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FINAL GROUNDWATER TREATABILITY STUDY WORK PLAN IN SITU CHEMICAL OXIDATION PILOT STUDY FOR OPERABLE UNIT 4 (OU 4) NTC ORLANDO FL

2/1/2001

ABB ENVIRONMENTAL

GROUNDWATER TREATABILITY STUDIES IN-SITU CHEMICAL OXIDATION PILOT STUDY USING POTASSIUM PERMANGANATE

OPERABLE UNIT 4
AREA C
NAVAL TRAINING CENTER, ORLANDO, FLORIDA

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

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

Harding Lawson Associates

February 28, 2001

Document No.: 2545.040

Commanding Officer
SOUTHNAVFACENGCOM
ATTN: Ms. Barbara Nwokike, Code 187300
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SUBJECT: **Final $KMnO_4$ Pilot Study Report**
Operable Unit (OU) 4
Naval Training Center (NTC), Orlando, Florida
Contract No. N62467-89-D-0317/CTO 135

Dear Barbara:

Enclosed please find two copies of the Final NTC Orlando OU 4 Potassium Permanganate ($KMnO_4$) Pilot Study Report. This report documents the final results and conclusions of the in-situ chemical oxidation pilot study conducted at OU 4 from February – August 2000.

If you have questions or comments regarding this document, please contact me at (781) 213-5652 or John Kaiser at (407) 522-7570.

Very truly yours,

HARDING LAWSON ASSOCIATES

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GROUNDWATER TREATABILITY STUDIES
IN-SITU CHEMICAL OXIDATION PILOT STUDY

OPERABLE UNIT 4

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

Unit Identification Code: N65928

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

Prepared by:

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February 2001

CERTIFICATION OF TECHNICAL
DATA CONFORMITY (MAY 1987)

The Contractor, Harding Lawson Associates, 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: February 28, 2001

NAME AND TITLE OF CERTIFYING OFFICIAL: Mark Salvetti, P.E.
Task Order Manager

NAME AND TITLE OF CERTIFYING OFFICIAL: John Kaiser
Program Manager

(DFAR 252.227-7036)

FOREWORD

To meet its mission objectives, the U.S. Navy performs a variety of operations, some of which require the use, handling, storage, and/or disposal of hazardous materials. Through accidental spills and leaks, or as a result of past conventional methods of disposal, hazardous materials may have entered the environment in ways unacceptable by current standards. As knowledge of the long-term effects of hazardous materials on the environment has grown, the Department of Defense (DOD) has 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 (CERCLA), Executive Order 12580, and the statutory provisions of Defense Environmental Restoration Program, the National Environmental Policy Act, and any other applicable statutes that protect natural and cultural resources.

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 (USEPA), and the Florida Department of Environmental Protection (FDEP) collectively coordinate the cleanup activities through the BRAC cleanup team, called the Orlando Partnering Team (OPT). 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 (NTC), Orlando should be addressed to the SOUTHNAVFACENGCOM BRAC Environmental Coordinator, Mr. Wayne Hansel, at (407) 895-6714, or the SOUTHNAVFACENGCOM Engineer-in-Charge, Ms. Barbara Nwokike, at (843) 820-5566.

The engineering evaluations and professional opinions rendered in this document that describes the potassium permanganate pilot study for Operable Unit 4, Naval Training Center, Orlando, Florida, were conducted or developed in accordance with commonly accepted procedures consistent with applicable standards of practice. This document is not intended to be used for construction.

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Expires: February 28, 2003

EXECUTIVE SUMMARY

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

Site investigations have identified a plume of chlorinated solvent-contaminated groundwater originating from the area around Building 1100, the former base laundry, and migrating into the adjacent Lake Druid. 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 (VC). Source areas appear to be multiple and are likely located adjacent to and beneath Building 1100.

In-situ chemical oxidation using potassium permanganate ($KMnO_4$) was identified as an innovative technology with the potential to oxidize the source area and to treat areas with high concentrations of VOCs in groundwater. The basic stoichiometry for the oxidation of PCE is as follows:

$$C_2Cl_4 + MnO_4^- \rightarrow \text{Carboxylic Acid (CA)} + 4Cl^- + 2MnO_2\,\text{(solid)}$$

Oxidation of chlorinated compounds to CA's occurs at pH's above 3. This reaction does not generate excess heat or vapor, and any excess $KMnO_4$ is stable, allowing it to be flushed through a source area by pumping to maximize contact with the contaminant zone.

This report presents the procedures, results, conclusions, and recommendations from the pilot test conducted to evaluate the use of $KMnO_4$ to oxidize PCE at OU 4. The pilot test was operated from February through June 2000, with groundwater monitoring continuing until August 2000.

The objective of the chemical oxidation pilot test was to provide site-specific performance data for the $KMnO_4$ technology at OU 4. Site-specific performance factors to be evaluated during the pilot test were as follows:

1. Ability to create and maintain groundwater circulation cell;
2. Optimum $KMnO_4$ aqueous concentration required to oxidize the OU 4 source area VOCs;
3. Ability to treat source area VOCs both above and below the layer of dense sand; and
4. Maximum reduction of groundwater VOC concentrations achievable with this technology.

The ability to create and maintain the treatment cell was evaluated by monitoring changes in groundwater gradient within the cell due to system operation and by monitoring groundwater quality in wells located downgradient of the treatment cell. Groundwater elevation data collected during the pilot study indicate that when the system is operating, the groundwater gradient is increased in the treatment cell above and below the layer of dense sand. The ability to treat the source zone above and below the dense sand layer has been evaluated by comparing estimated travel times to the actual movement of treated water in the cell and the reduction of VOC concentrations in the treatment cell. Changes in VOC concentrations and groundwater conductivity indicate that treated water is generally moving more rapidly than predicted in the shallow zone and more slowly than predicted in the deep zone. Dramatic decreases in total VOC concentrations have occurred in the shallow zone, but have been slower to develop in the deep zone. However, the average half life within the circulation cell for VOC reduction is approximately the same in both the shallow and deep zones, about 7 to 8 weeks.

The reduction of contaminants achievable by this technology has been evaluated by comparing baseline VOC concentrations with data collected during the sampling rounds. The maximum VOC concentration detected during the baseline sampling was 24,300 μg/L (23,000 μg/L PCE) in shallow microwell GMP-11. Within two months, VOC concentrations in GMP-11 were below detection limits, indicating that the technology is capable of reductions of more than 99.995 percent of PCE in a fairly short time frame. Furthermore, by late May 2000 (116 days after startup, 66 days of system run time), VOC concentrations in four additional shallow monitoring wells had been reduced to or below MCLs. Other monitoring wells at a greater distance from the injection wells showed approximately two orders of magnitude reduction in VOC concentrations. By June 28, 2000, VOC concentrations had decreased to MCL levels or below in three additional shallow wells.

In the deep zone, significant reductions in VOCs did not occur until April. This is apparently due to much higher concentrations of natural organic material on the soil particles in the lower zone, which must be also be oxidized, and therefore slows the migration of the VOC oxidation front. Evidence of higher total organic carbon (TOC) concentrations was found during the remedial investigation. However, significant destruction of VOCs in the deep zone did occur during the month of April, and by July 13, 2000, average concentrations of VOCs in the deep zone had decreased by an order of magnitude.

It is apparent that in situ chemical oxidation using $KMnO_4$ is very effective at destroying the VOC contamination in the source area at OU 4. We therefore recommend its full-scale application to the source zone.

The recommendations for full-scale implementation include:

- The anticipated average $KMnO_4$ dosage will be 1 g/L, however during the latter stages of treatment, the $KMnO_4$ feed may only be makeup to maintain the 1 g/L in the injected groundwater. Although this is less than the 4 g/L used in the pilot test, recent conversations with Colorado School of Mines researchers have suggested that at lower concentrations, less of the natural TOC in the aquifer will be oxidized, leaving a higher percentage of the injected $KMnO_4$ available to oxidize VOCs. The lower $KMnO_4$ concentration will oxidize the VOCs more slowly, but this is not a handicap since the source area will be flooded and soaked in the oxidant;

- Separate injection wells for the shallow and deep zones, to allow targeting of the $KMnO_4$ solution and preferential injection into just the deeper zone once the shallow aquifer becomes saturated with $KMnO_4$;

- Replacement of the cartridge filtration system used to control solids generated by the oxidation reaction (MnO_2) with a more efficient and less maintenance-intensive alternative, such as a rotary drum filter, stacked disks, or membranes.

The cost estimate for the $KMnO_4$ alternative in the OU 4 Feasibility Study was competitive with the other remedial alternatives evaluated. The pilot study results have demonstrated the effectiveness and implementability of this technology. Based on these results, we recommend preparing an OU 4 Proposed Plan that includes use of in-situ oxidation of the OU 4 source area using $KMnO_4$.

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GLOSSARY

ABB-ES	ABB Environmental Services, Inc.
bls	below land surface
BRAC	Base Realignment and Closure (Act)
CA	carboxylic acid
DCE	dichloroethene
EBS	Environmental Baseline Survey
FS	Feasibility Study
Ft/day	feet per day
Ft/ft	feet per foot
g/L	gram per liter
gpm	gallons per minute
HLA	Harding Lawson Associates
ID	Inside diameter
IW	Injection well
$KMnO_4$	potassium permanganate
MCL	maximum contaminant level
mg/L	milligrams per liter
µG/L	MICROGRAMS PER LITER
MnO_2	manganese dioxide
NTC	Naval Training Center
OU	Operable Unit
PCE	tetrachloroethene
PVC	polyvinyl chloride
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RW	(Recovery) extraction well
TAL	Target Analyte List
TCE	trichloroethene
TCL	target compound list
UIC	Underground Injection Control
USGS	US Geological Survey
VC	vinyl chloride
VOC	volatile organic compound

1.0 INTRODUCTION

The pilot study evaluating in-situ chemical oxidation using potassium permanganate ($KMnO_4$) as a groundwater source area treatment technology was begun at Naval Training Center (NTC), Orlando Operable Unit (OU) 4 on February 14, 2000. This report presents the results of that study which has demonstrated that injection of $KMnO_4$ in the OU 4 source area is a viable alternative for source area remediation.

This report includes a summary of system installation, startup, operation, and performance monitoring. It includes an interpretation of the results, and provides conclusions and recommendations that will allow design of a full-scale source area treatment system.

Based on the results presented herein, and weighing alternatives already evaluated in the OU 4 FS (HLA, 2001a), HLA recommends that the Navy proceed with full-scale implementation of in-situ chemical oxidation using $KMnO_4$ in the OU 4 source area.

1.1 FACILITY HISTORY.

OU 4 is located at Area C, at NTC Orlando, Florida (Figure 1-1). OU 4 consists of Study Areas 12, 13, and 14 at Area C (Figure 1-2). Building 1100, located in Study Area 13, was constructed in 1943 and was used as a laundry and dry-cleaning facility. Prior to construction of the facility in 1943, the land was undeveloped. Laundry operations at Building 1100 ended in 1994. Building 1100 was identified during the Environmental Baseline Survey (EBS) as a site where releases of hazardous materials had occurred. Photographs of Area C and the interior of Building 1100 are included in Appendix B, Figures 1 and 2.

1.2 PREVIOUS INVESTIGATIONS.

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 investigation. Results from the investigations conducted at OU 4 to date are summarized in the OU 4 Remedial Investigation (RI) Workplan (ABB Environmental Services, Inc. [ABB-ES], 1997b) and the Final OU 4 RI Report (HLA, 2001b).

