to intercept and treat the majority of the contaminated groundwater before reaching Lake Druid.

At OU 4, an initial technology screening evaluation was conducted to evaluate remedial options for contaminated groundwater and source area treatment. Remedial technologies that were identified for potential treatability study at OU 4 include phytoremediation; air sparging; *in situ* chemical oxidation; and natural attenuation. This work plan was prepared as part of the treatability study process to present the technical approach for evaluating air sparging at OU 4.

Air sparging was selected based on the type of contaminants present in the groundwater (PCE and its degradation products) and their ability to readily volatilize. If successfully piloted, air sparging could be used for source removal and to treat areas with high concentrations of VOCs in groundwater.

This work plan presents the technical scope of work and schedule for conducting fieldwork to determine if air sparging is a feasible technology for OU 4. The pilot study is intended to determine if site-specific conditions may inhibit or prohibit the use of air sparging at OU 4, and to establish necessary design and performance criteria for full-scale implementation. These criteria include radius of influence, operating pressure, optimum air injection rate, and contaminant mass removal efficiency. The applicability of this technology as a groundwater or source area treatment remedy will be determined from a performance, implementability, and cost review during the Feasibility Study.

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Operable Unit 4
Naval Training Center, Area C
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Appendix B: Air Emissions Estimate

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GLOSSARY

ABB-ES	ABB Environmental Services, Inc.
bls	below land surface
BRAC	Base Realignment and Closure (Act)
cfm	cubic feet per minute
COC	chain of custody
CO_2	carbon dioxide
DCE	dichloroethene
DO	dissolved oxygen
°F	degrees Fahrenheit
FDEP	Florida Department of Environmental Protection
FID	flame ionization detector
FS	Feasibility Study
FSP	field sampling plan
GMP	groundwater monitoring point
IDW	investigation-derived wastes
IRA	interim remedial action
mg/ℓ	milligrams per liter
NAS	Naval Air Station
NTC	Naval Training Center
OU	Operable Unit
PCE	tetrachloroethene
POP	Project Operations Plan
ppb	parts per billion
ppm	parts per million
psi	pounds per square inch
RI	remedial investigation
ROI	radius of influence
SOUTHNAV-FACENGCOM	Southern Division, Naval Facilities Engineering Command
TCE	trichloroethene
USEPA	U.S. Environmental Protection Agency
VC	vinyl chloride
VMP	vapor monitoring point
VOC	volatile organic compounds

1.0 INTRODUCTION

ABB Environmental Services, Inc. (ABB-ES), under contract to Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), has prepared this work plan for an air sparging pilot study at Operable Unit (OU) 4, at the Naval Training Center (NTC), Area C, in Orlando, Florida. This work plan has been prepared under contract number N62467-89-D-0317/135.

Remedial technologies that may be effective in treating groundwater contaminated with volatile organic compounds (VOCs) at OU 4 have been screened for evaluation prior to preparation of the OU 4 Feasibility Study (FS). Technologies that require additional information regarding performance, implementability, and full-scale cost to adequately perform a feasibility assessment have been recommended for further evaluation during treatability studies. Ordinarily, screening of remedial technologies and treatability studies would be executed during the FS process following the remedial investigation (RI). However, the site screening and interim remedial action (IRA) activities conducted at OU 4 have provided sufficient site characterization data to allow the technology screening and treatability studies to run concurrent with the RI.

Remedial technologies that were identified for potential treatability studies at OU 4 include phytoremediation; air sparging; *in situ* chemical oxidation; and natural attenuation. This work plan was prepared as part of the treatability study process to present the technical approach for evaluating air sparging at OU 4.

This work plan has incorporated elements of the Project Operations Plan (POP) (ABB-ES, 1997a), which contains the requirements of a Quality Assurance Project Plan, Health and Safety Plan, and elements of a Field Sampling Plan (FSP) related to sampling equipment, procedures, and sample handling and analysis. Other FSP elements specific to this site, including sampling objectives and sample location and frequency, will be addressed in this work plan. A site-specific addendum to the health and safety plan found in the POP is included as an Appendix to this document.

1.1 SITE DESCRIPTION. OU 4 is composed of Study Areas 12, 13, and 14 at Area C (Figure 1-1 and 1-2). Building 1100, located in Study Area 13, was constructed in 1943 and was used as a laundry and dry-cleaning facility, serving the entire military base. Prior to construction of the facility in 1943, the land was undeveloped. The laundry was closed in 1994. Building 1100 (the laundry) was identified as a site where releases of hazardous materials had occurred.

Several investigations have already occurred at OU 4, either under the Base Realignment and Closure (BRAC) Act site screening program or under subsequent efforts to characterize the contamination discovered during the site screening. Preliminary data from the OU 4 RI are also currently available. Results from the investigations conducted at OU 4 through July 1997 are summarized in the OU 4 RI Workplan (ABB-ES, 1997b).

These efforts have identified a plume of chlorinated solvent-contaminated groundwater originating from the area around the former base laundry and migrating into the adjacent Lake Druid. Contour lines illustrating the approximate defined boundary of the 100 parts per billion (ppb) total VOCs are shown on Figure 1-3. VOCs detected in groundwater and surface water from Lake

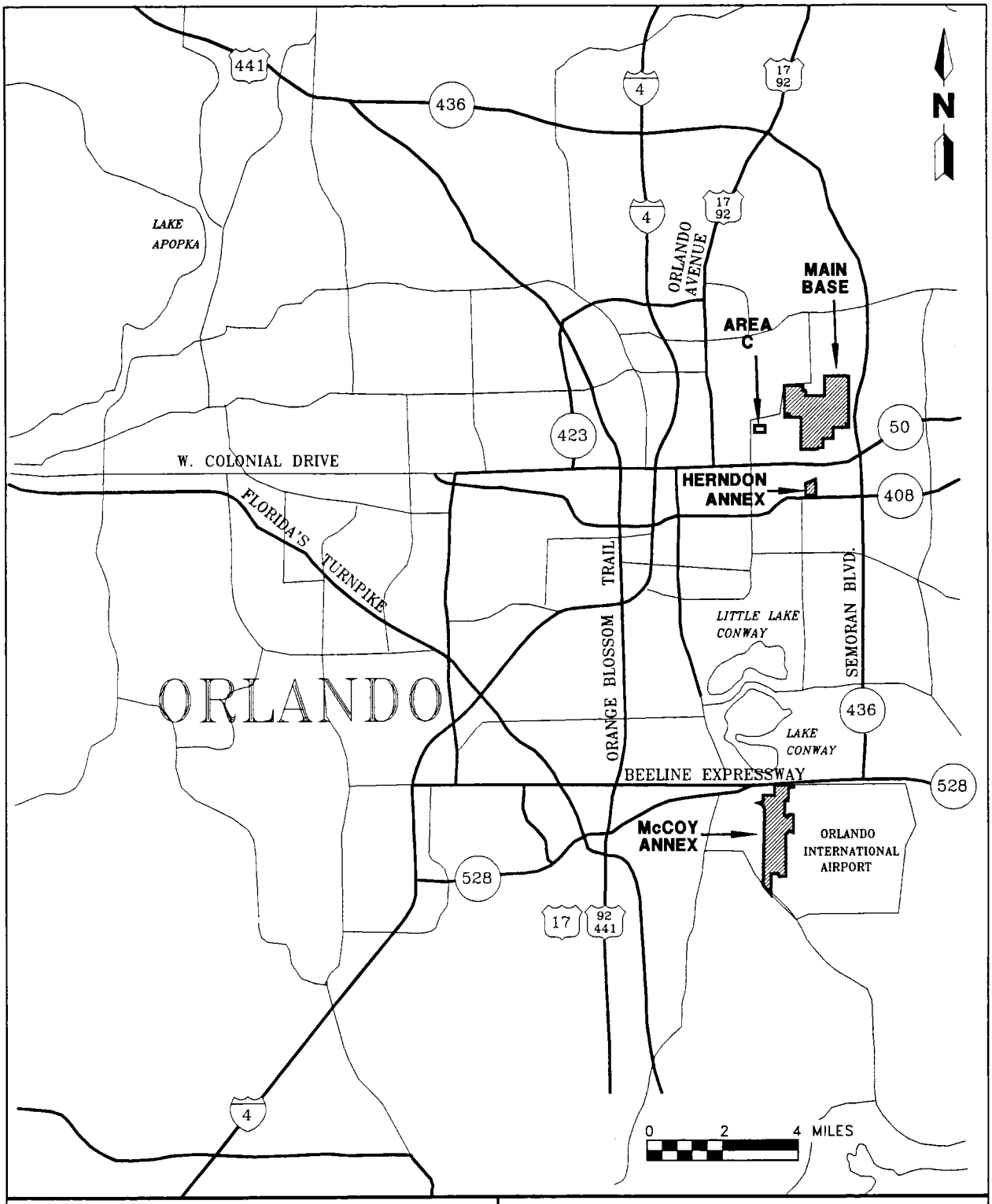

FIGURE 1-1
SITE LOCATION MAP

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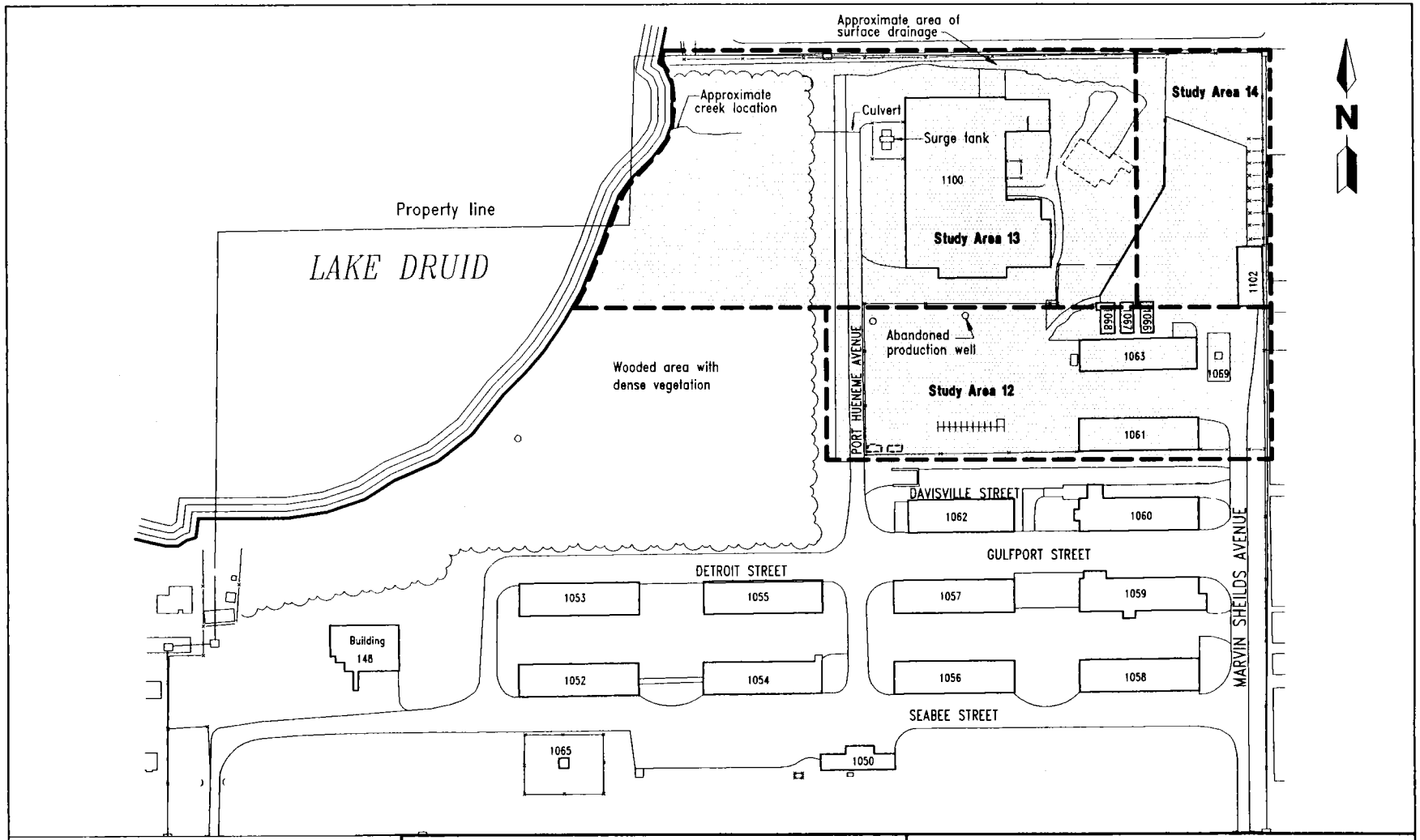

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FIGURE 1-2
MAP OF AREA C

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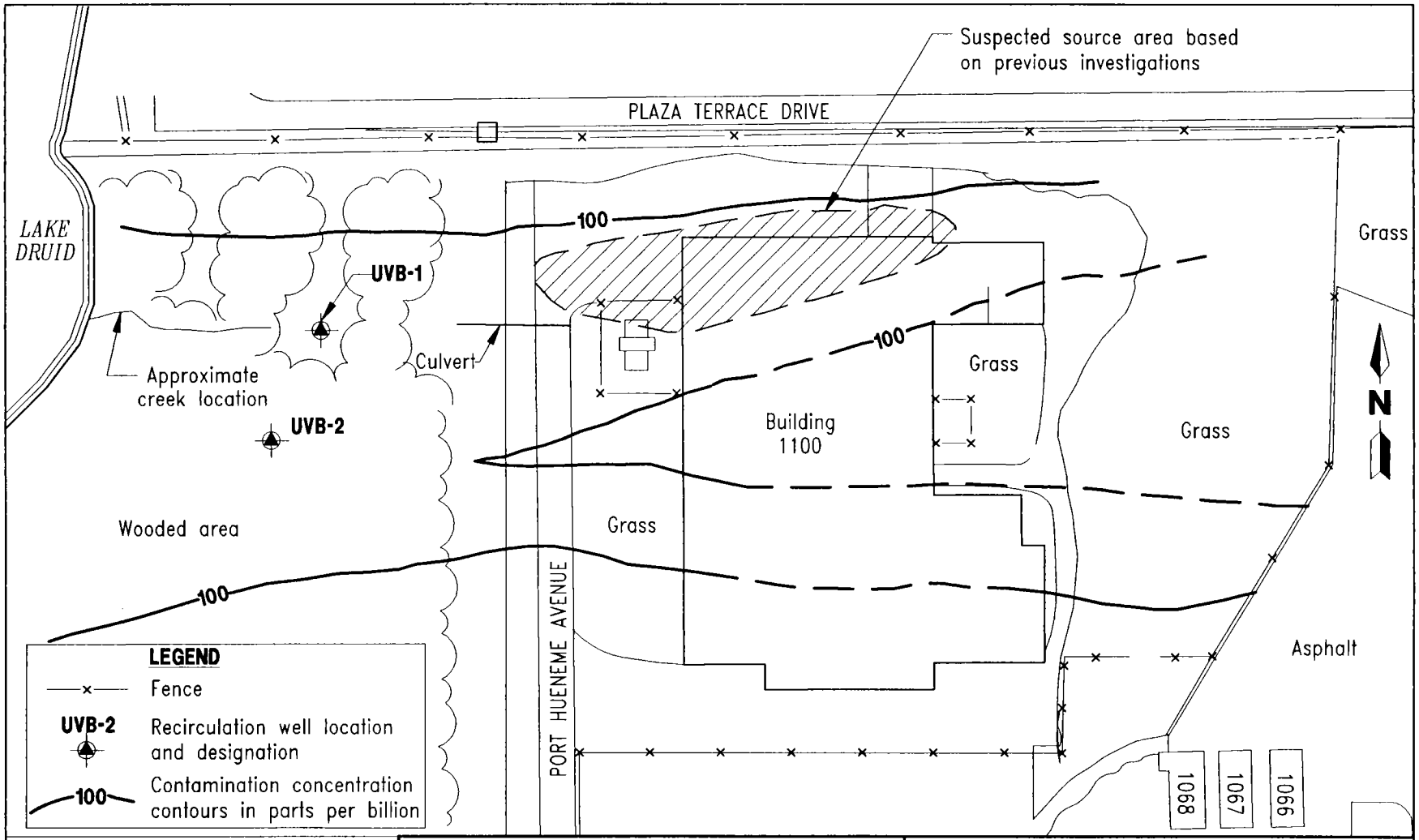

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FIGURE 1-3
APPROXIMATE OPERABLE UNIT 4 GROUNDWATER CONTAMINANT PLUME AND SUSPECTED SOURCE AREA(S)

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Druid included tetrachloroethene (PCE), trichloroethene (TCE), *cis*-1,2-dichloroethene (DCE), *trans*-1,2-DCE, 1,1-DCE, and vinyl chloride (VC). Source areas appear to be multiple and are likely located adjacent to and beneath the former laundry, Building 1100. The approximate extent of the suspected multiple source areas is also shown on Figure 1-3. An IRA, consisting of two recirculation wells (UVB-1 and UVB-2, locations shown on Figure 1-3), has been implemented to intercept and treat the majority of the contaminated groundwater before reaching Lake Druid.

Based on the OU 4 Focused Field Investigation (ABB-ES, 1997c) and the source investigation (ABB-ES, 1997d), the chlorinated solvent groundwater plume ranges from approximately 4 to 45 feet below land surface (bls) with total VOCs in excess of 30 milligrams per liter (mg/ℓ) in the source area(s), and up to approximately 6 mg/ℓ between the laundry and Lake Druid. The water table between Lake Druid and the laundry varies seasonally from less than 1 foot to 4 feet bls.

1.2 EVALUATION OF AIR SPARGING AS A REMEDIAL ALTERNATIVE. In principle, air sparging is a relatively simple process of injecting air through wells, into an aquifer beneath the water table to strip VOCs from groundwater and residual pure product from the pore spaces. At OU 4, it is assumed that air sparging would be implemented by injecting atmospheric air into the aquifer with the use of a compressor. The injected air will rise through the matrix of the aquifer. When the injected air contacts the contaminated groundwater or pure product, it induces the mass transfer of VOCs into the air phase through volatilization. The stripped volatiles will then rise through the vadose zone and into the atmosphere.

In some cases, the sparging system works in conjunction with a vapor extraction system to enhance removal of the stripped volatiles from the vadose zone and capture the off-gases. The vadose zone at OU 4 varies seasonally from 1 to 4 feet thick. Due to the lack of vadose zone, a vapor extraction system is not proposed at this time. However, a suitable full-scale vapor collection system could be designed if the pilot study determines that one would be necessary to meet Florida Department of Environmental Protection (FDEP) air emission requirements.

Air sparging works best in homogeneous, coarse-grained materials, where air flow is relatively uniform and predictable. During this pilot study, the air flow migration patterns will be studied to determine if air sparging is an acceptable alternative with the geological conditions that exist at OU 4. Special attention will be placed on the dense layer of fine-grained sand approximately 18 to 22 feet bls to determine if the layer is impeding the air flow through the aquifer.

At OU 4, natural processes are partially degrading the contaminant plume as it migrates toward Lake Druid. The remedial goal at OU 4 is to "actively" lower the contaminant levels within the surficial aquifer, between the laundry and the lake, enough so that the natural processes can passively remediate the remainder of the chlorinated solvent groundwater plume prior to entering Lake Druid.

1.3 PURPOSE OF THE AIR SPARGING PILOT TEST. This work plan presents the technical scope of work and schedule for conducting fieldwork to determine if air sparging is a feasible technology to effectively reduce the areas of highest

groundwater contamination. The applicability of this technology as a groundwater treatment remedy will be determined from performance, implementability, and cost reviews during the FS.

1.4 AIR SPARGING PILOT TEST OBJECTIVES. The objective of the air sparging pilot test is to provide site-specific data supporting assessment of alternatives in the FS. Site-specific parameters to be evaluated during the pilot test are as follows:

1. breakthrough pressure (pressure at which the water column will be displaced and air begins to get injected into the aquifer)

2. optimum air flow rate (air flow rate that maximizes the radius of influence [ROI] and at which high contaminant mass removal rates can be maintained over an extended period of time)

3. ROI of the sparge well based on the distribution of the dissolved oxygen (DO), carbon dioxide (CO_2), pressure fields around the sparging well, water-level fluctuations, and vapor VOC concentrations in the vadose zone

1.5 ORGANIZATION OF THE AIR SPARGING WORK PLAN. The remainder of this work plan presents the pilot-test design, the test procedure and types of data to be collected, the methodology of the field and analytical programs, and methodology for data analysis and interpretation.

2.0 PILOT TEST IMPLEMENTATION

This chapter will describe the layout and necessary equipment to perform the air sparging pilot test. The test layout and well installation will be described followed by the description and arrangement of other necessary equipment. At the conclusion of this chapter, site closure and demobilization activities will be discussed.

2.1 AIR SPARGING TEST LAYOUT. During the RI, three monitoring wells, OLD-13-41B, OLD-13-42B, and OLD-13-43C were installed. Those three wells, plus two additional existing monitoring wells, OLD-13-07A and OLD-13-08C, will be utilized during the air sparging pilot test and are shown on Figure 2-1.

OLD-13-43C was installed to a total depth approximately 50 feet bls, with a 5-foot screen. OLD-13-43C will become the sparge well for this pilot test with an air sparging injection depth of approximately 45 feet bls (top of screen). A construction detail for OLD-13-43C is shown on Figure 2-2. Two additional wells, OLD-13-41B and OLD-13-42B, were each installed to a total depth of approximately 28 feet bls with 5-foot screens. OLD-13-07A is a water table well, installed to a total depth of 18.5 feet bls with a 15-foot screen. OLD-13-08C was installed to a total depth of approximately 62 feet bls with a 5-foot screen. OLD-13-41B, OLD-13-42B, OLD-13-07A, and OLD-13-08C, along with additional shallow wells will be monitored to gain insight as to the effects of the air sparging pilot test on the shallow and deep portions of the surficial aquifer, as well as any effects the dense fine sand layer may have on the effectiveness of the technology.