These investigations have identified a plume of chlorinated solvent-contaminated groundwater originating from the area around Building 1100, the former base laundry, and migrating into the adjacent Lake Druid. Contour lines illustrating the approximate defined boundary of the groundwater plume are shown on Figure 1-3. 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 (VC). Source areas appear to be multiple and are likely located adjacent to and beneath Building 1100. The approximate extent of the suspected multiple source areas is also shown on Figure 1-3. No source area associated with the southern portion of the plume has been identified. Because VOC concentrations are several orders of magnitude lower than in the northern plume, the source for the southern plume was likely a small release that has either been depleted or removed.

Based on the OU 4 Focused Field Investigation (ABB-ES, 1996a), the source investigation (ABB-ES, 1997c), and the OU 4 RI (HLA, 2001b), the vertical extent of the chlorinated solvent groundwater plume ranges from approximately 4 to 45 feet below land surface (bls). Total groundwater VOCs in excess of 30 milligrams per liter (mg/L) have been detected in the source area(s), and up to approximately 6 mg/L between the laundry (Building 1100) and Lake Druid. The maximum depth of the plume in the source area shown on Figure 1-3 is approximately 30 to 35 feet bls, increasing to 45 feet bls in downgradient areas. The water table between Lake Druid and the laundry varies seasonally from less than 1 foot to 7 feet bls, with the greatest depths to water occurring at the laundry (Building 1100).

The soil density of the surficial aquifer typically ranges from medium dense to dense, with the exception of a hard layer (very dense) approximately 15 to 20 feet bls, with varying thickness of 2 to 5 feet. However, this hard layer does not appear to act as either a hydraulic or chemical barrier.

In 1997, the US Geological Survey (USGS) re-evaluated the results from a pumping test that had been conducted at OU 4 in August 1996 (USGS, 1998). The USGS analysis of the pumping test data indicated that the surficial aquifer could be separated into two zones. From the groundwater surface to approximately 20 feet bls (where a "hard" layer exists consisting of a 3-foot thick cemented silty sand in the area of the pilot test), the horizontal hydraulic conductivity is about 10 feet per day (ft/day). Below that point to approximately 55 feet bls, the horizontal hydraulic conductivity is about 40 ft/day. In both zones the vertical hydraulic conductivity was determined to be about three times lower than the horizontal hydraulic conductivity.

2.0 IN-SITU CHEMICAL OXIDATION PILOT STUDY

2.1 BACKGROUND ON CHEMICAL OXIDATION PROCESS.

In-situ chemical oxidation involves the injection of a chemical oxidant into the zone of contamination. The contaminant is destroyed through contact with the chemical oxidizer. Byproducts include carbonyl acids (CAs), carbon dioxide, water, and chloride (when chlorinated compounds are oxidized). The oxidation is non-specific, and all compounds present that can be oxidized by a given reagent will react. Chlorinated compounds (particularly those with double bonds, such as PCE, TCE, DCE, etc) are readily destroyed when contacted with chemical oxidants.

The two most common chemical oxidants used for in-situ oxidation are the Fenton's reagent (hydrogen peroxide and ferrous sulfate) and $KMnO_4$. The Fenton's reaction is highly exothermic and also produces quantities of oxygen from the decomposition of excess hydrogen peroxide. The reactants are unstable and short-lived. This process has been commercialized and is offered by several firms that specialize in this technology.

$KMnO_4$ has been shown to be an effective oxidant for PCE and TCE (Schnarr et al, 1997; Hood et al, 1998; West et al, 1997). In-situ oxidation is accomplished when an aqueous solution of $KMnO_4$ is injected or flushed through the source area. The basic stoichiometry for the oxidation of PCE is as follows:

$$C_2Cl_4 + MnO_4^- \rightarrow CA + 4Cl^- + 2MnO_2\,(solid)$$

Oxidation of chlorinated compounds to CA's occurs at pH's above 3. Carbon dioxide is formed instead at lower pH's (Huang et al, 2000). This reaction does not generate excess heat or vapor, and any excess $KMnO_4$ is stable, allowing it to be flushed through a source area by pumping to maximize contact with the contaminant zone. $KMnO_4$ has also been shown to be more effective at oxidizing PCE and TCE than the Fenton's process (West et al, 1997).

2.2 OBJECTIVES OF IN-SITU CHEMICAL OXIDATION.

The objective of the chemical oxidation pilot test is to provide site-specific performance data for the $KMnO_4$ technology at OU 4. Site-specific performance factors to be evaluated during the pilot test are as follows:

1. Ability to create and maintain groundwater circulation cell;
2. Optimum $KMnO_4$ aqueous concentration required to oxidize the OU 4 source area VOCs;
3. Ability to treat source area VOCs both above and below the layer of dense sand; and
4. Maximum reduction of groundwater VOC concentrations achievable with this technology.

2.3 EXECUTION OF THE PILOT TEST

2.3.1 Well Installation

Wells were installed for the pilot study to allow extraction and injection of groundwater (thereby creating a treatment cell), and to supplement existing wells for monitoring groundwater above and below the hard layer. The number and locations of the new wells were selected based on results from hydraulic modeling of the site as described in Treatability Study Work Plan No. 3 (HLA, 1999).

Three injection wells (IW-2, IW-3, and IW-4) were installed adjacent to the northeast corner of Building 1100 (Figure 1-3). These wells are spaced approximately 10 feet apart. Each injection well has a 4-inch inside diameter (ID) and a total depth of approximately 35 feet. The wells are screened from 5 to 30 feet bls and have a 5 foot sump from 30 to 35 feet bls. Three recovery wells (RW-2, RW-3, and RW-4) were also installed approximately 65 feet to the west of the injection wells (Figure 1-3). These wells are spaced approximately 10 feet apart. Each extraction well has a 4-inch ID and a total depth of approximately 35 feet. The extraction wells are screened from 10 to 30 feet bls and have a 5 foot sump from 30 to 35 feet bls.

Three deep wells (OLD-13-44B, OLD-13-45B and OLD-13-46B) and seven shallow wells (GMP-11 through GMP-17) were installed for the pilot study. The three deep wells were installed below the hard layer and are 2-inch ID, a total depth of 30 feet, and are screened from 20 to 30 feet bls. The seven shallow wells are ½-inch ID microwells installed to a total depth of approximately 20 feet, screened at and above the hard layer with 9-foot pre-packed screens from 11 to 20 feet bls. Other pre-existing deep and shallow wells were utilized during the pilot test, and the location of all wells within the pilot study treatment zone is shown on Figure 2-1. Shallow microwells GMP-7 through GMP-10 were previously installed for the unsuccessful air sparging pilot study (HLA, 2001a). These four wells are similar in construction to GMP-11 through GMP-17, except 3-foot prepacked screens were used. Monitoring well OLD-13-07A is 2-inch ID with 15 feet of screen and a total depth of 18.5 feet. Deep wells OLD-13-41B and OLD-13-42B are 2-inch ID with 5 feet of screen and a total depth of 28 feet. Table D-1 in Appendix D shows the well construction details of the wells installed for this pilot test.

Wells GMP-17 and OLD-13-46B were installed as a shallow and deep pair at a location downgradient of the treatment cell. These were installed to provide a means during the pilot study to demonstrate that hydraulic control of the $KMnO_4$ was being maintained, and after the pilot study to monitor the migration of the injected $KMnO_4$ solution after shutdown.

The shallow microwells were installed using a GeoProbe direct push rig. All other wells were installed with a Rotosonic drilling rig.

2.3.2 Baseline Groundwater Sampling

Groundwater samples were collected between February 1 and February 9, 2000, to provide baseline reference data prior to system startup. Groundwater samples were collected from the upper and lower zone monitoring wells, and from the extraction and injection wells, and were submitted to an off-site laboratory for analysis (see Table 2-1). VOC concentrations were established to provide baseline data to monitor the oxidation performance of the $KMnO_4$. Inorganics were also analyzed to monitor changes in concentration caused by the introduction of dissolved metals from the injected $KMnO_4$, and oxidation of inorganics such as iron and manganese.

Groundwater samples from 11 shallow zone wells were analyzed for halogenated VOCs during the baseline sampling event. Results are shown on Figure 2-1. PCE was detected in all 11 of the wells sampled at concentrations ranging from 38 micrograms per liter (µg/L) to 23,000 µg/L. TCE was detected in 9 of the monitoring wells sampled at concentrations ranging from 7 µg/L to 8,700 µg/L. Cis-1,2-DCE was only detected in 3 of the wells sampled at concentrations of 12 µg/L, 31 µg/L and 2,000 µg/L; however, detection limits were very high for most samples.

Groundwater samples from six shallow zone wells were also analyzed for Target Analyte List (TAL) metals. Calcium, iron, magnesium, manganese, mercury, potassium, sodium, and vanadium were detected in the six wells sampled during the baseline sampling event. Calcium concentrations ranged from 16 to 56 mg/L. Magnesium concentrations ranged from 2 to 5.1 mg/L. Potassium concentrations ranged from 0.7 to 1.8 mg/L. Sodium concentrations ranged from 2.5 to 7.2 mg/L. Iron was detected in one sample at a concentration of 0.23 mg/L. Manganese was detected in one sample at a concentration of 0.012 mg/L. Vanadium was detected in two samples at concentrations of 0.01 and 0.02 mg/L. Mercury was detected in two samples at concentrations of 0.0002 and 0.00021 mg/L, which was between the method detection level and the practical quantitation level for the analyses. Analytical tables for VOCs and TAL metals in the shallow zone wells are included as Tables A-1 and A-2 in Appendix A.

Groundwater samples from four deep zone wells were analyzed for halogenated VOCs during the baseline sampling event. Results are shown on Figure 2-1. PCE was detected in all 4 of the wells at concentrations ranging from 140 µg/L to 3,300 µg/L. TCE was detected in all 4 of the wells at concentrations ranging from 1,300 µg/L to 4,700 µg/L. Cis-1,2-DCE was detected in 3 of the wells at concentrations ranging from 700 µg/L to 1,500 µg/L.

Groundwater samples from the four deep zone wells were also analyzed for TAL metals. Aluminum, calcium, iron, magnesium, manganese, potassium, and sodium were detected in all deep zone wells. Calcium concentrations ranged from 3.4 mg/L to 9.3 mg/L. Iron concentrations ranged from 0.072 mg/L to 3.7 mg/L. Magnesium concentrations ranged from 1.2 mg/L to 1.4 mg/L. Potassium concentrations ranged from 1.0 mg/L to 1.2 mg/L. Sodium concentrations ranged from 9.7 mg/L to 15 mg/L. Aluminum was detected in two samples at concentrations of 0.067 mg/L and 0.078 mg/L. Manganese was detected in two samples at concentrations of 0.018 mg/L and 0.028 mg/L. Analytical tables for VOCs and TAL metals in the deep zone wells are included as Tables A-3 and A-4 in Appendix A.

Groundwater samples from the six injection and recovery wells were analyzed for halogenated VOCs during the baseline sampling event. Results are presented on Figure 2-1. In the 3 extraction wells, PCE was detected at concentrations ranging from 1,600 µg/L to 8,400 µg/L, TCE was detected at concentrations ranging from 470 µg/L to 1,000 µg/L, and cis 1,2 DCE was detected at concentrations ranging from 160 µg/L to 400 µg/L. PCE was detected in all 3 injection wells at concentrations ranging from 68 µg/L to 8,400 µg/L. In 2 of the 3 injection wells, TCE was detected at concentrations ranging from 110 µg/L to 330 µg/L, and cis 1,2 DCE was detected at concentrations of 130 µg/L and 540 µg/L. The analytical table for VOCs in the injection and recovery wells is included as Table A-5 in Appendix A.

2.3.3 System Installation

An equipment schematic for the chemical oxidation system is shown as Figure 2-2. The $KMnO_4$ pilot study system consisted of two 1,600 gallon polyethylene tanks fitted with electric mixers and piped in series (Tank 1 and Tank 2), a $KMnO_4$ feed system, extraction and injection pumps, cartridge filters used to filter the $KMnO_4$ solution prior to injection, and a control system. This system was designed and constructed by Carus Chemical of Peru, Illinois (the sole domestic producer of $KMnO_4$), based on the conceptual design requirements included in the pilot study workplan (HLA, 1999). The system was rented from Carus on a monthly basis, and then returned to Carus at the conclusion of the pilot study. Photographs of the system are included in Appendix B, Figures 3, 4, and 5.

The $KMnO_4$ was fed using two drum inverters, each emptying a 330-lb drum of $KMnO_4$ into the hopper of a screw feeder (Appendix B, Figures 6 and 7). The screw feeders were fitted with level sensors; when one hopper was empty, the control system switched to the second feeder. Once the second feeder emptied, the system was shutdown unless a new drum of $KMnO_4$ had been fitted to the first feeder. In this fashion, 660 lbs. of $KMnO_4$ could be loaded at one time, allowing over three days of unattended operation before additional $KMnO_4$ needed to be loaded. Each screw feeder was manually controlled by adjusting the setting on a potentiometer fitted to each unit. The relationship between the potentiometer setting and feed rate was established for each feeder by field calibration; adjustments to $KMnO_4$ feed rate were made manually as necessary. The two screw feeders emptied into a polyethylene washdown tank where the $KMnO_4$ was dissolved by a stream of Tank 1 water and returned to Tank 1 via an eductor connected to the bottom of the washdown tank (Appendix B, Figure 7).

The filtration system consisted of two Harmsco filter housings piped in parallel. Each housing contained eight, 20-inch long pleated filter cartridges that were designed to be hosed off for cleaning. The filters were rated at a nominal one micron removal efficiency. Pressure sensors on the filter piping controlled a three-way valve on the filter housing inlet, allowing the system to automatically switch to the second filter housing when the filter cartridges in the first housing clogged.

Polyethylene tubing was used to connect the three extraction wells to a polyvinyl chloride (PVC) header, which was in turn connected to the intake of an ITT Jabsco flexible impeller pump using 2-inch ID hose. Extracted groundwater was fed to Tank 1. Groundwater from Tank 1 was pumped to the $KMnO_4$ feed system and then recycled back to the tank. The electric mixer in Tank 1 was operated to ensure complete dissolution of the $KMnO_4$. Treated groundwater then flowed from Tank 1 and into the bottom of Tank 2 by gravity. The mixer in Tank 2 was not used, in order to provide MnO_2 particulates that had formed an opportunity to settle to the bottom of the tank. The $KMnO_4$ solution overflowed out of Tank 2 through a standpipe that extended to nearly the top of the tank (to maximize residence time) to an ITT Jabsco injection pump. The solution was filtered to remove MnO_2 solids that did not settle and then piped to the injection wells through a header and tubing assembly identical to that used for extraction. The control system varied the injection rate to maintain the setpoint water level in Tank 2. The two-tank arrangement was used to provide adequate residence time for complete dissolution of the $KMnO_4$ and to allow the VOCs in the extracted water to oxidize to below Maximum Contaminant Limits (MCLs) prior to injection.

The kinetics for the oxidation of the VOCs in the extracted groundwater are described in the pilot study workplan (HLA, 1999). Because of the electric mixer, Tank 1 operated as a constantly stirred tank reactor (CSTR). With the mixer in Tank 2 not operating, the tank functioned similar to a plug flow reactor.

2.3.4 System Startup

Following system installation, system start up activities included $KMnO_4$ drum sampling, system operation and adjustment, and onsite laboratory analysis.

The $KMnO_4$ powder was purchased from Carus Chemical in 330 pound drums. $KMnO_4$ samples were collected from drums representing each manufacturing lot in the inventory. These samples were sent to an offsite laboratory for inorganic analysis to confirm metals concentrations were within the limits allowed by the Underground Injection Control (UIC) variance (HLA, 1999). Analytical results for 4 gram per liter (g/L) $KMnO_4$ solutions are presented in Appendix A as Table A-6.

The pilot study workplan states that the concentration of injected $KMnO_4$ would be confirmed based on color measured by a spectrophotometer calibrated for various $KMnO_4$ solutions. However, at concentrations above approximately 0.025 g/L, the $KMnO_4$ solution is too opaque for the spectrophotometric method without repeated dilutions. Instead, the $KMnO_4$ concentration was established based on the conductivity of the solutions. The relationship between conductivity and $KMnO_4$ concentration is linear. The conductivity of a 2 g/L $KMnO_4$ solution is approximately 1,250 µmhos/cm, and the conductivity of a 4 g/L solution is approximately 2,500 µmhos/cm.

System startup began on February 11. Groundwater was extracted at a total rate of 3.5 to 4.0 gallons per minute (gpm) from all three extraction wells. $KMnO_4$ was added at a rate that corresponded to a 4 g/L solution. Approximately 190 pounds of $KMnO_4$ per day were required at 4 gpm. Groundwater samples were collected periodically from the extraction piping and from the $KMnO_4$ solution in the mixing tanks. This allowed real-time evaluation of system performance, and ensured that VOC MCLs were achieved prior to injection. Analytical tables for the influent and effluent samplescollected on February 11, 2000 are included in Appendix A as Table A-7.

As expected (based on literature and bench-scale testing), the TCE and DCE in the extracted groundwater were quickly oxidized. TCE (approximately 780 µg/L) and DCE (approximately 320 µg/L) in the extracted groundwater were not detected in the overflow from Tank 1 to Tank 2. PCE was reduced from approximately 3,000 µg/L in the extracted groundwater to approximately 80 µg/L in the Tank 1 overflow. PCE was oxidized to below the MCL of 3 µg/L after 2.2 hours in Tank 2. As over 6 hours of residence time was available for the treated groundwater in Tank 2 (at 4 gpm), these results indicated that the system was capable of easily oxidizing VOCs in the extracted groundwater to below MCLs prior to injection.

A comparison of the field kinetic results with those predicted using the bench-scale derived rate constants (HLA, 1999) is included in Appendix E. Using the CSTR formula for a first order reaction and the PCE rate constant for a 4 g/L $KMnO_4$ solution, the predicted PCE concentration overflowing Tank 1 is 123 µg/L. Therefore, Tank 1 destroyed PCE more efficiently than predicted. However, the kinetic formulas do not account for any volatilization induced by the electric mixer. The solution in Tank 1 is strongly churned by the mixer, and volatilization of PCE in the solution would be expected. Some volatilization could also occur in the washdown tank for the $KMnO_4$ feeders. These mechanisms could account for the more efficient removal of PCE in Tank 1.

The plug flow first order reaction formula was used to predict the oxidation efficiency in Tank 2. As shown in Appendix A, Table A-7, a PCE concentration of 1.5 µg/L was achieved 2 hours and 14 minutes after Tank 1 began to flow into Tank 2. Assuming an average initial PCE concentration of 80µg/L entering Tank 2, the calculation in Appendix E predicts a PCE concentration of only 0.02 µg/L after 2.2 hours. Therefore, Tank 2 appears to be less efficient than predicted. However, when water first begins to enter Tank 2 from Tank 1, the conditions in Tank 2 are far from plug flow. Because the volume of water in Tank 2 is initially very low as the tank fills, the stream of water entering Tank 2 serves to keep the solution slightly stirred, which would be closer to CSTR operation than plug flow. If the CSTR equation is used to predict Tank 2 oxidation during this 2.2 hour period, a PCE concentration of 8.7 µg/L would be expected. The results of the plug flow and CSTR calculations show that for the early time period as Tank 2 fills, performance is somewhere between a CSTR and plug flow reactor. The observed performance (80 µg/L oxidized to 1.5 µg/L) would be expected after 1.1 hours of plug flow operation, approximately half the period observed.

Analytical and operational variability may also explain differences when comparing actual and predicted results. Note that the last water sample from Tank 2 in Table A-7 shows a PCE concentration of 3.8 µg/L, when a value less than 1.5 µg/L would have been expected.

2.3.5 System Operation

After successfully demonstrating the ex-situ oxidation of VOCs, continuous operation of the system began on February 14, 2000. Table 2-2 shows the operating and sampling schedules. Various system improvements and repairs were required during the first month of operation, which reduced the number of days the system was operating. These difficulties included a leaking $KMnO_4$ circulation pump, power failures, replacement of the extraction pump impeller, and the replacement of long lengths of polyethylene suction tubing with shorter tubing and more 2-inch hose to reduce suction head losses and decrease the load on the extraction pump. System availability is illustrated in Table 2-2.

From mid-March to mid-April, the system was functioning continuously at 4 gpm, with the exception of some down-time due to a power failure on April 3. However, during this period the efficiency of the injection wells declined and high water levels were observed in IW-3 and IW-4. Sulfamic acid was used to treat fouling in IW-3 and IW-4 on March 31 and the water levels in these wells showed a marked decrease. IW-3 and IW-4 again required treatment with sulfamic acid on April 7 and April 10, with less effective results than previous treatments.

The extraction rate of the system was reduced to 3.0 GPM on April 11 due to high water levels in the injection wells. On April 14, the touch pad controlling the system malfunctioned due to moisture after torrential rain, preventing adjustment to the system. Because of the inoperable touch pad and high water levels in the injection wells, the system was shut down on April 17.

The touch pad required replacement, which was performed by a Carus engineer on May 3. As addition of sulfamic acid had become less effective in addressing injection well fouling, the injection wells were redeveloped with a surge block, and a significant volume of solids was removed from the well sumps with a peristaltic pump. The quantity of solids in the wells was apparently due to breakthrough past the cartridge filters.

The redevelopment technique made use of a rubber K-Packer fastened to a length of PVC pipe. The K-Packer was sized to tightly fit inside the 4-inch ID injection wells. To try and avoid forcing solids out through the well screen and into the filter pack, the PVC pipe connected to the K-Packer was left open at both ends. As the K-Packer was slowly lowered into the well, water was displaced up into the pipe rather than forced out through the screen. Solids scraped off the inside of the well were pushed down into the well sump. The first time the K-Packer was lowered into the well, the fit was extremely tight. When the K-Packer reached the bottom of the screen, it was raised and then slowly lowered back into the well. On this second pass, it was possible to feel the K-Packer rubbing on the well slots, and the resistance was less. This indicated that there was a considerable layer of solids on the inside of the well screen that were removed on the first pass.

The well redevelopment returned injection well performance close to that experienced at original system startup; that is, water levels increased only a few inches during injection of treated groundwater at 4 gpm. This demonstrated that the majority of the fouling had only occurred on the inside of the well screens, and the MnO_2 solids had not clogged the filter pack or the aquifer. Following the injection well redevelopment and cartridge filter replacement, the system was restarted at 4.0 gpm on May 4. High pressure conditions in the cartridge filter system caused shutdowns on May 6 and May 9. It was thought that solids that had accumulated in Tank 2 were now being carried out over the standpipe to thecartridge filter system. Therefore, the contents of Tank 2 were removed on May 15 with a vacuum truck and disposed of off site. Cost was minimal, as the water and solids were considered non-hazardous (there were no VOCs in the water, and the solids passed TCLP analysis for metals). The filter cartridges were replaced and the system was operated at 4.0 GPM until high-pressure conditions again caused a system shut down on May 20. The system operated intermittently until May 23. On May 23, thecartridge filters were replaced and the mixer in Tank 1 was shut off in an attempt to reduce the concentration of solids in suspension being transferred to Tank 2. Tanks 1 and 2 were now both operating as plug flow reactors. This configuration is kinetically more efficient than operation with Tank 1 as a CSTR, so VOCs in extracted groundwater would have oxidized more quickly than at startup conditions.