Previous air sparging pilot tests conducted at sites with lithology similar to that of OU 4 have shown ROIs between 70 and 150 percent of the sparge well depth. Therefore, it is expected that an injection depth of 45 feet would yield a ROI between 31 and 68 feet. Based on this estimate, 10 clusters of monitoring points will be installed (5 clusters to the south and 5 clusters to the east of OLD-13-43C) to evaluate the system performance.

Each cluster will consist of a groundwater monitoring point (GMP) installed approximately 18 feet bls and a vapor monitoring point (VMP) installed within the vadose zone, approximately 2 feet bls. Organic vapor field readings, water-level measurements, pressure readings, and groundwater samples to analyze for DO and CO_2 will be collected from GMPs to assist in estimating the ROI of the system. Groundwater samples will also be analyzed for VOCs at an off-site laboratory to assist in estimating the mass removal and efficiency of the system. The VMPs will be monitored for vapor off-gassing and VOCs to confirm the ROI and mass removal rate.

The five clusters of monitoring points located south of OLD-13-43C will have well groups spaced at 10, 25, 40, 55, and 75 feet from OLD-13-43C. The same spacing intervals will be used for clusters to the east of OLD-13-43C. The air sparge test layout is shown on Figure 2-1.

2.1.1 Monitoring Point Installation and Development The GMPs will be installed using a direct-push technology via ABB-ES's TerraProbe^{SM}. They will be 0.5-inch microwells with 3-foot screens installed approximately 18 feet bls. A GMP microwell construction detail is shown on Figure 2-3.

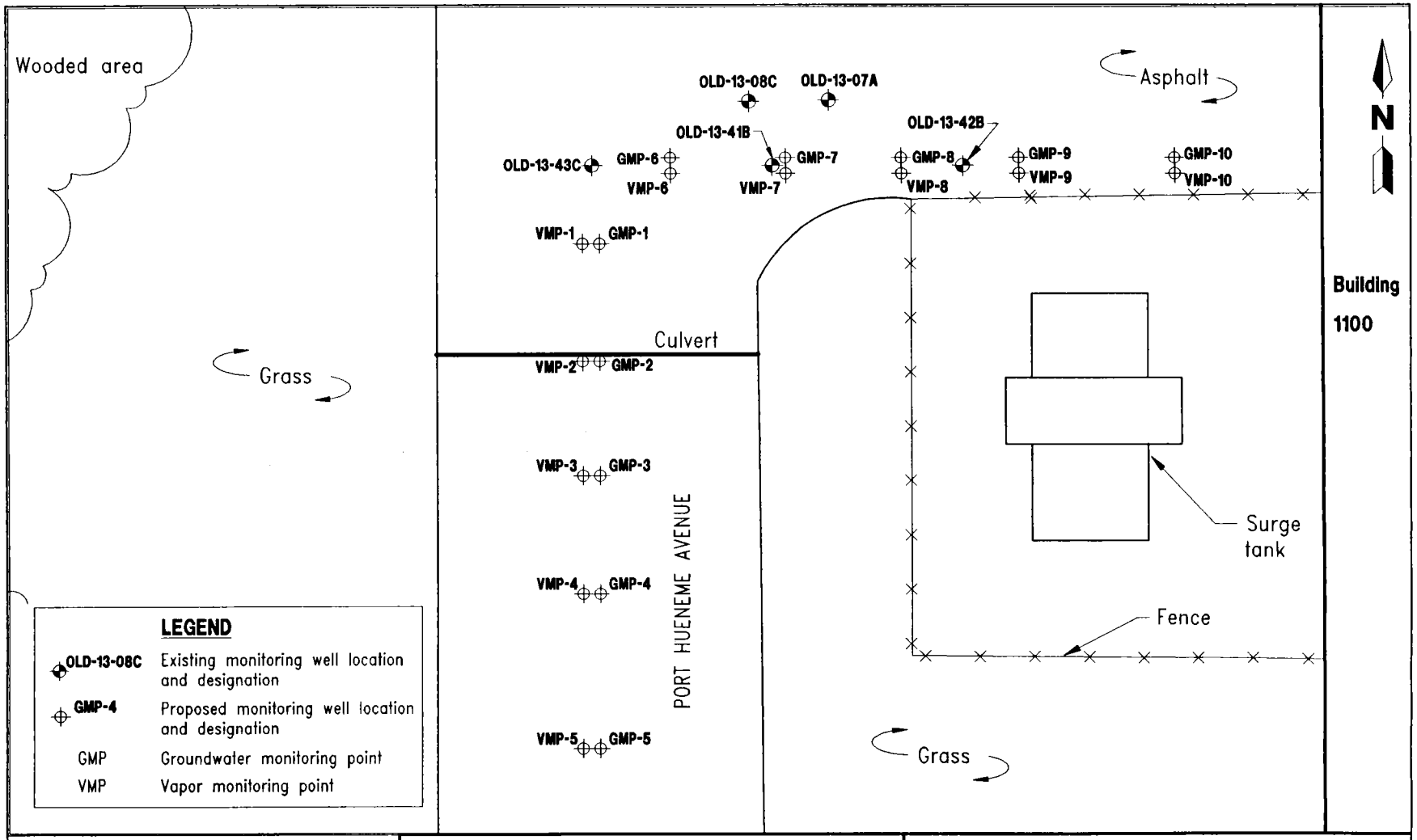

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FIGURE 2-1
AIR SPARGE PILOT-TEST LAYOUT

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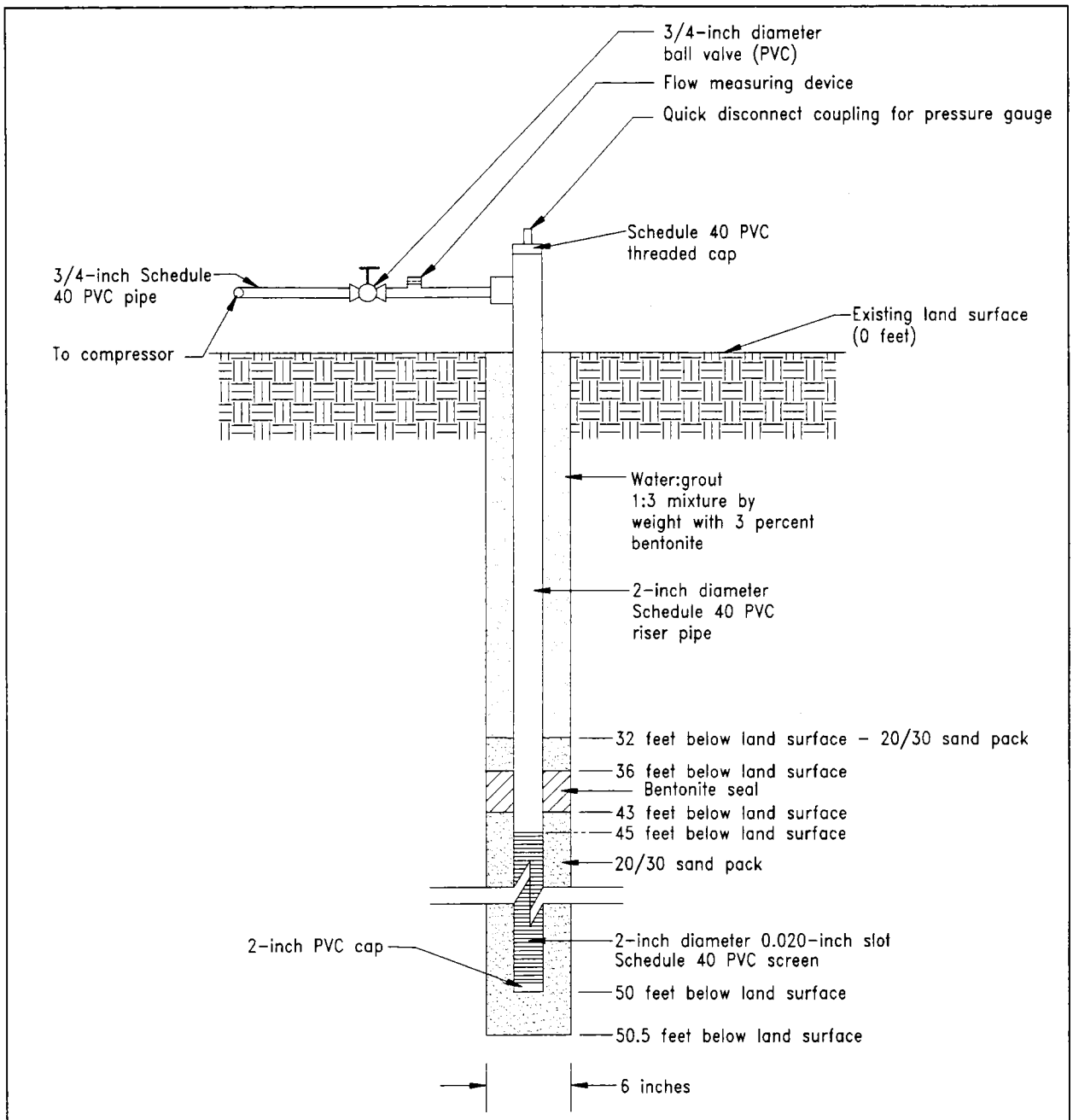

LEGEND:

PVC Polyvinyl chloride

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FIGURE 2-2
CONSTRUCTION DETAIL FOR OLD-13-43C

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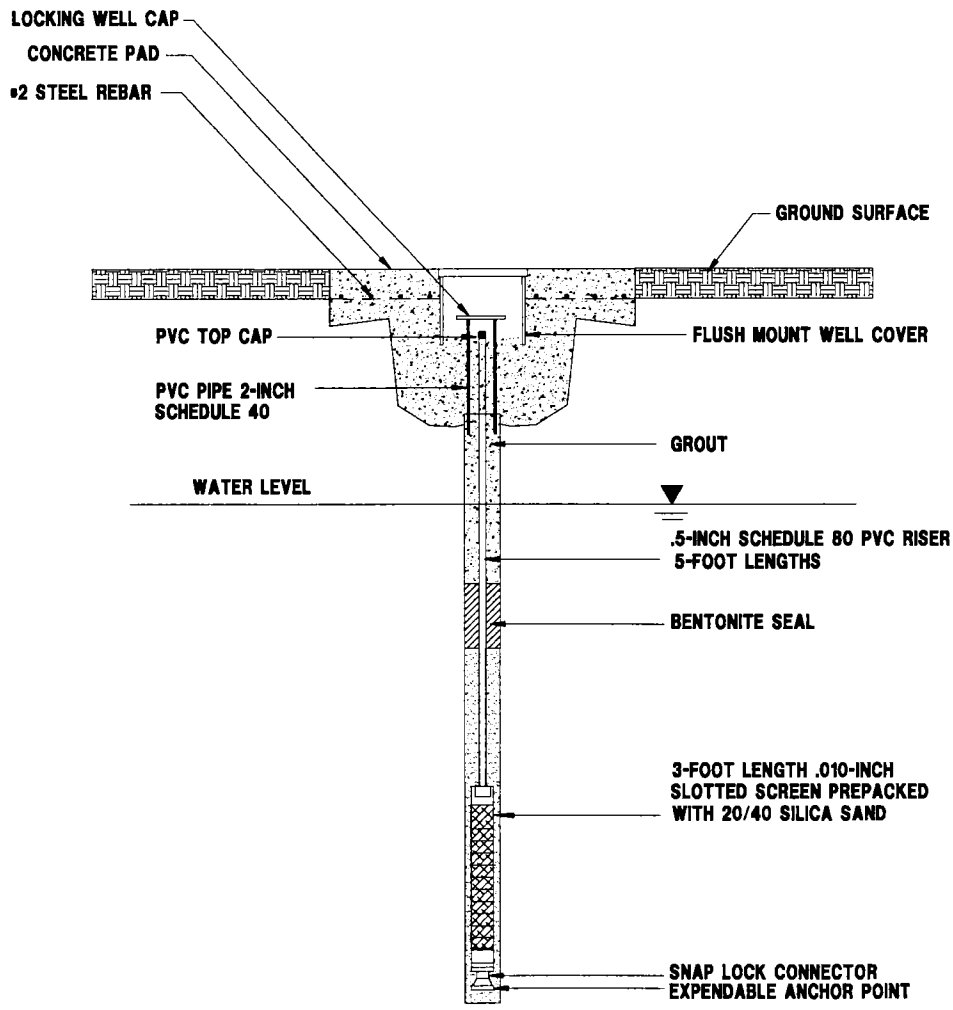

NOTE:
PVC = Polyvinyl chloride

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FIGURE 2-3
GROUNDWATER MONITORING POINT
MICROWELL CONSTRUCTION DIAGRAM

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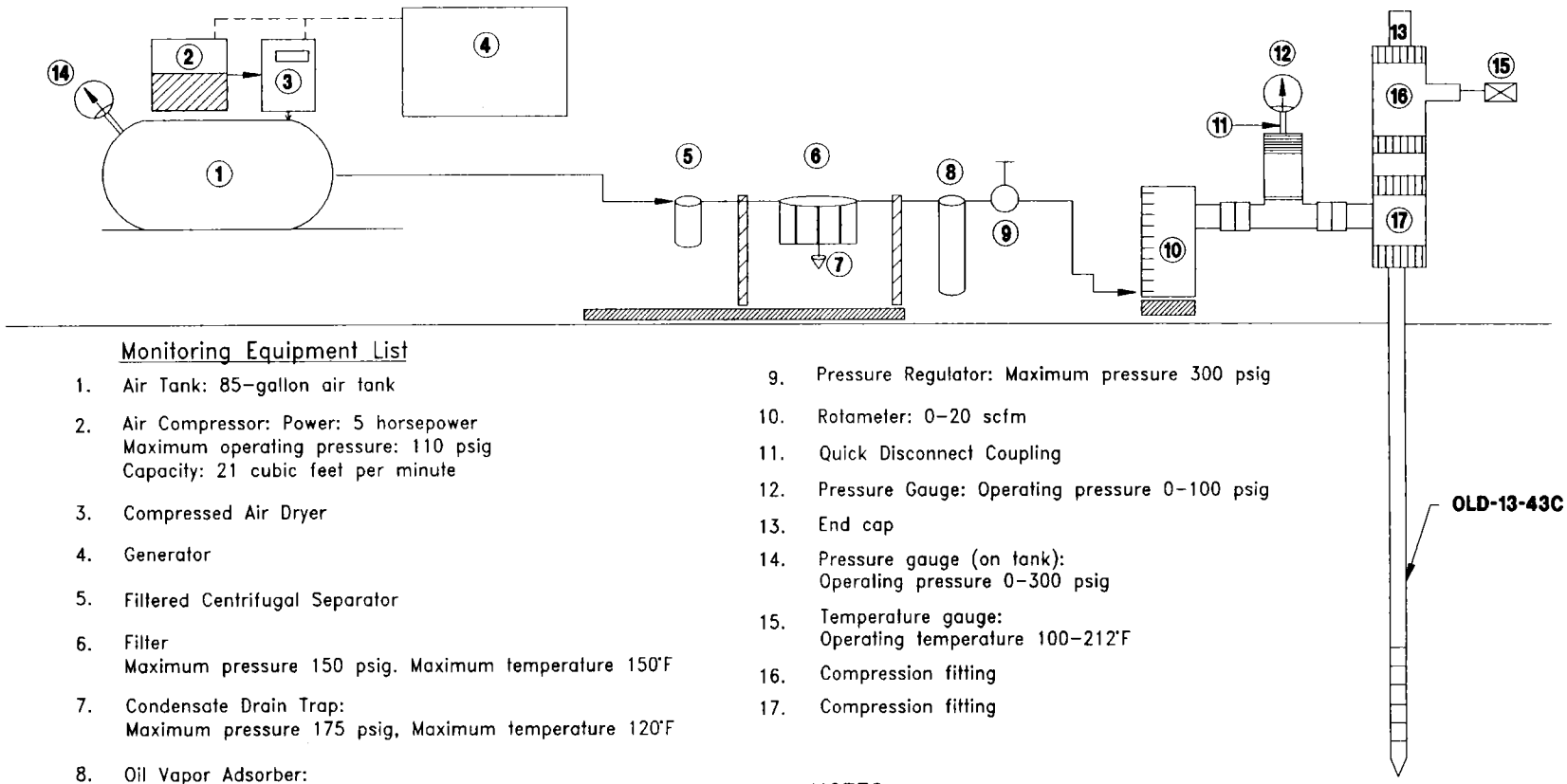
Development of the GMPs will be accomplished using a peristaltic pump. Pump tubing shall be lowered to the bottom of the well so that fines are agitated and removed from the well in the development water. Development shall continue until a minimum of 10 well casing volumes of water are removed from the well and the pH, temperature, specific conductivity, and redox potential of the groundwater have stabilized. Well development investigation-derived waste (IDW) will be collected and stored. Refer to the NTC, Orlando POP for further details about development procedures and IDW management (ABB-ES, 1997a).

The VMPs will be installed by hand augering approximately 2 feet bls and installing a 2-inch-diameter polyvinyl chloride screen. The screen will be attached to a small riser, and the boring will be sealed with grout to ensure air emissions escape only through the riser.

2.1.2 Air Sparging Equipment A schematic of the equipment layout is provided on Figure 2-4. The equipment and minimum performance requirements provided on Figure 2-4 are based on prior pilot testing conducted by ABB-ES at Naval Air Station (NAS) Cecil Field, Jacksonville, Florida. Not shown on Figure 2-4 are a water-level indicator, a peristaltic pump for sampling, and other assorted pressure gauges. The equipment list is a generic list and may change slightly depending upon the vendor providing the equipment.



Monitoring Equipment List

1. Air Tank: 85-gallon air tank
2. Air Compressor: Power: 5 horsepower
   Maximum operating pressure: 110 psig
   Capacity: 21 cubic feet per minute
3. Compressed Air Dryer
4. Generator
5. Filtered Centrifugal Separator
6. Filter
   Maximum pressure 150 psig. Maximum temperature 150°F
7. Condensate Drain Trap:
   Maximum pressure 175 psig, Maximum temperature 120°F
8. Oil Vapor Adsorber:
   Maximum pressure 175 psig, Maximum temperature 120°F
9. Pressure Regulator: Maximum pressure 300 psig
10. Rotameter: 0-20 scfm
11. Quick Disconnect Coupling
12. Pressure Gauge: Operating pressure 0-100 psig
13. End cap
14. Pressure gauge (on tank):
    Operating pressure 0-300 psig
15. Temperature gauge:
    Operating temperature 100-212°F
16. Compression fitting
17. Compression fitting

NOTES:

psig = pounds per square inch gauge
scfm = standard cubic foot per minute

NOT TO SCALE

FIGURE 2-4
AIR SPARGING EQUIPMENT LAYOUT

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3.0 TEST PROCEDURE AND DATA COLLECTION

Test procedures for air sparging are provided in this chapter. Portions of these procedures will entail laboratory or field analyses of vapor and groundwater samples. Estimated air emissions and compliance with regulatory limits are discussed in Appendix B.

3.1 ESTIMATING BASELINE CONDITIONS. The following test procedure will be used to estimate baseline conditions for the air sparging pilot test:

- Measure and record the initial water level in OLD-13-43C, OLD-13-41B, OLD-13-42B, OLD-13-07A, OLD-13-08C, and GMPs 1 through 10.

- Collect baseline groundwater samples in accordance with Field Sampling and Analysis Procedures (Chapter 4.0) from OLD-13-43C, OLD-13-41B, OLD-13-42B, OLD-13-07A, OLD-13-08C, and GMPs 1 through 10. Samples will be shipped to an off-site laboratory for analysis of VOCs by U.S. Environmental Protection Agency (USEPA) Method 8021. Groundwater from each well will also be analyzed for DO and CO_2 using HACH test kits.

- Collect air samples from OLD-13-07A, and VMPs 1 through 10 in accordance with Field Sampling and Analysis Procedures (Chapter 4.0). Monitoring well OLD-13-07A is included as a vapor point because it is screened across the water table and because of the high concentration (approximately 30 mg/ℓ) of PCE in groundwater at this location. Samples will be shipped to an off-site laboratory for analysis of VOCs by USEPA Method TO14. Flame ionization detector (FID) readings will also be collected from each of the wells.

3.2 ESTABLISH INITIAL OPERATING PARAMETERS. The initial operation of the pilot study will determine the breakthrough pressure and flow rates necessary to maximize stripping efficiency.

3.2.1 Breakthrough Pressure The breakthrough pressure is defined as the air pressure necessary to initiate air sparging. This pressure must overcome the hydrostatic pressure of the water column above the point of injection and the capillary entry resistance to displace pore water in the formation. The capillary pressure is a function of the air/water surface tension and grain size. Finer sediments will have higher capillary entry pressures than courser sediments. At OU 4, the capillary pressure is expected to be insignificant compared to the hydrostatic pressure.

Breakthrough is reached when the water level in the sparge well has been driven down to the top of the screen and a continuous flow of air is released at the sparge well. Since the top of the screen in OLD-13-43C is 42 feet below the water table, the breakthrough pressure must at a minimum overcome the hydrostatic head of 42 feet (18.2 pounds per square inch [psi]). The breakthrough pressure will be determined using a step test beginning at 70 percent of the hydrostatic head (12.8 psi). The applied pressure will be increased 1 psi every 2 to 5 minutes until breakthrough is achieved. Once the breakthrough pressure is found, the test will be conducted by controlling the flow rate.