The pleated cartridge filters proved impossible to clean (Appendix B, Figures 9 and 10). The filters in each housing were clogging after only 2 or 3 days. The filter cartridges were switched from the pleated filters to a polypropylene wound cartridge rated at 5 microns to try and extend filter life. However, this only added one day. The flow rate of the system was also reduced to 3.0 GPM on May 26 to extend filter life. The system was then operated at 3.0 GPM until it was finally shut down on June 21 (after being damaged by lightning).

Based on the frequent cartridge filter replacement now required, it was apparent that solids had likely been bypassing the filtration system since startup, with most of the MnO_2 produced during the ex-situ oxidation step (an estimated 100 to 150 grams per day) transferred into the injection wells. However, even with this quantity of solids bypassing the filters, well clogging was not apparent until after over 40 days of operation.

2.3.6 Performance Monitoring

Groundwater samples were collected from within the treatment cell during system operation to evaluate performance. Table 2-3 summarizes sampling locations and dates of sampling. Samples of influent and effluent from the system were collected when the system was running. Sodium thiosulfate was added to each water sample to consume any excess $KMnO_4$, and prevent further VOC oxidation within the sample vials after collection. As stated in the workplan (HLA, 1999) all water samples (groundwater and system influent and effluent) were filtered through a 0.45 micron filter prior to inorganic analysis. The filtering was performed to remove the suspended solids that form in the KMnO4 solution due to the oxidation reaction.

Synoptic rounds of static water level measurements were made at the beginning of each sampling event to evaluate the hydraulic performance of the treatment cell. The initial sampling schedule for performance monitoring was specified in the work plan (HLA, 1999), based on the results of groundwater modeling for the site. The actual sampling schedule was adjusted during the study to account for differences in predicted $KMnO_4$ travel times, due primarily to a lower actual groundwater pumping rate than was assumed in the workplan.

2.3.6.1 Water Levels

A round of water level measurements was collected prior to each groundwater sampling round. Water levels were measured in the wells within the treatment cell and the injection and extraction wells. Since the injection rate of the discharge pump and the amount of well clogging affected the water levels in the injection wells, the water level was also measured in OLD-13-20A, which is located between IW-3 and IW-4. Water levels were also measured in OLD-13-45B, OLD-13-43C and GMP-17, which are located at the downgradient edge of the treatment cell (see Figure 2-1). Background water levels were measured in the well cluster OLD-13-01A, OLD-13-40B, OLD-13-02C (located north of Building 1100) and the intermediate well OLD-13-26B, which is located upgradient of the treatment system inside Building 1100.

Evaluation of water level data for the shallow and deep zones indicates that operation of the system is altering groundwater flow in the treatment cell. The groundwater gradient in the shallow zone before the system was started and when the system was not operating (during Round 7) ranged from 0.0033 to 0.0035 feet per foot (ft/ft) (Table 2-4). The deep zone gradient ranged from 0.0032 to 0.0038 ft/ft before system installation and during Round 7. When the system was operating at flow rates of 3.0 and 3.5 GPM, the shallow zone gradient increased to 0.0077 ft/ft (2.26 times the equilibrium value) and the deep zone gradient increased to 0.0065 ft/ft (1.86 times the equilibrium value). At a flow rate of 4.0 gpm, the shallow zone gradient ranged from 0.0096 ft/ft to 0.0104 ft/ft (approximately 2.94 times the equilibrium value) and the deep zone gradient ranged from 0.0068 ft/ft to 0.0076 ft/ft (approximately 2.06 times the equilibrium value). Graphs of shallow and deep zone water levels are provided in Appendix C.

The increases in gradient measured in the shallow and deep zones are consistent with creation of a circulating groundwater cell within the natural groundwater flow system.

2.3.6.2 Groundwater Monitoring

Analytical tables for VOCs and TAL metals in the shallow and deep zone wells are included as Tables A-1 through A-4 in Appendix A. Table A-5 presents analytical results for VOCs in the injection and recovery wells. Tables A-8 and A-9 present analytical tables for VOCs and TAL metals for influent and effluent samples taken during the pilot study. These tables demonstrate that the system was capable of easily oxidizing VOCs in the extracted groundwater to below MCLs prior to injection.

The progression of the injected $KMnO_4$ across the treatment cell was best observed by measuring groundwater conductivity and color. Groundwater conductivity increases due to the increase in dissolved solids introduced by the $KMnO_4$ solution. However, conductivity alone is not an adequate measure of permanganate strength, as the potassium in solution is enough to raise the conductivity, even if all of the permanganate ion is consumed. Color was also used as an indicator for the presence of permanganate. As the injected $KMnO_4$ migrates across the treatment cell, groundwater color changes from a pale yellow through amber and brown. The brown color is from the MnO_2 in suspension. After this stage, groundwater color typically became purple, indicating that the organic matter in the vicinity of that monitoring point was oxidized and no longer consuming the purple permanganate ion.

Figures 2-3 through Figure 2-6 show VOC concentrations and conductivity versus time for both the shallow and deep monitoring wells. Figures 2-7 and 2-8 present averages of VOC concentrations and conductivity for all wells sampled during this investigation, and demonstrate more clearly the global trends present across the treatment cell as a function of time. And finally, Figures 2-9 through 2-12 present contour maps of VOC concentrations for the shallow and deep zones of the treatment cell. Figure 2-9 presents contours of the VOC concentrations in the shallow zone on February 2, 2000 prior to startup, and Figure 2-10 shows the shallow VOC contours on August 2, 2000 following completion of the pilot test. Figure 2-11 presents contours of the VOC concentrations in the deep zone prior to startup, and Figure 2-12 shows the deep VOC contours following completion of the pilot test.

Shallow Zone

As can be seen from Figure 2-3, VOC concentrations in the shallow zone decreased dramatically in most of the monitoring wells during the period of operation spanning February 13 to June 21, 2000. These wells, which include GMP-08, -09, -10, -12, -14, -15, and -16, experienced a reduction in the concentrations of VOCs from levels as high as 18,000 µg/L (at GMP-09) to levels that are near or below MCLs. In well OLD-13-07A, reductions in total VOCs of an order of magnitude were observed. VOC concentrations in GMP-11 (with initial total VOCs of 24,300 µg/L) and GMP-13 rebounded from sampling rounds in which no detections of VOCs were found to as high as 1,090 µg/L in Round 16 on 8/2/00. These two wells were on the south and north edges of the circulation cell, respectively, and at the upgradient end of the cell. Therefore, these wells would have detected the arrival of the upgradient contaminant plume from the untreated source area under Building 1100 following the shut down of the treatment cell. The treatment system was shut off on June 21, 2000, giving a period of 42 days for upgradient contamination to migrate toward these wells. However there were shut down periods prior to this final shut down that should be considered when interpreting the data. For instance there was a period between April 17 and May 17 when the system was operational for only four days. The most upgradient monitoring well within the treatment cell,GMP-10, also shows rebound, from 5.0 µg/L on April 24, 2000 to 24.0 µg/L on August 2, 2000. In fact, most of the wells show some rebound during the period from system shut down on June 21 to the Round 16 sampling on August 2. This would be expected due to the migration of contamination from upgradient source areas into the treatment cell area after the groundwater circulation cell was ended.

The dramatic decreases in concentration of total VOCs are accompanied by increases in conductivity as can be seen on Figure 2-5. The increase in conductivity is due to an increase in dissolved solids with the arrival of the $KMnO_4$ at these locations. The inverse relationship between conductivity and VOC concentration can be clearly seen by comparing Figure 2-3 with Figure 2-5. For example, at beginning of the pilot test, the conductivity in GMP-10, -11 and –12 (Figure 2-5) increased more rapidly than that in other wells. Correspondingly, the VOC concentrations in these wells (Figure 2-3) decreased most rapidly and significantly. During mid-test, the VOC concentration in GMP-13 decreased suddenly by more than 100 times; this was accompanied by an abrupt increase in conductivity. And near the end of the pilot test, the most significant VOC rebounds of GMP-11 and –13 (Figure 2-3) are accompanied by the two most significant decreases in conductivity as shown in Figure 2-5, indicating that untreated upgradient groundwater was moving into the treatment cell.

At some locations, VOC concentrations were initially substantially reduced from baseline, yetcontinued to be detected in groundwater even after the groundwater had achieved a purple color. The purple indicated that excess $KMnO_4$ was present in groundwater at that monitoring point, which would suggest all VOCs should have been oxidized. After a brief leveling-off, VOC concentrations eventually were no longer detected at these locations. This behavior may be due to the presence of tight, low permeability zones within the aquifer that the $KMnO_4$ was slow to penetrate, or free-phase residual PCE trapped within the sand pores. Because of the soaking effect achieved by the circulation cell, the $KMnO_4$ eventually reached these residual VOC sources and completed the contaminant oxidation in these areas.

Deep Zone

In the deep zone, the decreases in VOC concentrations during the pilot test were more modest: a decrease was not observed until after Week 6 (Figure 2-4). And, as expected, the corresponding increases in conductivity were also small and only began to increase after Week 6 (Figure 2-6). This would suggest that the natural organic carbon concentrations are higher in the deeper zone, causing the $KMnO_4$ to be consumed by the natural organics, thereby impeding the migration of $KMnO_4$ to the deep zone wells.

Figure 2-7 shows average VOC concentrations within the treatment cell for both the deep and shallow zone wells. It can be seen that although the decreases in VOC concentrations for the deep zone appeared to be modest in Figure 2-4, and the overall concentrations within the deep zone remained an order of magnitude greater than those in the shallow zone at the end of the test, the slope of the concentration vs. time data on Figure 2-7 indicates that the half-lives of the average concentration in the treatment cell were approximately the same for both the deep and shallow zones. On Figure 2-7 it can be seen that the average conductivity within the treatment cell is much greater for the shallow zone, and it increases at a faster rate than in the deep zone, indicating that the concentration of $KMnO_4$ in the shallow zone is much greater than in the deep zone.

Figures 2-9 through 2-12 show the contours of plume maps for both the shallow and deep zones at the beginning of the pilot test (baseline conditions) and at the end of the pilot study on 8/2/00. These contour plots clearly show the effectiveness of the VOC destruction due to $KMnO_4$ oxidation.

Changes in VOC concentrations and groundwater conductivity (Table 2-5) were used to evaluate actual travel times of treated groundwater within the treatment cell compared to the travel times predicted by the groundwater model. The predicted times in the work plan were based on an extraction rate of 0.92 gpm per extraction well. However, an extraction rate of 4 gpm corresponds to 1.33 gpm per well, or approximately 45 percent greater than the work plan model. Actual pilot study travel times would therefore be expected to be approximately 45 percent quicker than predicted. Actual travel times are affected by the variations in pumping rate during the pilot study (3 to 4 gpm), and by the periods when the system was not operating. The estimated travel times in the following discussion have been adjusted for the 45 percent difference in flow rates, but no attempt has been made in this report to account for any of the other variables that affect flow velocities.

Data from the shallow zone monitoring points indicate that treated groundwater, determined by decreases in VOC concentrations and increases in groundwater conductivity, has generally moved more rapidly in the shallow zone than predicted. Data collected during round 3 (21 run days/39 calendar days) showed decreases in VOC concentrations and increases in conductivity in GMP-14 (estimated 30 days travel time) and GMP-09 (estimated 55 days travel time). Data collected during round 7 (44-45 run days/66-67 calendar days) showed decreases in VOC concentrations and increases in conductivity in GMP-08 (estimated 85 days travel time) and GMP-09 (estimated 55 days travel time). Data collected during round 8 (53-54 run days/101-102 calendar days) showed decreases in VOC concentrations and increases in conductivity in GMP-16 (estimated 85 days travel time) and OLD-13-07A (estimated 100 days travel time).