3.2.2 Air Flow Rate Once the operating pressure has been obtained, air flow rates between 1 and 15 cubic feet per minute (cfm) will be tested. The test will begin at 1 cfm and increase as site and test conditions begin to stabilize (i.e. groundwater mounding stabilizes or subsides). Changes in flow rates will occur on an as-needed basis. Stripping efficiency and ROI will be determined from organic vapor readings taken from the VMPs and periodic pressure measurements in the GMPs. The flow rate for the steady-state performance test will be determined when a flow rate is established that appears to produce the greatest ROI and maximizes stripping efficiency.

3.3 CONDUCT STEADY-STATE PERFORMANCE TEST. The steady-state performance test will be performed under 72-hour continuous operation at the breakthrough pressure and optimum air flow rate established during the initial tests.

Following start-up, air samples will be collected from VMP 1 through VMP 10 and OLD-13-07A and shipped to an off-site laboratory for analysis of VOCs by USEPA Method TO14.

The parameters listed below will be measured every 2 hours for the first 24 hours of continuous operation, and every 4 hours thereafter.

- compressor pressure, well-head pressure, temperature, and flow rate
- organic vapors by FID in parts per million (ppm) from VMP 1 through VMP 10, OLD-13-41B, OLD-13-42B, OLD-13-07A, and OLD-13-08C
- water-level readings from GMP 1 through GMP 10, OLD-13-41B, OLD-13-42B, OLD-13-07A, and OLD-13-08C
- groundwater samples from GMP 1 through GMP 10, OLD-13-41B, OLD-13-42B, OLD-13-07A, and OLD-13-08C for analysis of DO and CO_2
- measure pressure within GMP 1 through GMP 10, OLD-13-41B, OLD-13-42B, OLD-13-07A, and OLD-13-08C

At the midpoint of the test, groundwater samples will be collected from GMP 1 through GMP 10, OLD-13-41B, OLD-13-42B, OLD-13-07A, and OLD-13-08C. These groundwater samples will be shipped to an off-site laboratory for analysis of VOCs by USEPA Method 8021.

Air samples will be collected from VMP 1 through VMP 10 and OLD-13-07A during the 23rd, 47th, and 71st hours of operation. These air samples will be shipped to an off-site laboratory for analysis of VOCs by USEPA Method TO14.

At the end of the test, groundwater samples will be collected from GMP 1 through GMP 10, OLD-13-41B, OLD-13-42B, OLD-13-07A, OLD-13-08C, and OLD-13-43C and shipped to an off-site laboratory for analysis of VOCs by USEPA Method 8021. This sampling will be repeated 7 days and 21 days after completion of the pilot test to evaluate contaminant rebound.

4.0 FIELD SAMPLING AND ANALYSIS PROCEDURES

This chapter documents the field sampling procedures to be used during the air sparging pilot test.

4.1 GROUNDWATER SAMPLE COLLECTION FOR LABORATORY ANALYSIS. Groundwater samples will be collected using a low-flow technique as described in the NTC, Orlando POP (ABB-ES, 1997a). Samples will be collected before testing, at the halfway point, and three times after testing is complete (immediately, 7 days, and 21 days).

4.2 SAMPLING FOR LABORATORY VAPOR ANALYSIS. All vapor samples will be collected using the sampling technique outlined below to help ensure the collection of a representative sample.

- The sample must be obtained in such a way to assure that it is representative of actual emissions. The top of each sampling point will be sealed with a suitable air-tight cap with a sample port. An air sampling pump will be attached to the port and used to withdraw vapors from the sampling point and into a Tedlar bag. Clean or dedicated Teflon™ tubing will be used for sample collection.

- Immediately following collection, place the filled Tedlar bag into the cooler(s) and chill to 4 degrees Celsius.

- Record sample types and quantities collected and time and date of collection in the field logbook. Prepare chain-of-custody (COC) forms. Prepare samples for shipment to the laboratory.

4.3 FIELD VAPOR ANALYSIS. Field air monitoring equipment will include an organic vapor analyzer/FID and methane calibration gas. Operation and calibration methods described in instruction manuals and in the NTC, Orlando POP (ABB-ES, 1997a) for the recommended detectors should be followed. Calibration data and field measurements will be logged in the field logbook.

5.0 DATA ANALYSIS AND INTERPRETATION

Data collected from this pilot study will be reviewed, processed, and presented to aid in determining the suitability of air sparging as a source removal technology at OU 4. These results will be considered in the technology evaluation process required in the FS.

When evaluating the air-sparging pilot data, the focus will be as follows:

- determine whether site-specific factors would inhibit or prohibit the technology's use,
- establish the breakthrough pressure required to force the air into the aquifer matrix, and
- confirm the optimum air flow rate based on maximizing the ROI and assess contaminant mass removal effectiveness.

5.1 SITE-SPECIFIC FACTORS. Various factors may inhibit or prohibit the use of air sparging at OU 4. By measuring groundwater levels in GMPs, the extent of mounding can be determined. If excessive mounding is encountered, air sparging may not be a preferred alternative. It is probable that mounding will dissipate once a steady air flow is established; however, the determination of the extent of mounding will be critical at OU 4 because of the shallow vadose zone present.

Water level and pressure measurements collected from wells at different depth intervals will assist in determining the effect, if any, that the dense layer of fine sand has on the air flow channels through the aquifer. If water-level fluctuations are only seen deep in the surficial aquifer, then it could be concluded that the dense layer of fine sand is prohibiting the vertical air migration. Another indicator of a restrictive layer would be the absence of vapors in the VMPs.

5.2 BREAKTHROUGH PRESSURE AND FLOW RATE. Breakthrough pressure is the pressure needed to displace the water column to the point where air begins to be injected into the aquifer. Once the pressure is established, the air flow rate that maximizes the ROI and the contaminant mass removal rates will be determined.

5.3 RADIUS OF INFLUENCE. ROI will be estimated from vapor measurements recorded from the VMPs and from the DO and CO_2 concentrations along with water level and pressure measurements from the GMPs and monitoring wells at varying air flow rates.

5.4 MASS REMOVAL EFFECTIVENESS. The mass removal effectiveness will be estimated based on the vapor concentrations in the vadose zone and air flow rate being injected. These results can be used to estimate the VOC removal rate of a full-scale system for air permitting and treatment duration purposes.

5.5 APPLICABILITY OF AIR SPARGING TECHNOLOGY. The applicability of air sparging at OU 4 will be analyzed based on the findings from the pilot test study, which will be presented in a Technical Memorandum. A consideration of the site-specific factors, ROI, and mass removal effectiveness will be provided in the Technical Memorandum.

6.0 SCHEDULE

It is expected that this air sparging work plan will be presented to the Orlando Partnering Team in mid-March 1998. Procurement of equipment, well installations, system assembly, operation, and data collection could be completed within 60 days of work plan approval. A summary and interpretation of pilot study results will be provided as a Technical Memorandum within 60 days from pilot study completion.

REFERENCES

ABB Environmental Services, Inc. (ABB-ES). 1997a. *Project Operations Plan for Site Investigations and Remedial Investigations, Naval Training Center (NTC), Orlando, Florida.* Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina (August).

ABB-ES. 1997b. *Remedial Investigation and Feasibility Study Workplan, Operable Unit 4, NTC, Orlando, Florida.* Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina (July).

ABB-ES. 1997c. *Interim Remedial Action, Focused Field Investigation Report, Operable Unit 4, NTC, Orlando, Florida.* Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina (May).

ABB-ES. 1997d. *Technical Memorandum, Interim Remedial Action Focused Investigation/Source Confirmation Building 1100 Surge Tank, Operable Unit 4, NTC, Orlando, Florida.* Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina (May).

APPENDIX A

HASP ADDENDUM

Preface

The following pages constitute the Health and Safety Plan (HASP) addendum for the Naval Training Center (NTC), Orlando Project Operations Plan for Site Investigations and Remedial Investigations. This addendum must be used in conjunction with the existing generic HASP for NTC, Orlando. The pages in this addendum should be inserted, where indicated, in the generic HASP. The generic HASP, with these pages correctly inserted, completes the update of the NTC, Orlando HASP for the air sparging pilot study at Operable Unit (OU) 4.

2.3 SCOPE OF WORK (WORK PLAN). The air sparging pilot study will consist of the injection of air into the subsurface. The contaminants found in groundwater and potentially as residual pure product will volatilize into the injected air and discharge through the ground surface and specifically installed vapor monitoring points.

Objective: Install appropriate equipment to allow the pilot testing and monitoring of an air sparging system.

Methods:
- microwell installation by TerraProbe℠
- installation of vapor monitoring points by hand auger
- installation of appropriate piping to connect skid-mounted equipment to the sparge well

Objective: Establish if air sparging is a viable remediation technology for OU 4. Determine optimum air injection pressure and flowrate, and determine the sparging radius of influence and contaminant removal rates.

Methods:
- groundwater sampling
- pressure monitoring
- off-gas monitoring and sampling

2.4.5 Monitoring The work environment will be monitored to ensure that "Immediately Dangerous to Life and Health" or other dangerous conditions are identified. At a minimum, monitoring will include evaluations for combustible atmospheres, oxygen-deficient environments, and hazardous concentrations of airborne contaminants. The combustible gas meter, set to alarm at 10 percent of the lower explosive limit (LEL), will be continuously used.

2.4.6 Air Sampling To the extent feasible, the presence of airborne contaminants will be evaluated through the use of direct reading instrumentation. Information gathered will be used to ensure the adequacy of the levels of protection being used at the site and may be used as the basis for upgrading or downgrading the levels of protection in conformance with action levels provided in this HASP and at the direction of the site health and safety officer. Contaminants expected to be a concern at OU 4 are shown in Table 2-2.

The following sampling equipment will be used at the site:

1. PORTA-FID organic vapor analyzer (OVA), and
2. LEL/oxygen meter.

Refer to Appendix F for information on the calibration and maintenance of the equipment.

If the OVA reads steadily above background in the breathing zone, continue working in modified Level D until the OVA reads 8 ppm above background in the breathing zone, at which time upgrade to Level C. If the OVA reads 116 ppm (or greater) above background, upgrade to Level B.

If the LEL meter reads 10 percent of the LEL or greater, use nonsparking tools. IF the LEL meter reads 20 percent of the LEL or greater, stop work and evacuate the site.

Table 2-2
Contaminants of Concern at Operable Unit 4

Treatability Study Work Plan No. 2
Data Collection Plan for Assessing Air Sparging
Operable Unit 4
Naval Training Center, Area C
Orlando, Florida

Chemical	Approximate Odor Threshold (ppm)	Permissible Exposure Limits (ppm)	Threshold Limit Value (ppm)	Physical Characteristics	Dermal Toxicity	Remarks
1,2-Dichloroethene	500	200	200	Colorless liquid, sweet odor.	Moderate skin irritant.	Nausea, vomiting, weakness, tremor, cramps, CNS depression.
Tetrachloroethylene	47	25	25	Colorless liquid with an odor like chloroform.	Moderate skin irritant.	Inhalation may irritate eyes and nose and cause CNS damage.
Trichloroethene	82	50	50	Colorless liquid, sweet odor.	Can cause dermatitis.	Eye and nose irritation, blurred vision, nausea, CNS damage.

Notes: RI/FS = Remedial Investigation and Feasibility Study.
ppm = parts per million.
CNS = central nervous system.
A1 = Known Human Carcinogen.

Sources: American Industrial Hygienists Association, 1989.
U.S. Department of Transportation and U.S. Coast Guard, 1991.
National Institute of Occupational Safety and Health, 1990.
American Conference of Governmental and Industrial Hygienists.
Occupational Safety and Health Administration, 1989.

The above action limits are summarized below.

Level B PPE required if:

- OVA greater than or equal to 116 ppm,

Level C PPE required if:

- OVA greater than or equal to 8 ppm but less than 116 ppm.

Level D PPE required if:

- OVA less than 8 ppm.

Wherever feasible, engineering controls will be used to avoid the need to upgrade from Level D. An example is the use of industrial-sized fans to blow hazardous vapors from the breathing zone.

If air monitoring instrumentation indicates the need to upgrade to Level B along the northern property line, all work will be suspended to avoid the possibility of creating a dangerous condition outside Navy property.

3.0 CHEMICAL HAZARDS RESPONSE INFORMATION SYSTEM (CHRIS) DATA SHEETS

TETRACHLOROETHYLENE

TTE

Common Synonyms	Watery liquid	Colorless	Sweet odor
Tetracap Perclene Perchloroethylene Perk	Sinks in water. Irritating vapor is produced.		

Stop discharge if possible.
Avoid contact with liquid and vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

Not flammable.
Poisonous gases are produced when heated.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose and throat.
If inhaled, will cause difficult breathing, or loss of consciousness.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Irritating to skin and eyes.
Harmful if swallowed.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.

Water Pollution

Effect of low concentrations on aquatic life is unknown.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)
Should be removed
Chemical and physical treatment

2. LABEL

2.1 Category: None
2.2 Class: Not pertinent

3. CHEMICAL DESIGNATIONS

3.1 CG Compatibility Class: Not listed
3.2 Formula: $Cl_2C{=}CCl_2$
3.3 IMO/UN Designation: 9.0/1897
3.4 DOT ID No.: 1897
3.5 CAS Registry No.: 127-18-4

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Liquid
4.2 Color: Colorless
4.3 Odor: Ethereal; like chloroform; mildly sweet

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: For high vapor concentrations use approved canister or air-supplied mask; chemical goggles or face shield; plastic gloves.
5.2 Symptoms Following Exposure: Vapor can affect central nervous system and cause anesthesia. Liquid may irritate skin after prolonged contact. May irritate eyes but causes no injury.
5.3 Treatment of Exposure: INHALATION: if illness occurs, remove patient to fresh air, keep him warm and quiet, and get medical attention. INGESTION: induce vomiting only on physician's recommendation. EYES AND SKIN: flush with plenty of water and get medical attention if irritation or injury occurs.
5.4 Threshold Limit Value: 50 ppm
5.5 Short Term Inhalation Limits: 100 ppm for 60 min.
5.6 Toxicity by Ingestion: Grade 2; LD_{50} = 0.5 to 5 g/kg
5.7 Late Toxicity: None
5.8 Vapor (Gas) Irritant Characteristics: Vapors cause a slight smarting of the eyes or throat if present in high concentrations. The effect is temporary.
5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.
5.10 Odor Threshold: 5 ppm
5.11 IDLH Value: 500 ppm

6. FIRE HAZARDS

6.1 Flash Point: Not flammable
6.2 Flammable Limits in Air: Not flammable
6.3 Fire Extinguishing Agents: Not pertinent
6.4 Fire Extinguishing Agents Not to be Used: Not pertinent
6.5 Special Hazards of Combustion Products: Toxic, irritating gases may be generated in fires.
6.6 Behavior in Fire: Not pertinent
6.7 Ignition Temperature: Not flammable
6.8 Electrical Hazard: Not pertinent
6.9 Burning Rate: Not flammable
6.10 Adiabatic Flame Temperature: Data not available
6.11 Stoichiometric Air to Fuel Ratio: Data not available
6.12 Flame Temperature: Data not available

7. CHEMICAL REACTIVITY

7.1 Reactivity With Water: No reaction
7.2 Reactivity with Common Materials: No reaction
7.3 Stability During Transport: Stable
7.4 Neutralizing Agents for Acids and Caustics: Not pertinent
7.5 Polymerization: Not pertinent
7.6 Inhibitor of Polymerization: Not pertinent
7.7 Molar Ratio (Reactant to Product): Data not available
7.8 Reactivity Group: Data not available

8. WATER POLLUTION

8.1 Aquatic Toxicity: Data not available
8.2 Waterfowl Toxicity: Data not available
8.3 Biological Oxygen Demand (BOD): None
8.4 Food Chain Concentration Potential: None

9. SHIPPING INFORMATION

9.1 Grades of Purity: Dry cleaning and industrial grades: 95+%
9.2 Storage Temperature: Ambient
9.3 Inert Atmosphere: No requirement
9.4 Venting: Pressure-vacuum

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)
A-X

11. HAZARD CLASSIFICATIONS

11.1 Code of Federal Regulations: ORM-A
11.2 NAS Hazard Rating for Bulk Water Transportation:

Category	Rating
Fire	0
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self Reaction	1

11.3 NFPA Hazard Classification: Not listed

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 15°C and 1 atm: Liquid
12.2 Molecular Weight: 165.83
12.3 Boiling Point at 1 atm: 250°F = 121°C = 394°K
12.4 Freezing Point: −6.3°F = −22.4°C = 250.8°K
12.5 Critical Temperature: 657°F = 347°C = 620°K
12.6 Critical Pressure: Not pertinent
12.7 Specific Gravity: 1.63 at 20°C (liquid)
12.8 Liquid Surface Tension: 31.3 dynes/cm = 0.0313 N/m at 20°C
12.9 Liquid Water Interfacial Tension: 44.4 dynes/cm = 0.0444 N/m at 25°C
12.10 Vapor (Gas) Specific Gravity: Not pertinent
12.11 Ratio of Specific Heats of Vapor (Gas): 1.116
12.12 Latent Heat of Vaporization: 90.2 Btu/lb = 50.1 cal/g = 2.10×10^5 J/kg
12.13 Heat of Combustion: Not pertinent
12.14 Heat of Decomposition: Not pertinent
12.15 Heat of Solution: Not pertinent
12.16 Heat of Polymerization: Not pertinent
12.25 Heat of Fusion: Data not available
12.26 Limiting Value: Data not available
12.27 Reid Vapor Pressure: Data not available

NOTES

TTE	TETRACHLOROETHYLENE

12.17 SATURATED LIQUID DENSITY		12.18 LIQUID HEAT CAPACITY		12.19 LIQUID THERMAL CONDUCTIVITY		12.20 LIQUID VISCOSITY	
Temperature (degrees F)	Pounds per cubic foot	Temperature (degrees F)	British thermal unit per pound-F	Temperature (degrees F)	British thermal unit-inch per hour-square foot-F	Temperature (degrees F)	Centipoise
35	103.400	0	.198		N	55	.958
40	103.099	10	.200		O	60	.929
45	102.900	20	.201		T	65	.900
50	102.599	30	.202			70	.873
55	102.299	40	.203		P	75	.848
60	102.000	50	.204		E	80	.823
65	101.700	60	.205		R	85	.800
70	101.400	70	.206		T	90	.777
75	101.099	80	.207		I	95	.756
80	100.799	90	.208		N	100	.736
85	100.500	100	.210		E	105	.716
90	100.200	110	.211		N	110	.698
95	99.910	120	.212		T	115	.680
100	99.610	130	.213			120	.663
105	99.320	140	.214			125	.647
110	99.020	150	.215			130	.631
115	98.730	160	.216			135	.616
120	98.429	170	.217			140	.601
125	98.139	180	.218			145	.588
130	97.839	190	.220			150	.574
135	97.549	200	.221			155	.561
140	97.250	210	.222			160	.549
145	96.959					165	.537
150	96.669					170	.526
155	96.370					175	.515
160	96.080						

12.21 SOLUBILITY IN WATER		12.22 SATURATED VAPOR PRESSURE		12.23 SATURATED VAPOR DENSITY		12.24 IDEAL GAS HEAT CAPACITY	
Temperature (degrees F)	Pounds per 100 pounds of water	Temperature (degrees F)	Pounds per square inch	Temperature (degrees F)	Pounds per cubic foot	Temperature (degrees F)	British thermal unit per pound-F
68.02	.016	60	.236	60	.00702	0	.108
		70	.318	70	.00929	25	.110
		80	.425	80	.01216	50	.113
		90	.561	90	.01575	75	.116
		100	.732	100	.02022	100	.118
		110	.948	110	.02571	125	.120
		120	1.217	120	.03242	150	.122
		130	1.548	130	.04055	175	.125
		140	1.953	140	.05032	200	.127
		150	2.446	150	.06199	225	.129
		160	3.042	160	.07583	250	.131
		170	3.756	170	.09215	275	.132
		180	4.607	180	.11130	300	.134
		190	5.616	190	.13360	325	.136
		200	6.805	200	.15940	350	.138
		210	8.199	210	.18910	375	.139
		220	9.824	220	.22330	400	.141
		230	11.710	230	.26230	425	.142
		240	13.890	240	.30660	450	.143
		250	16.390	250	.35680	475	.144
		260	19.260	260	.41330	500	.146
		270	22.520	270	.47680	525	.147
		280	26.230	280	.54790	550	.148
						575	.148
						600	.149

TRICHLOROETHYLENE

TCL

Common Synonyms			
Trichloroethylene Trichlene; Algylen Chlorylen Germalgene Trethylene Trichloran; Triline	Watery liquid	Colorless	Sweet odor
	Sinks in water. Irritating vapor is produced.		

Stop discharge if possible. Keep people away.
Avoid contact with liquid and vapor.
Call fire department.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

Combustible.
POISONOUS GASES ARE PRODUCED IN FIRE.
Wear goggles and self-contained breathing apparatus.
Extinguish with dry chemical, carbon dioxide, or foam.

Exposure

CALL FOR MEDICAL AID

VAPOR
Irritating to eyes, nose and throat.
If inhaled, will cause nausea, vomiting, difficult breathing, or loss of consciousness.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Irritating to skin and eyes.
If swallowed, will cause nausea, vomiting, difficult breathing, or loss of consciousness.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk and have victim induce vomiting.
IF SWALLOWED and victim is UNCONSCIOUS OR HAVING CONVULSIONS, do nothing except keep victim warm.