Data from the deep zone monitoring points indicate that treated groundwater has moved more slowly in parts of the deep zone than predicted. Data collected from OLD-13-44B (estimated 7 days travel time) indicate that treated water did not reach that point until round 5 (33 run days/52 calendar days). Treated water did not reach OLD-13-42B (estimated 15 days travel time) until round 6 (40-41 run days/59-60 calendar days). VOC concentration for OLD-13-41B decreased from 4,600 ug/L (baseline) to 990 ug/L during the active portion of the pilot test, but conductivity values remained virtually the same throughout this period. Decreases in VOC concentration and increases in conductivity have not been as pronounced in the deep zone monitoring points as those observed in the shallow zone. Data collected from OLD-13-45B (estimated 15 days travel time), which is located in the middle of the treatment cell, indicate that treated water reached that point by round 3 (21 run days/39 calendar days). The VOC concentrations measured during this sampling round were substantially lower than baseline values, but conductivity of the groundwater had not increased as would be expected if the lowered VOC concentrations were due to oxidation by $KMnO_4$. Between March 23 and June 2, 2000 the VOC concentration in OLD-13-45B is relatively constant, then from June 2 to June 21 it decreases along with an abrupt increase in conductivity indicating that this decrease is due to $KMnO_4$ oxidation. Given its location and comparison to the VOC concentration and conductivity variation in other deep wells, the substantial decrease in VOC concentration between baseline and March 23, 2000 in OLD-13-45B is anomalous and not likely caused by $KMnO_4$ oxidation.

Analysis of inorganics in the $KMnO_4$ solution was complicated by the presence of very high dissolved solids concentrations, and also interference from the manganese introduced by the $KMnO_4$. Particular problems were encountered quantifying concentrations of chromium, nickel, selenium, and thallium. For example, initial chromium analysis of the $KMnO_4$ solutions created from the various lotsprior to startup reported chromium concentrations in excess of 1,000 µg/L, compared to the MCL of 100 µg/L. However, because chromium concerns had been carefully investigated during the pilot study permitting phase, it was clear these values were incorrect. Further review by the laboratory (and Carus Chemical quality control and laboratory data) confirmed actual chromium concentrations in the solution were closer to 40 µg/L. Similarly elevated concentrations of nickel, selenium, and thallium were also occasionally reported by the laboratory, even after the problems were believed to have been corrected.

The analytical data indicate that no analytes have been introduced into the aquifer at concentrations exceeding GCTLs, with the possible exception of thallium. However, as noted above, thallium analyses were suspect, exceedances of the GCTL in the injected solution were detected inconsistently, and no increases in thallium concentrations in groundwater were detected. The only inorganic compounds that appear to have been introduced into the aquifer at concentrations of interest are manganese and potassium. At the conclusion of the pilot test on August 2, 2000, manganese (with a secondary standard of 50 µg/L) was present in GMP-10 and GMP-12 at concentrations of 140 µg/L and 490 µg/L, respectively. However, further downgradient from these two wells within the treatment cell, manganese concentrations drop to levels well below the secondary standard. Manganese from unreacted permanganate is present in a dissolved state. However, after the permanganate has been consumed by the oxidation reactions, all of the manganese has been converted to MnO_2 and is removed during groundwater filtration. Potassium, an essential nutrient with no primary or secondary standards, appears to have increased in concentration by one to three orders of magnitude within the treatment cell.

A few inorganics appear to have been temporarily mobilized due to the oxidation process and have been detected as elevated concentrations during the pilot test. However, after the test these concentrations tend to decrease. For example, mercury was <0.0002 mg/L in groundwater in every well prior to the test. In the shallow zone during the period of active oxidation, mercury levels were detected at GMP-09 and GMP-10 at 0.0042 mg/L and 0.0023 mg/L respectively, exceeding the MCL of 0.002 mg/L. However, during the final round of groundwater sampling on August 2, 2000, the concentration in GMP-10 had decreased to 0.0013 mg/L (GMP-9 was not sampled for metals on that date). In the downgradient well GMP-17, mercury has shown a very small increase from <0.0002 mg/L before the test to 0.00079 mg/L on January 5, 2001. Chromium concentrations in groundwater were also observed to increase above baseline during the pilot, exceeding the MCL in GMP-12 (0.17 mg/L on March 30). However, as with mercury, chromium concentrations decreased after injection of $KMnO_4$ ceased (chromium in GMP-12 had decreased to 0.11 mg/L on August 2). Mercury was never detected in the injected $KMnO_4$ solution, and chromium concentrations in the $KMnO_4$ were never high enough to account for the increase observed in GMP-12. Other inorganics such as aluminum, magnesium, and iron have shown modest increases during the pilot test but then show decreasing trends after system shut-down (see Appendix A, Table A-2).

2.3.7 Natural Attenuation Parameters

Natural attenuation (NA) parameters were analyzed from six shallow zone wells and four deep zone wells as specified in Table 2-1. The NA parameters were measured during baseline sampling and again at the end of the pilot test to assess the impact of the pilot test on these parameters. The NA parameters are included on Tables A-2 (shallow) and A-4 (deep) in Appendix A.

Note that many of the parameters collected during baseline sampling were measured using field test kits. However, most of these kits are colorimetric, and were unusable during final round sampling because of the color introduced to groundwater by the $KMnO_4$ solution. Therefore and offsite laboratory was used to analyze for all parameters collected during the final round sampling. This may have introduced some inconsistencies between the baseline and final round data.

1. In the shallow zone:

    - TOC concentrations in groundwater have increased within the source area from 6 mg/L to 8 mg/L during baseline measurements to a range of 46 mg/L to 180 mg/l on August 2, 2000; background/upgradient values measured during the RI were 14 to 27 mg/L outside the plume, with depleted values of less than 10 mg/L within the plume. This increase in TOC is no doubt due to the creation of carboxylic acids (CA) during the oxidation process.

    - Sulfate concentrations were 5 mg/L to 68 mg/L at the end of the pilot test which are increased over baseline conditions of <1 mg/L everywhere. However, these values are consistent with measurements made during the RI (4 mg/L to 32 mg/L).

    - Dissolved iron remained at low (<3 mg/L) or undetectable concentrations throughout the pilot test, but manganese in groundwater increased from 0.02 mg/L or less to values as high as 490 mg/L (due to the presence of unreacted $KMnO_4$). However, in the downgradient well GMP-17, manganese remained at non-detectable levels even 5 months

(January 5, 2001) after the pilot test system was shut down. The elevated manganese is due to presence of unreacted permanganate in solution. However, as the permanganate is consumed through oxidation of organics, the manganese is converted to MnO_2 particulates that are removed by filtration prior to inorganic analysis.

- Dissolved oxygen concentrations remained less than 1 mg/L, and hence anaerobic conditions have been maintained.

- Oxidation reduction potential (ORP) both increased and decreased depending on location within the circulation cell: the ORP at GMP-9 decreased from –78 (baseline) to –277 (August 2); GMP-10 increased from –191 (baseline) to +350 (August 2); GMP-12 initially decreased from +84 (baseline) to –268 (March 10) then increased to +753 (August 2); GMP-13 increased from +126 (baseline) to +395 (August 2); and GMP-15 decreased from –67 (baseline) to –253 (August 2). The ORP in GMP-17 downgradient of the circulation cell remained constant [–54 (baseline) to –58 (August 2)] during the pilot test, but then increased to +190 (January 5, 2001) showing that after circulation cell shut down, the unused oxidant within the cell has migrated under natural gradient conditions to the downgradient location of GMP-17.

2. In the deep zone:

   - TOC values have increased in OLD-13-41B and OLD-13-44B from baseline values of 6 to 8 mg/L respectively to 200 mg/L to 140 mg/L on August 2; as with the shallow zone wells, this is no doubt due to creation of CA during the oxidation process.

   - As with the shallow zone, sulfate values increased over baseline but were consistent with values measured during the RI.

   - Dissolved iron shows no significant change from its baseline value of approximately 1 mg/L throughout the test, and manganese shows modest increases from nondetectable at 0.01 mg/L detection limit to a range of approximately 0.02 to 0.04 mg/L. However, in the downgradient well OLD-13-46B the values of manganese show a consistent downward trend from 0.028 mg/L at baseline to 0.019 mg/L on August 2 to 0.012 mg/L on January 5, 2001.

   - Dissolved oxygen concentrations at baseline were surprisingly high at 5.1 mg/L to 8.4 mg/L in deep zone wells OLD-13-44B, -45B and -46B; OLD-13-41B had 0.1 mg/L. At the end of the treatment system operation on August 2, the D.O. values in these wells were all less than 1 mg/L.

   - ORP for the deep wells were all between -100 and -200 at baseline, by the end of the system operation on August 2, 2000 there were modest increases in ORP at all of the wells, but the values were still negative and ranged from -63 to –116. On January 5, 2001, 5 months after treatment system shut down, in OLD-13-46B downgradient of the treatment cell, the ORP had increased to +10.4. This is no doubt due to the migration of residual $KMnO_4$ to and through this location.

3. In the recovery wells (RWs) and injection wells (IWs):

   - ORP in all RWs and IWs ranged from -102 to -228 at baseline; ORP values remained in this range for the RWs throughout the test, but the ORP for the IWs was in the range of +698 to +724 at the end of the system operation on 8/2/00. The high positive values would be expected since at this time the IW area is flooded with unreacted permanganate.

   - At the end of system operation on August 2, 2000, D.O. was less than 1.0 mg/L for all RWs, but was 2.1 mg/L for the IWs. This is no doubt due to the introduction of some oxygen in the mixing tanks before discharge to the injection wells.

The values of pH in the shallow zone monitoring wells were in the range of 5.7 to 6.3 during baseline, but had increased to the range of 6.3 to 7.1 by August 2. However, in the deep zone monitoring wells, the pH at baseline was in the range of 5.2 to 5.6 and by August 2 it had decreased slightly to the range of 4.6 to 5.5. The pH values in the RWs and IWs remained fairly constant in the range of 6.2 to 6.6 for all RWs and IWs at baseline, while at the end of system operation on August 2, the pH for the RWs was in the range of 6.4 to 6.6 and for the IWs it was 6.9 to 7.0. Therefore the shallow zone behaves similar to the area surrounding the IWs, which would be expected. The decrease in pH in the deep zone is apparently caused by the generation of CA and subsequent lack of sufficient migration and flushing by permanganate in the deep zone to increase the pH to the IW levels.

As would be expected, the addition of the oxidant and mixing in open tanks in the above-ground treatment system has increased the D.O. slightly and has caused the pH to move closer to neutral. In the underground treatment cell, the permanganate oxidation of the source area VOCs has produced dissolved organic carbon due to the creation of carboxylic acids resulting from the oxidation reaction (see equation in Section 2.1) and has caused some minor increases in dissolved manganese. It has also produced an increased ORP (which will be lowered as the upgradient natural groundwater flow carrying VOCs from the untreated upgradient portions of the source area under Building 1100 migrates into the treatment zone). Furthermore, as the residual permanganate gets flushed from the area, it is expected that geochemical conditions would return to baseline conditions.

Although there is little microbiological data for confirmation, it is likely that the production of CAs, which dramatically increases the TOC in groundwater and decreases the ORP, is a stimulating effect for natural bacteria in the aquifer. It appears that TOC in groundwater may remain elevated as the oxidation front moves through and ORP levels are greatly increased. Therefore it is probable that the overall natural bacterial degradation of contaminants has been enhanced by the operation of this pilot test.