Water Pollution

Effect of low concentrations on aquatic life is unknown.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)
Should be removed
Chemical and physical treatment

2. LABEL

2.1 Category: None
2.2 Class: Not pertinent

3. CHEMICAL DESIGNATIONS

3.1 CG Compatibility Class: Halogenated hydrocarbon
3.2 Formula: $CHCl=CCl_2$
3.3 IMO/UN Designation: 6.0/1710
3.4 DOT ID No.: 1710
3.5 CAS Registry No.: 79-01-6

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Liquid
4.2 Color: Colorless
4.3 Odor: Chloroform-like; ethereal

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Organic vapor-acid gas canister; self-contained breathing apparatus for emergencies; neoprene or vinyl gloves; chemical safety goggles; face-shield; neoprene safety shoes; neoprene suit or apron for splash protection.
5.2 Symptoms Following Exposure: INHALATION: symptoms range from irritation of the nose and throat to nausea, an attitude of irresponsibility, blurred vision, and finally disturbance of central nervous system resulting in cardiac failure. Chronic exposure may cause organic injury. INGESTION: symptoms similar to inhalation. SKIN: defatting action can cause dermatitis. EYES: slightly irritating sensation and lachrymation.
5.3 Treatment of Exposure: Do NOT administer adrenalin or epinephrine; get medical attention for all cases of overexposure. INHALATION: remove victim to fresh air; if necessary, apply artificial respiration and/or administer oxygen. INGESTION: have victim drink water and induce vomiting; repeat three times; then give 1 tablespoon epsom salts in water. EYES: flush thoroughly with water. SKIN: wash thoroughly with soap and warm water.
5.4 Threshold Limit Value: 50 ppm
5.5 Short Term Inhalation Limits: 200 ppm for 30 min.
5.6 Toxicity by Ingestion: Grade 3; LD_{50} = 50 to 500 mg/kg
5.7 Late Toxicity: Data not available
5.8 Vapor (Gas) Irritant Characteristics: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary.
5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.
5.10 Odor Threshold: 50 ppm
5.11 IDLH Value: 1,000 ppm

6. FIRE HAZARDS

6.1 Flash Point: 90°F C.C.; practically nonflammable
6.2 Flammable Limits in Air: 8.0%-10.5%
6.3 Fire Extinguishing Agents: Water fog
6.4 Fire Extinguishing Agents Not to be Used: Not pertinent
6.5 Special Hazards of Combustion Products: Toxic and irritating gases are produced in fire situations.
6.6 Behavior in Fire: Not pertinent
6.7 Ignition Temperature: 770°F
6.8 Electrical Hazard: Not pertinent
6.9 Burning Rate: Not pertinent
6.10 Adiabatic Flame Temperature: Data not available
6.11 Stoichiometric Air to Fuel Ratio: Data not available
6.12 Flame Temperature: Data not available

7. CHEMICAL REACTIVITY

7.1 Reactivity With Water: No reaction
7.2 Reactivity with Common Materials: No reaction
7.3 Stability During Transport: Stable
7.4 Neutralizing Agents for Acids and Caustics: Not pertinent
7.5 Polymerization: Not pertinent
7.6 Inhibitor of Polymerization: Not pertinent
7.7 Molar Ratio (Reactant to Product): Data not available
7.8 Reactivity Group: 36

8. WATER POLLUTION

8.1 Aquatic Toxicity: 660 mg/l/40 hr/daphnia/full/fresh water
8.2 Waterfowl Toxicity: Data not available
8.3 Biological Oxygen Demand (BOD): Data not available
8.4 Food Chain Concentration Potential: None

9. SHIPPING INFORMATION

9.1 Grades of Purity: Technical; dry cleaning; degreasing; extraction
9.2 Storage Temperature: Ambient
9.3 Inert Atmosphere: No requirement
9.4 Venting: Pressure-vacuum

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)
A-X-Y

11. HAZARD CLASSIFICATIONS

11.1 Code of Federal Regulations: ORM-A
11.2 NAS Hazard Rating for Bulk Water Transportation:

Category	Rating
Fire	1
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	2
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self Reaction	1

11.3 NFPA Hazard Classification:

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	1
Reactivity (Yellow)	0

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 15°C and 1 atm: Liquid
12.2 Molecular Weight: 131.39
12.3 Boiling Point at 1 atm: 189°F = 87°C = 360°K
12.4 Freezing Point: −123.5°F = −86.4°C = 186.8°K
12.5 Critical Temperature: Not pertinent
12.6 Critical Pressure: Not pertinent
12.7 Specific Gravity: 1.46 at 20°C (liquid)
12.8 Liquid Surface Tension: 29.3 dynes/cm = 0.0293 N/m at 20°C
12.9 Liquid Water Interfacial Tension: 34.5 dynes/cm = 0.0345 N/m at 24°C
12.10 Vapor (Gas) Specific Gravity: 4.5
12.11 Ratio of Specific Heats of Vapor (Gas): 1.116
12.12 Latent Heat of Vaporization: 103 Btu/lb = 57.2 cal/g = 2.4×10^4 J/kg
12.13 Heat of Combustion: Not pertinent
12.14 Heat of Decomposition: Not pertinent
12.15 Heat of Solution: Not pertinent
12.16 Heat of Polymerization: Not pertinent
12.25 Heat of Fusion: Data not available
12.26 Limiting Value: Data not available
12.27 Reid Vapor Pressure: 2.5 psia

NOTES

TCL	TRICHLOROETHYLENE

12.17 SATURATED LIQUID DENSITY	
Temperature (degrees F)	Pounds per cubic foot
0	94.669
5	94.410
10	94.150
15	93.889
20	93.629
25	93.370
30	93.110
35	92.849
40	92.589
45	92.330
50	92.070
55	91.809
60	91.549
65	91.290
70	91.030
75	90.770
80	90.509
85	90.250
90	89.990
95	89.730
100	89.469
105	89.209
110	88.950
115	88.690
120	88.429
125	88.169

12.18 LIQUID HEAT CAPACITY	
Temperature (degrees F)	British thermal unit per pound-F
0	.220
10	.221
20	.223
30	.225
40	.226
50	.228
60	.230
70	.231
80	.233
90	.235
100	.236
110	.238
120	.240
130	.241
140	.243
150	.245
160	.246
170	.248

12.19 LIQUID THERMAL CONDUCTIVITY	
Temperature (degrees F)	British thermal unit-inch per hour-square foot-F
	NOT PERTINENT

12.20 LIQUID VISCOSITY	
Temperature (degrees F)	Centipoise
15	.800
20	.775
25	.750
30	.727
35	.705
40	.684
45	.664
50	.645
55	.627
60	.610
65	.593
70	.577
75	.562
80	.548
85	.534
90	.521
95	.508
100	.496
105	.485
110	.474
115	.463
120	.453

12.21 SOLUBILITY IN WATER	
Temperature (degrees F)	Pounds per 100 pounds of water
77.02	.110

12.22 SATURATED VAPOR PRESSURE	
Temperature (degrees F)	Pounds per square inch
40	.508
50	.678
60	.894
70	1.166
80	1.507
90	1.929
100	2.448
110	3.081
120	3.846
130	4.765
140	5.862
150	7.163
160	8.695
170	10.490
180	12.580
190	15.010
200	17.810
210	21.020

12.23 SATURATED VAPOR DENSITY	
Temperature (degrees F)	Pounds per cubic foot
40	.01245
50	.01628
60	.02105
70	.02695
80	.03418
90	.04296
100	.05354
110	.06619
120	.08120
130	.09891
140	.11960
150	.14380
160	.17180
170	.20390
180	.24080
190	.28280
200	.33040
210	.38420

12.24 IDEAL GAS HEAT CAPACITY	
Temperature (degrees F)	British thermal unit per pound-F
0	.136
25	.139
50	.143
75	.146
100	.149
125	.152
150	.155
175	.157
200	.160
225	.162
250	.165
275	.167
300	.169
325	.172
350	.174
375	.176
400	.177
425	.179
450	.181
475	.182
500	.184
525	.185
550	.186
575	.187
600	.188

1,2-DICHLOROETHYLENE

DEL

Common Synonyms	Liquid	Colorless	Sweet pleasant odor
Acetylene dichloride sym-dichloroethylene Dioform cis-1, 2-dichloroethylene trans-1, 2-dichloroethylene	Sinks in water. Flammable, irritating vapor is produced		

Wear goggles and self-contained breathing apparatus
Shut off ignition sources. Call fire department
Stop discharge if possible. Keep people away
Isolate and remove discharged material
Notify local health and pollution control agencies

Fire

FLAMMABLE.
POISONOUS GASES MAY BE PRODUCED IN FIRE.
Containers may explode in fire.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.

Extinguish with dry chemicals, foam or carbon dioxide
Water may be ineffective on fire
Cool exposed containers with water

Exposure

CALL FOR MEDICAL AID

VAPOR
If inhaled will cause dizziness, nausea, vomiting, or difficult breathing

Move victim to fresh air
If breathing has stopped, give artificial respiration
If breathing is difficult, give oxygen

LIQUID
Harmful if swallowed.

IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk

Water Pollution

Effect of low concentrations on aquatic life is unknown.
May be dangerous if it enters water intakes.

Notify local health and wildlife officials
Notify operators of nearby water intakes

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook)

Issue warning-high flammability
Restrict access
Evacuate area
Should be removed
Chemical and physical treatment

2. LABEL

2.1 Category: Flammable liquid
2.2 Class: 3

3. CHEMICAL DESIGNATIONS

3.1 CG Compatibility Class: Not listed
3.2 Formula: ClCH = CHCl
3.3 IMO/UN Designation: 3.2/1150
3.4 DOT ID No.: 1150
3.5 CAS Registry No.: 540-59-0

4. OBSERVABLE CHARACTERISTICS

4.1 Physical State (as shipped): Liquid
4.2 Color: Colorless
4.3 Odor: Ethereal, slightly acrid, pleasant, chloroform-like

5. HEALTH HAZARDS

5.1 Personal Protective Equipment: Rubber gloves; safety goggles; air supply mask or self-contained breathing apparatus.
5.2 Symptoms Following Exposure: Inhalation causes nausea, vomiting, weakness, tremor, epigastric cramps, central nervous depression. Contact with liquid causes irritation of eyes and (on prolonged contact) skin. Ingestion causes slight depression to deep narcosis.
5.3 Treatment of Exposure: INHALATION: remove from further exposure, if breathing is difficult, give oxygen; if victim is not breathing, give artificial respiration, preferably mouth-to-mouth, give oxygen when breathing is resumed; call a physician. EYES: flush with water for at least 15 min. SKIN: wash well with soap and water. INGESTION: give gastric lavage and cathartics.
5.4 Threshold Limit Value: 200 ppm
5.5 Short Term Inhalation Limits: Data not available
5.6 Toxicity by Ingestion: Grade 2; oral LD_{50} = 770 mg/kg (rat)
5.7 Late Toxicity: Produces liver and kidney injury in experimental animals
5.8 Vapor (Gas) Irritant Characteristics: Data not available
5.9 Liquid or Solid Irritant Characteristics: Data not available
5.10 Odor Threshold: Data not available
5.11 IDLH Value: 4,000 ppm

6. FIRE HAZARDS

6.1 Flash Point: 37°F C.C.
6.2 Flammable Limits in Air: 9.7%-12.8%
6.3 Fire Extinguishing Agents: Dry chemical, foam, carbon dioxide
6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective
6.5 Special Hazards of Combustion Products: Phosgene and hydrogen chloride fumes may form in fires.
6.6 Behavior in Fire: Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back.
6.7 Ignition Temperature: 860°F
6.8 Electrical Hazard: Data not available
6.9 Burning Rate: 2.6 mm/min.
6.10 Adiabatic Flame Temperature: Data not available

(Continued)

7. CHEMICAL REACTIVITY

7.1 Reactivity With Water: No reaction
7.2 Reactivity with Common Materials: No reaction
7.3 Stability During Transport: Stable
7.4 Neutralizing Agents for Acids and Caustics: Not pertinent
7.5 Polymerization: Will not occur under ordinary conditions of shipment. The reaction is not vigorous.
7.6 Inhibitor of Polymerization: None used
7.7 Molar Ratio (Reactant to Product): Data not available
7.8 Reactivity Group: Data not available

8. WATER POLLUTION

8.1 Aquatic Toxicity: Data not available
8.2 Waterfowl Toxicity: Data not available
8.3 Biological Oxygen Demand (BOD): Data not available
8.4 Food Chain Concentration Potential: None

9. SHIPPING INFORMATION

9.1 Grades of Purity: Commercial
9.2 Storage Temperature: Ambient
9.3 Inert Atmosphere: No requirement
9.4 Venting: Pressure-vacuum

10. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook)

A-X-Y

11. HAZARD CLASSIFICATIONS

11.1 Code of Federal Regulations: Flammable liquid
11.2 NAS Hazard Rating for Bulk Water Transportation: Not listed
11.3 NFPA Hazard Classification:

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	2

12. PHYSICAL AND CHEMICAL PROPERTIES

12.1 Physical State at 15°C and 1 atm: Liquid
12.2 Molecular Weight: 97.0
12.3 Boiling Point at 1 atm:
cis: 140°F = 60°C = 333°K
trans: 118°F = 48°C = 321°K
12.4 Freezing Point:
cis: −114°F = −81°C = 192°K
trans: −58°F = −50°C = 223°K
12.5 Critical Temperature: Not pertinent
12.6 Critical Pressure: Not pertinent
12.7 Specific Gravity:
1.27 at 25°C (liquid)
12.8 Liquid Surface Tension:
24 dynes/cm = 0.024 N/m at 20°C
12.9 Liquid Water Interfacial Tension: (est.)
30 dynes/cm = 0.030 N/m at 20°C
12.10 Vapor (Gas) Specific Gravity: 3.34
12.11 Ratio of Specific Heats of Vapor (Gas): 1.1468
12.12 Latent Heat of Vaporization:
130 Btu/lb = 72 cal/g = 3.0 X 10^5 J/kg
12.13 Heat of Combustion: −4,847.2 Btu/lb = −2,692.9 cal/g = −112.67 X 10^5 J/kg
12.14 Heat of Decomposition: Not pertinent
12.15 Heat of Solution: Not pertinent
12.16 Heat of Polymerization: Not pertinent
12.25 Heat of Fusion: Data not available
12.26 Limiting Value: Data not available
12.27 Reid Vapor Pressure: Data not available

6. FIRE HAZARDS (Continued)

6.11 Stoichiometric Air to Fuel Ratio: Data not available
6.12 Flame Temperature: Data not available

1,2-DICHLOROETHYLENE

12.17 SATURATED LIQUID DENSITY

Temperature (degrees F)	Pounds per cubic foot
35	81.020
40	80.820
45	80.610
50	80.400
55	80.190
60	79.980
65	79.780
70	79.570
75	79.360
80	79.150
85	78.940
90	78.740
95	78.530
100	78.320
105	78.110
110	77.900
115	77.690
120	77.490
125	77.280
130	77.070
135	76.860
140	76.650

12.18 LIQUID HEAT CAPACITY

Temperature (degrees F)	British thermal unit per pound-F
35	.193
40	.196
45	.198
50	.200
55	.202
60	.204
65	.207
70	.209
75	.211
80	.213
85	.216
90	.218
95	.220
100	.222
105	.224
110	.227
115	.229
120	.231
125	.233
130	.236
135	.238
140	.240

12.19 LIQUID THERMAL CONDUCTIVITY

Temperature (degrees F)	British thermal unit-inch per hour-square foot-F
65	.907
70	.894
75	.882
80	.869
85	.857
90	.844
95	.832
100	.819
105	.807
110	.794
115	.782
120	.769
125	.757
130	.744

12.20 LIQUID VISCOSITY

Temperature (degrees F)	Centipoise
40	.478
50	.454
60	.432
70	.411
80	.393
90	.376
100	.360
110	.345
120	.331
130	.319
140	.307
150	.296
160	.286
170	.276
180	.267
190	.259
200	.251
210	.244

12.21 SOLUBILITY IN WATER

Temperature (degrees F)	Pounds per 100 pounds of water
68	.630

12.22 SATURATED VAPOR PRESSURE

Temperature (degrees F)	Pounds per square inch
55	3.009
60	3.396
65	3.824
70	4.297
75	4.817
80	5.389
85	6.016
90	6.702
95	7.453
100	8.272
105	9.164
110	10.130
115	11.190
120	12.330
125	13.560
130	14.900
135	16.340
140	17.890

12.23 SATURATED VAPOR DENSITY

Temperature (degrees F)	Pounds per cubic foot
55	.05284
60	.05906
65	.06587
70	.07330
75	.08141
80	.09023
85	.09980
90	.11020
95	.12140
100	.13360
105	.14660
110	.16070
115	.17590
120	.19220
125	.20960
130	.22830
135	.24820
140	.26960

12.24 IDEAL GAS HEAT CAPACITY

Temperature (degrees F)	British thermal unit per pound-F
0	.150
20	.153
40	.156
60	.159
80	.162
100	.165
120	.167
140	.170
160	.173
180	.176
200	.179
220	.182
240	.185
260	.188
280	.191
300	.194
320	.197
340	.200
360	.203
380	.205
400	.208
420	.211
440	.214

APPENDIX B

AIR EMISSIONS ESTIMATE

NTC Orlando
OU 4 Sparge Test
Air Emissions Estimate

The requirements for controlling air emissions are based on allowable pollutant loads and health and safety limits. Pollutant load limits are discussed below. Health and safety limits are discussed in the site HASP. FDEP guidance for air emissions for remedial actions at petroleum contamination sites requires a limit of 13.7 pounds per day of total VOAs as measured by USEPA Method 18 (reference Chapter 62-770.700(5) FAC). The proposed maximum test air flow rate is 15 standard cubic feet per minute. The maximum allowable emission concentration can be calculated by dividing the allowable emission rate by the maximum air flow rate.

$$\frac{13.7\,\frac{lb}{day} \times 453.6\,\frac{g}{lb} \times 1000\,\frac{mg}{g}}{15\,\frac{ft^3}{\min} \times 0.02832\,\frac{m^3}{ft^3} \times 1440\,\frac{\min}{day}} = 10{,}158.9\,{}^{mg}/_{m^3}$$

This number is likely to be greater than actual emission concentrations during the test. To estimate actual emission concentrations, several conservative assumptions are necessary.

1. A single observed concentration in groundwater will be considered representative of concentrations throughout the sparge test area. About a fourth of the test area overlaps the source area where residual product may be present. Any increase in emission rates resulting from the potential presence of residual product would be offset by emissions from the remainder of the test area where contaminant concentrations are significantly lower.
2. During the sparge test, air-water partitioning will reach equilibrium instantaneously and uniformly through all the injected air.
3. The concentration in groundwater will not be significantly reduced during the sparge test period.

The volatile compounds observed at the test area are PCE, TCE, and cis 1,2-DCE. Using the physical properties from standard references a Henry's Law Constant (H_c) is calculated for each compound and converted to a dimensionless form. The concentration of each volatile compound in groundwater is then multiplied by its H_c and the appropriate unit conversions. The results are then summed to obtain the estimated vapor emission concentration of total volatiles.

	Conc	Molecular	Vapor	Water	Calculated	Henry's Law	Conc.
CONTAMINANT	In GW	Weight	Pressure	Solubility	Henry's Law Const	Constant	In Air
	ug/l		atm	mg/l	atm*m^3/mole	dimensionless	ug/m^3
Tetrachloroethene	5000	165.83	0.021632653	200	0.017936714	0.746	3730155.982
Trichloroethene	1000	131.39	0.079319728	1385	0.007524779	0.313	312973.7065
cis 1,2-Dichloroethene	500	97	0.292312925	6996	0.004052938	0.169	84285.73046
Total VOAs in GW =	6500	ug/l			Total VOAs in Air =	4,127,415.42	ug/m^3

The calculated emission concentration multiplied by the air injection rate is the estimated emission rate.

$$4{,}128.415\,\frac{mg}{m^3} \times 15\,\frac{ft^3}{\min} \times 0.002205\,\frac{lb}{g} \times 0.02832\,\frac{m^3}{ft^3} \times 0.001\,\frac{g}{mg} \times 1440\,\frac{\min}{day} = 5.567\,{}^{lb}/_{day}$$

The current emission rate from the existing site remediation systems (recirculation wells) is less than 0.5 lb/day. Therefore, based on these conservative estimates, we do not expect the air emissions from the sparge test to reach the 13.7 lb/day limit.

Operations will be monitored by FID OVA to measure compliance with this limit during the test. This monitoring will be based on the average OVA measurement versus the 13.7 lb/day limit (minus the existing 0.5 lb/day emissions). The threshold OVA value is calculated as follows.

The maximum allowable continuous emission concentration is:

$$\frac{(13.7\,\frac{lb}{day} - 0.5\,\frac{lb}{day}) \times 453.6\,\frac{g}{lb} \times 10^6\,\frac{ug}{g}}{15\,\frac{ft^3}{\min} \times 0.02832\,\frac{m^3}{ft^3} \times 1440\,\frac{\min}{day}} = 9{,}788{,}135.6\,{}^{ug}\!/_{m^3}$$

Conservatively assuming all emissions are PCE at 1 atmosphere and 25°C and converting to parts per million, the threshold is:

$$\frac{9{,}788{,}135.6\,{}^{ug}\!/_{m^3}}{165.83\,\frac{g}{g \cdot mole} \times 0.0409\,\frac{g \cdot mole}{l} \times 1000\,\frac{ug \cdot l}{g \cdot m^3}} = 1443\,ppm$$

Therefore, if average total VOA measurements by OVA exceed 1400 ppm, test operations will be modified to reduce the emissions to an acceptable average or operations will be discontinued when the daily emission limit is reached.