SECTION 3.0

3.0 CONCLUSIONS

The objective of the chemical oxidation pilot test was to provide site-specific data supporting assessment of this alternative in the Final OU 4 FS. The following performance objectives were evaluated during the pilot test:

1. ability to create and maintain a groundwater circulation cell

2. optimum $KMnO_4$ aqueous concentration required to oxidize the OU 4 source area VOCs

3. ability to treat source area VOCs both above and below the layer of dense sand

4. maximum reduction of groundwater VOC concentrations achievable with this technology

The ability to create and maintain the treatment cell was evaluated by monitoring changes in groundwater gradient within the cell due to system operation and by monitoring groundwater quality in wellslocated downgradient of the treatment cell (OLD-13-46B and GMP-17). Groundwater elevation data collected during the pilot study indicate that when the system is operating, the groundwater gradient is increased in the treatment cell above and below the layer of dense sand. The ability to treat the source zone above and below the dense sand layer has been evaluated by comparing estimated travel times to the actual movement of treated water in the cell and the reduction of VOC concentrations in the treatment cell. Changes in VOC concentrations and groundwater conductivity indicate that treated water is generally moving more rapidly than predicted in the shallow zone and more slowly than predicted in the deep zone. Dramatic decreases in total VOC concentrations have occurred in the shallow zone, but have been slower to develop in the deep zone. However, the average half life within the circulation cell for VOC reduction is approximately the same in both the shallow and deep zones (see Figure 2-7), about 7 to 8 weeks.

The reduction of contaminants achievable by this technology has been evaluated by comparing baseline VOC concentrations with data collected during the sampling rounds. The maximum VOC concentration detected during the baseline sampling was 24,300 μg/L (23,000 μg/L PCE), detected in GMP-11. By Round 6, VOC concentrations in GMP-11 were below detection limits, indicating that the technology is capable of reductions of more than 99.995 percent of PCE within 59 days. Furthermore, by Round 10 (116 days after startup, 66 days of system run time), VOC concentrations in four shallow monitoring wells (GMP-10, 11, 12 and 13) have been reduced to or below MCLs. Other monitoring wells at a greater distance from the injection wells showed approximately two orders of magnitude reduction in VOC concentrations (GMP-08, 09, 14 and 16). By Round 13 on June 28, 2000, VOC concentrations had decreased to MCL levels or below in three additional wells, GMP-14, GMP-15 and GMP-09.

In the deep zone, significant reductions in VOCs did not occur until April. This is apparently due to much higher concentrations of natural organic material on the soil particles in the lower zone, which must also be oxidized, and therefore slows the migration of the VOC oxidation front. Evidence of higher TOC concentrations was found during the RI (HLA, 2001b). However, significant destruction of VOCs in the deep zone did occur during the month of April, and by July 13, 2000, average concentrations of VOCs in the deep zone had decreased by an order of magnitude (see Figure 2-7).

Downgradient Groundwater

After treatment system shut down on June 21, 2000, groundwater within the treatment cell begins to migrate downgradient. Also untreated source area contamination from upgradient of the treatment cell (under Building 1100) begins to migrate into the area of the treatment cell. As shown on Figures 2-3, 2-5 and 2-7, VOC concentrations are beginning to increase between June 21 and August 2, 2000 due to the advancement of untreated upgradient groundwater. After treatment cell containment was lost on June 21, migration of groundwater from within the treatment cell proceeded downgradient. In accordance with the pilot study work plan, two groundwater monitoring points (GMP-17 shallow and OLD-13-46B deep) were installed approximately 20 feet west of the pilot study recovery wells at the downgradient end of the treatment cell.

By January 5, 2001, groundwater downgradient from the pilot study treatment cell exhibited evidence of the injection of $KMnO_4$ that had been confined to the treatment cell prior to shutdown on June 21,2000. The presence of the oxidant is most evident in analysis of color, TDS, conductivity, and potassium. Exceedances of Florida secondary standards for color, TDS, and aluminum have occurred or are possible. However, these exceedances should reach a maximum and then decrease as the treated groundwater disperses. Increases in groundwater concentrations of chromium and/or mercury were also observed. This is consistent with increases measured within the treatment cell during operation where these parameters showed occasional exceedances of Florida primary standards. However, concentrations appeared to decrease after $KMnO_4$ injections ceased. Mercury is not present in the permanganate solution which was being added to the groundwater treatment cell, and some of the chromium concentrations observed in groundwater were higher than the concentrations being injected. It is possible that the injected $KMnO_4$ solution oxidized the organic compounds on the aquifer solids thereby releasing soluble inorganics which may have been sorbed onto soil particles. After oxidation ceased, the inorganics have apparently re-sorbed onto aquifer solids or onto MnO_2 particles.

SECTION 4.0

4.0 RECOMMENDATIONS

It is apparent that in situ chemical oxidation using $KMnO_4$ is very effective at destroying the VOC contamination in the source area at OU 4. We therefore recommend its full-scale application to the source zone.

The Final Orlando OU 4 FS (HLA, 2001a) evaluated in-situ oxidation using $KMnO_4$ as a source area alternative. Various cost and performance assumptions required for the FS evaluation have been based on the results of the pilot study.

The recommendations for full-scale implementation include:

- The anticipated average $KMnO_4$ dosage will be 1 g/L, however during the latter stages of treatment, the $KMnO_4$ feed may only be makeup to maintain the 1 g/L in the injected groundwater. Although this is less than the 4 g/L used in the pilot test, recent conversations with Colorado School of Mines researchers have suggested that at lower concentrations, less of the natural TOC in the aquifer will be oxidized, leaving a higher percentage of the injected $KMnO_4$ available to oxidize VOCs. The lower $KMnO_4$ concentration will oxidize the VOCs more slowly, but this is not a handicap since the source area will be flooded and soaked in the oxidant. The lower $KMnO_4$ concentration will also likely result in the production of less MnO_2;

- Separate injection wells for the shallow and deep zones, to allow targeting of the $KMnO_4$ solution and preferential injection into just the deeper zone once the shallow aquifer becomes saturated with $KMnO_4$;

- Replacement of the cartridge filtration system with a more efficient and less maintenance-intensive alternative, such as a rotary drum filter, stacked disks, or membranes.

The cost estimate for the $KMnO_4$ alternative in the FS was competitive with the other remedial alternatives evaluated. The pilot study results have demonstrated the effectiveness and implementability of this technology. Based on these results, we recommend preparing an OU 4 Proposed Plan that includes use of in-situ oxidation of the OU 4 source area using $KMnO_4$.

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REFERENCES

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FIGURES

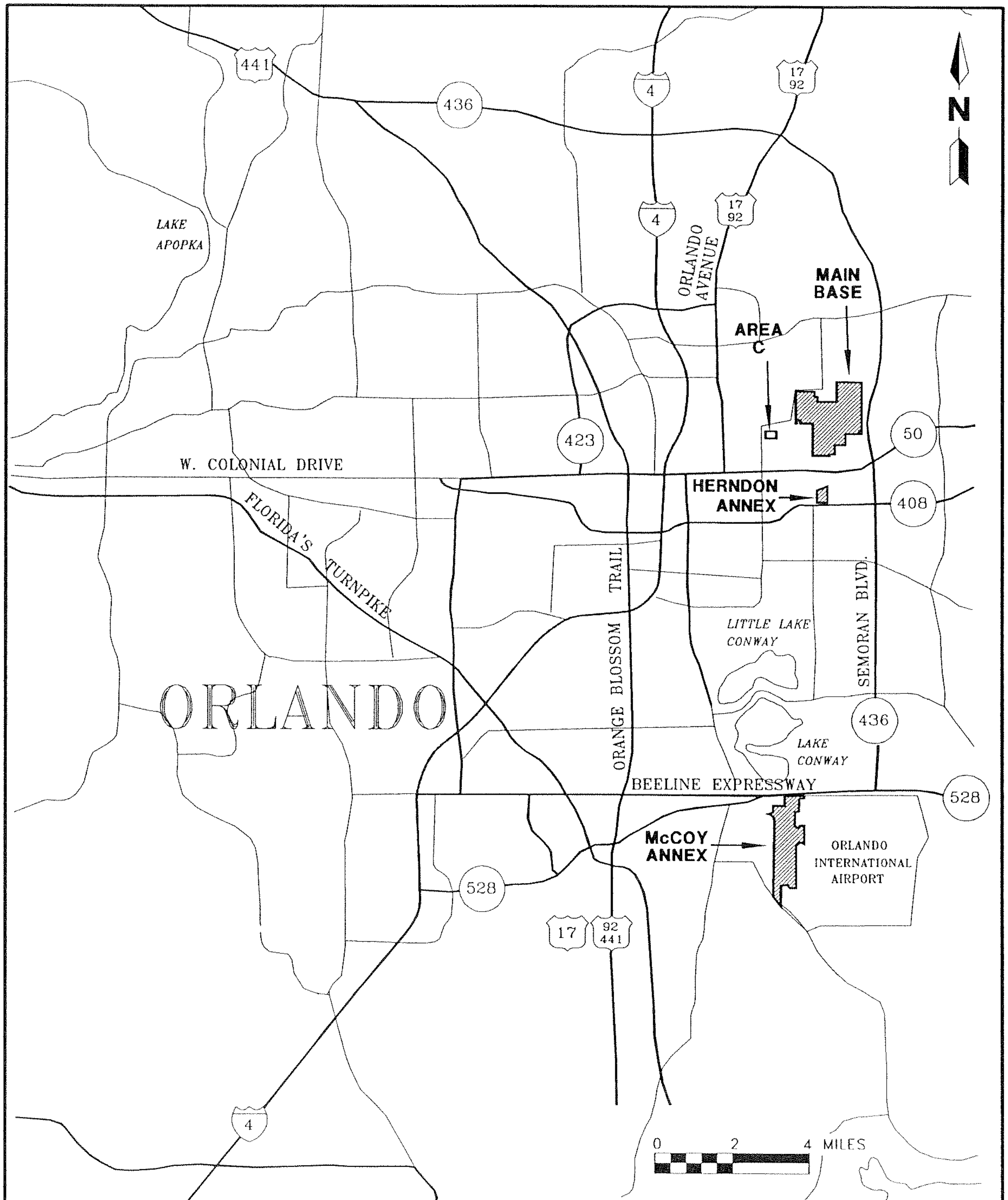

FIGURE 1-1
SITE LOCATION MAP

GROUNDWATER TREATABILITY STUDIES
IN-SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

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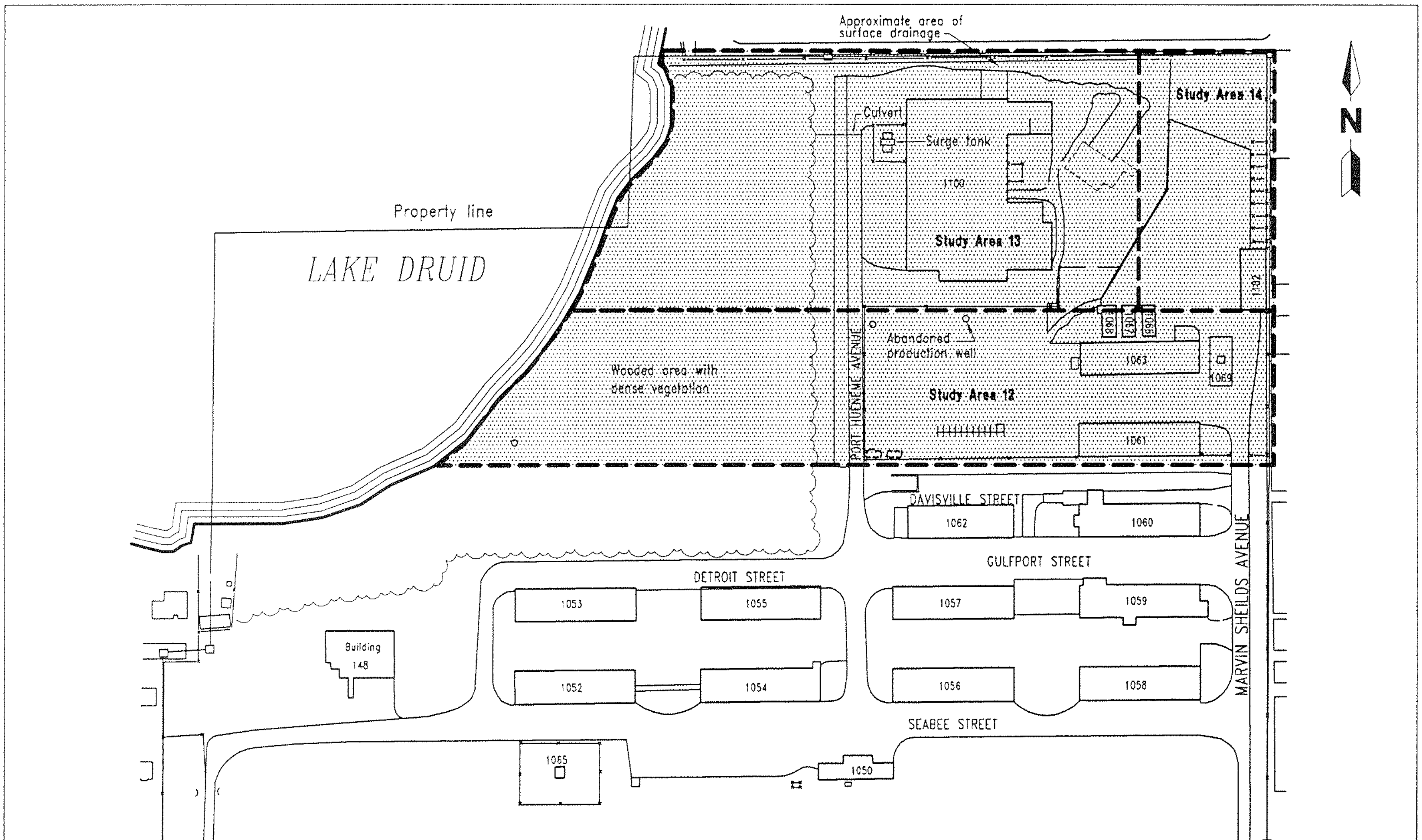

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SCALE: 1 INCH = 250 FEET

FIGURE 1-2
MAP OF AREA C

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GROUNDWATER TREATABILITY STUDIES
IN SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

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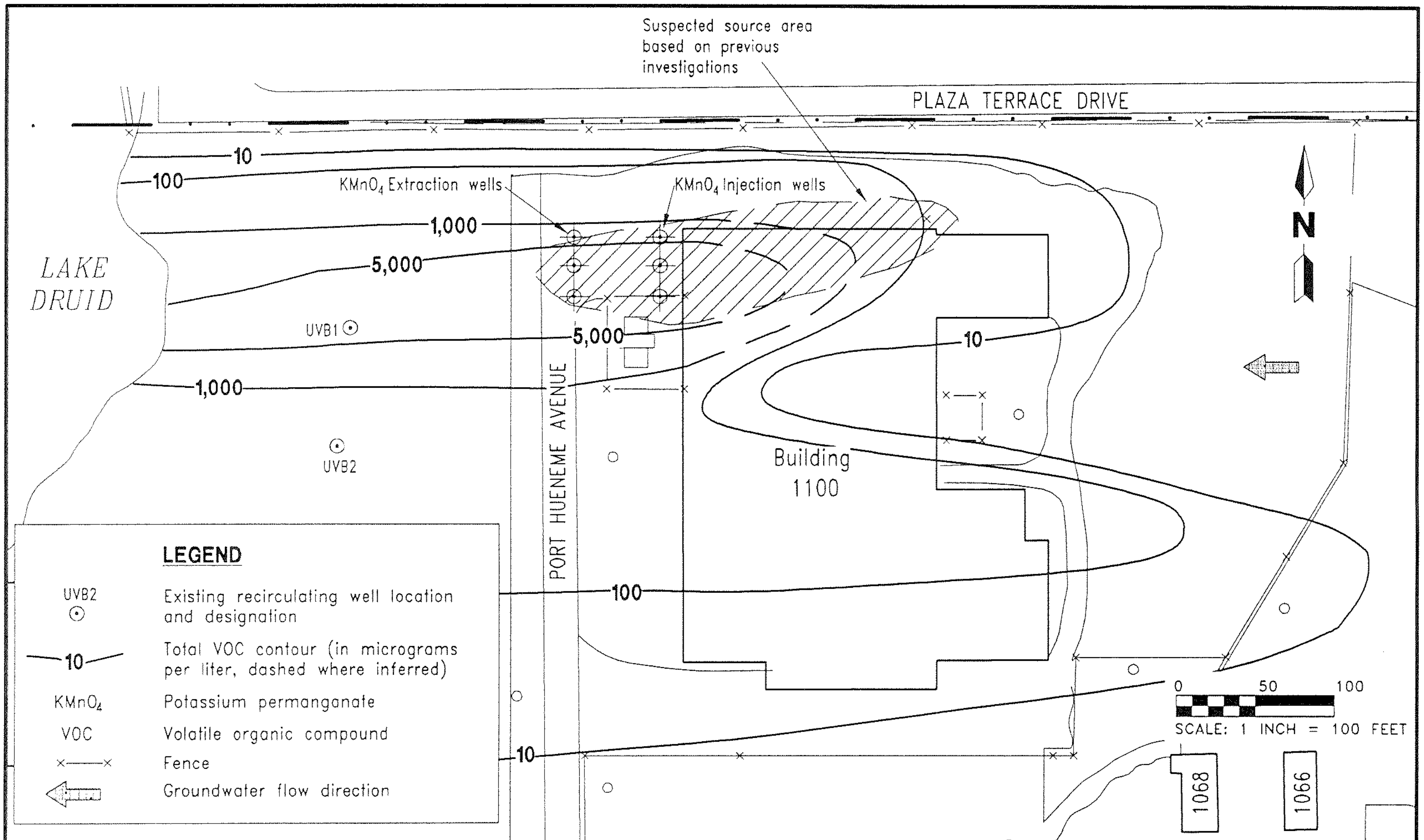

FIGURE 1-3
PILOT STUDY LOCATION

GROUNDWATER TREATABILITY STUDIES
IN SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
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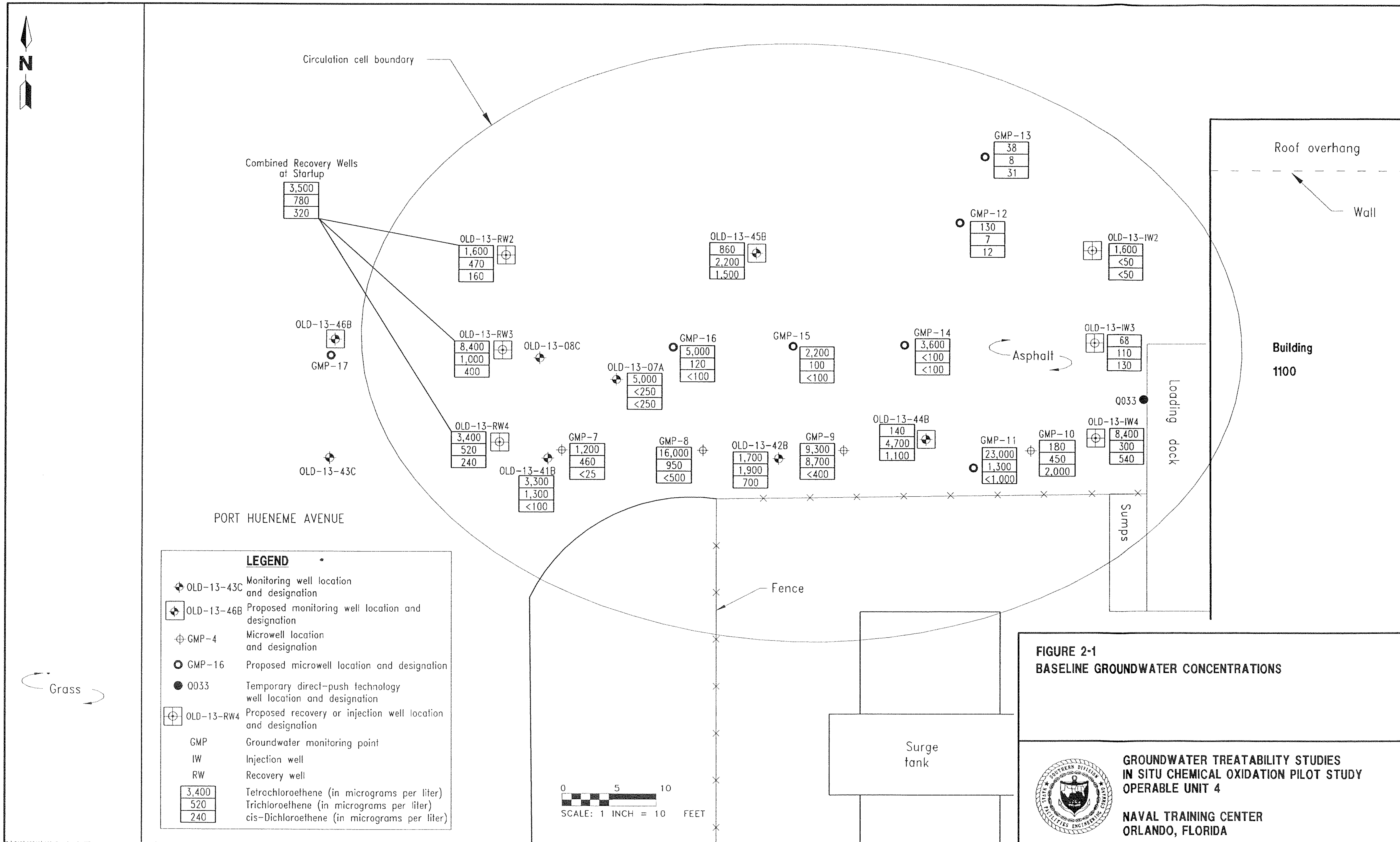
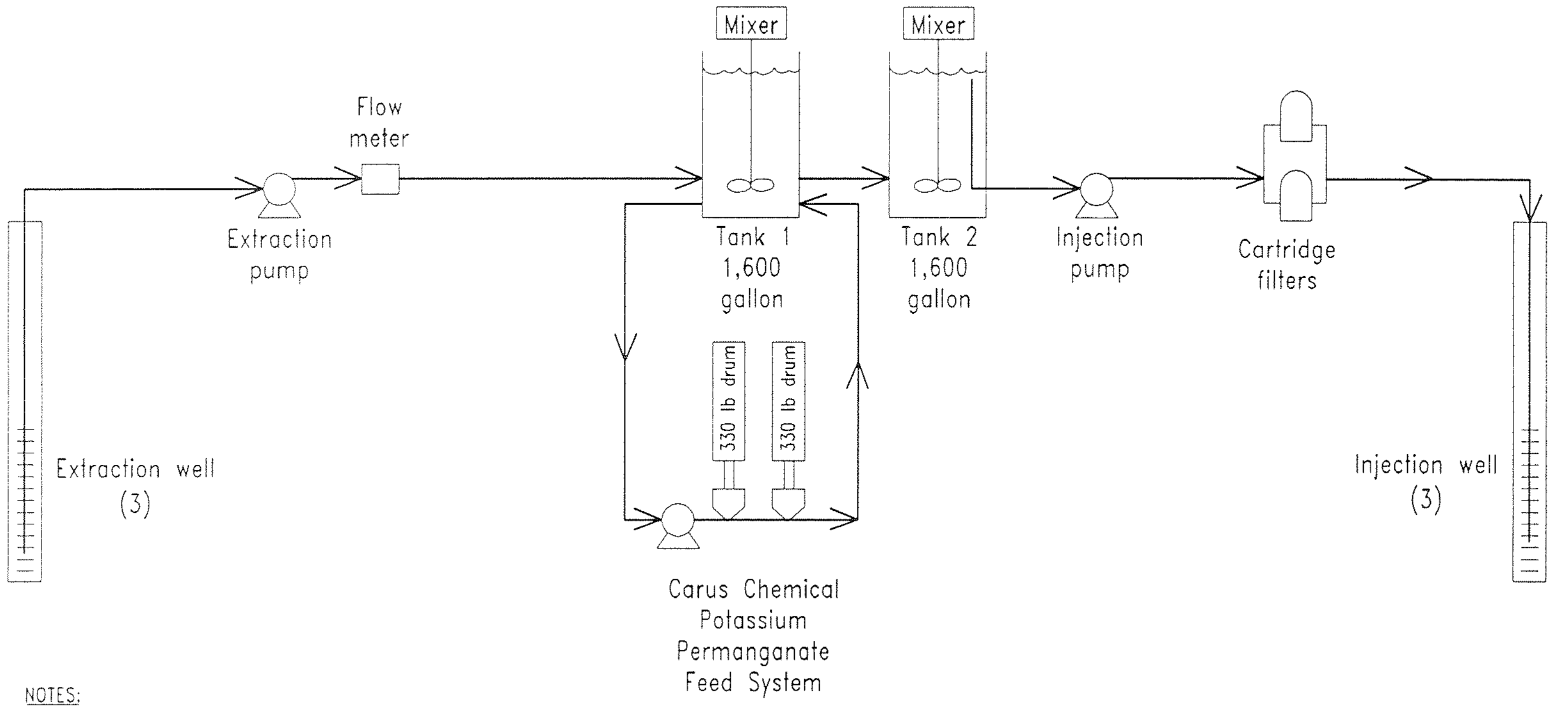


FIGURE 2-1
BASELINE GROUNDWATER CONCENTRATIONS



NOTES:
1. Maximum extraction/injection flow is 5 GPM total.
2. All materials of construction to be compatible with a 1% $KMnO_4$ solution at pH=10.
3. Instrumentation and control requirements not shown.

NOT TO SCALE

LEGEND

$KMnO_4$ Potassium permanganate

→ Water flow

FIGURE 2-2
CHEMICAL OXIDATION EQUIPMENT SCHEMATIC

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GROUNDWATER TREATABILITY STUDIES
IN SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

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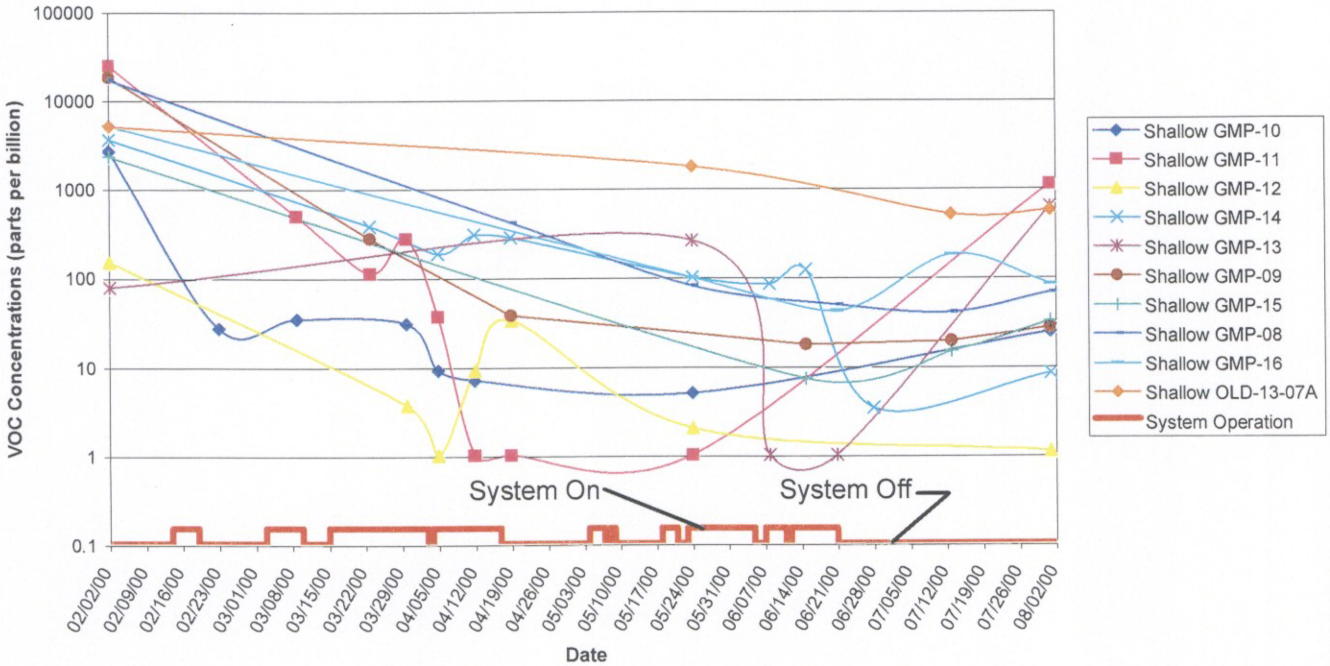

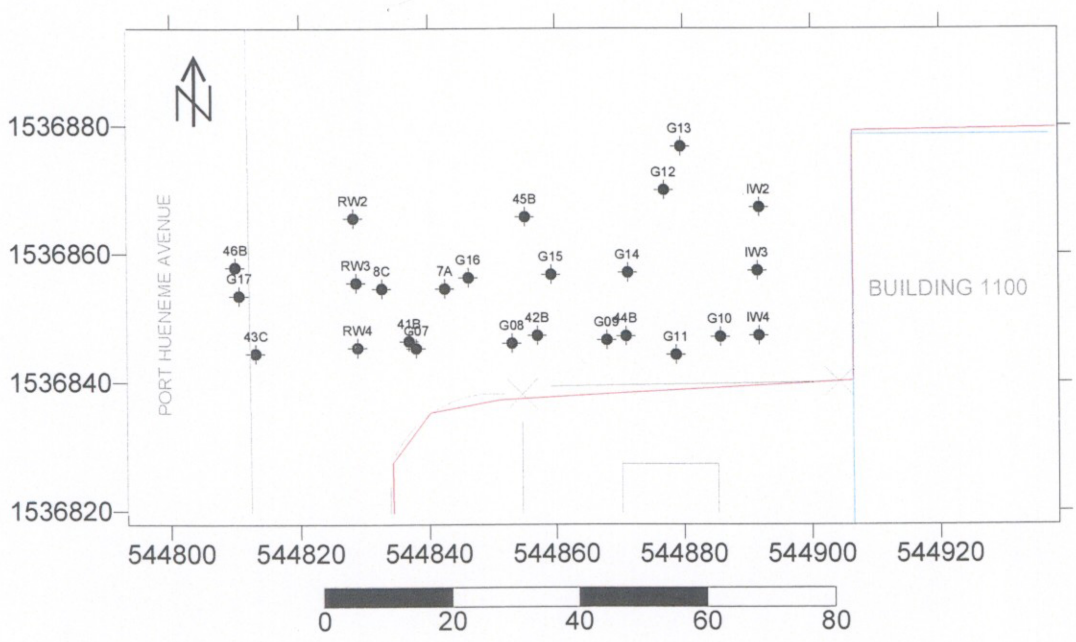

FIGURE 2-3
SHALLOW ZONE
VOC CONCENTRATIONS

GROUNDWATER TREATABILITY STUDIES
IN-SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

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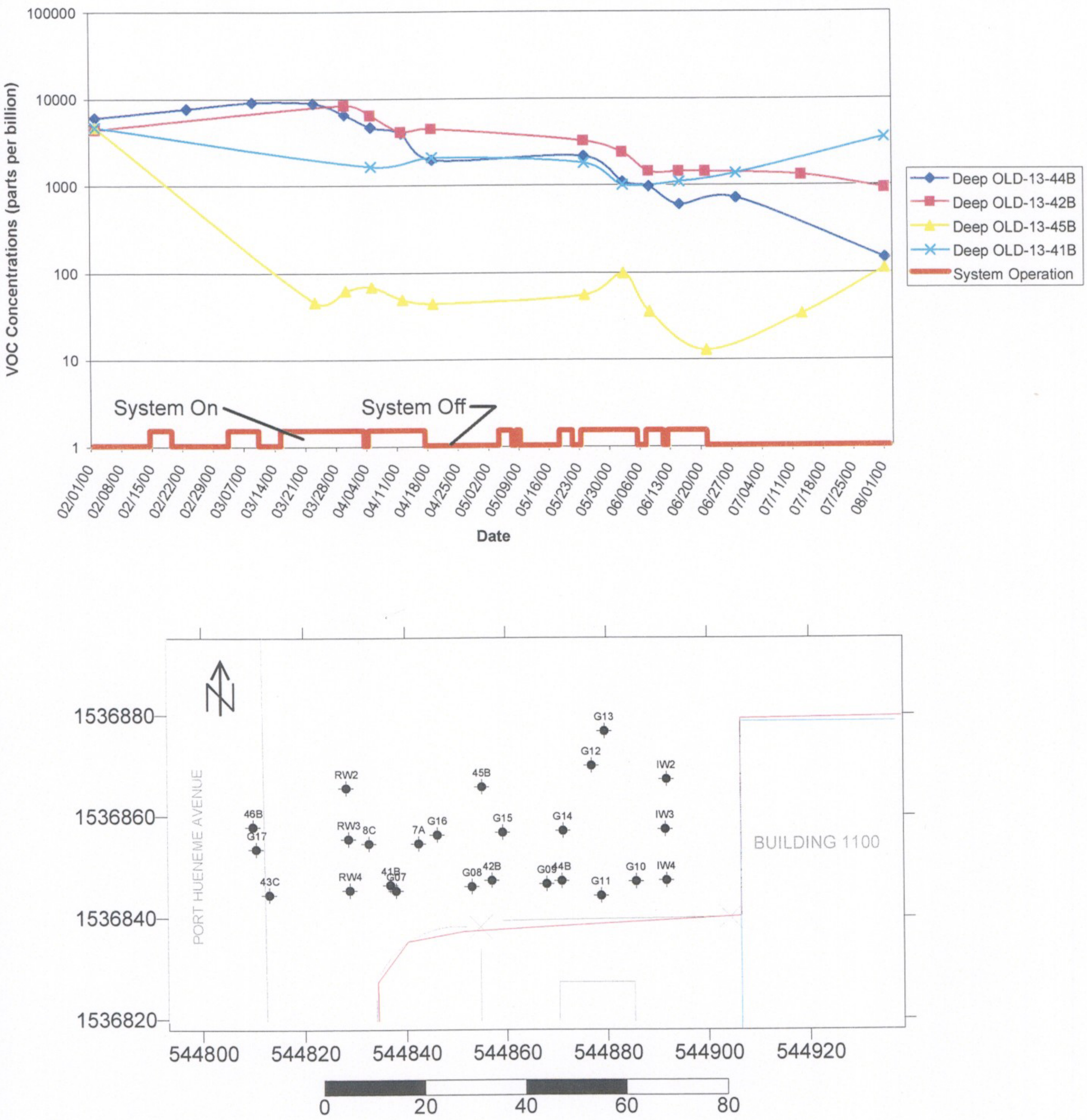

FIGURE 2-4
DEEP ZONE VOC CONCENTRATIONS

GROUNDWATER TREATABILITY STUDIES
IN-SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

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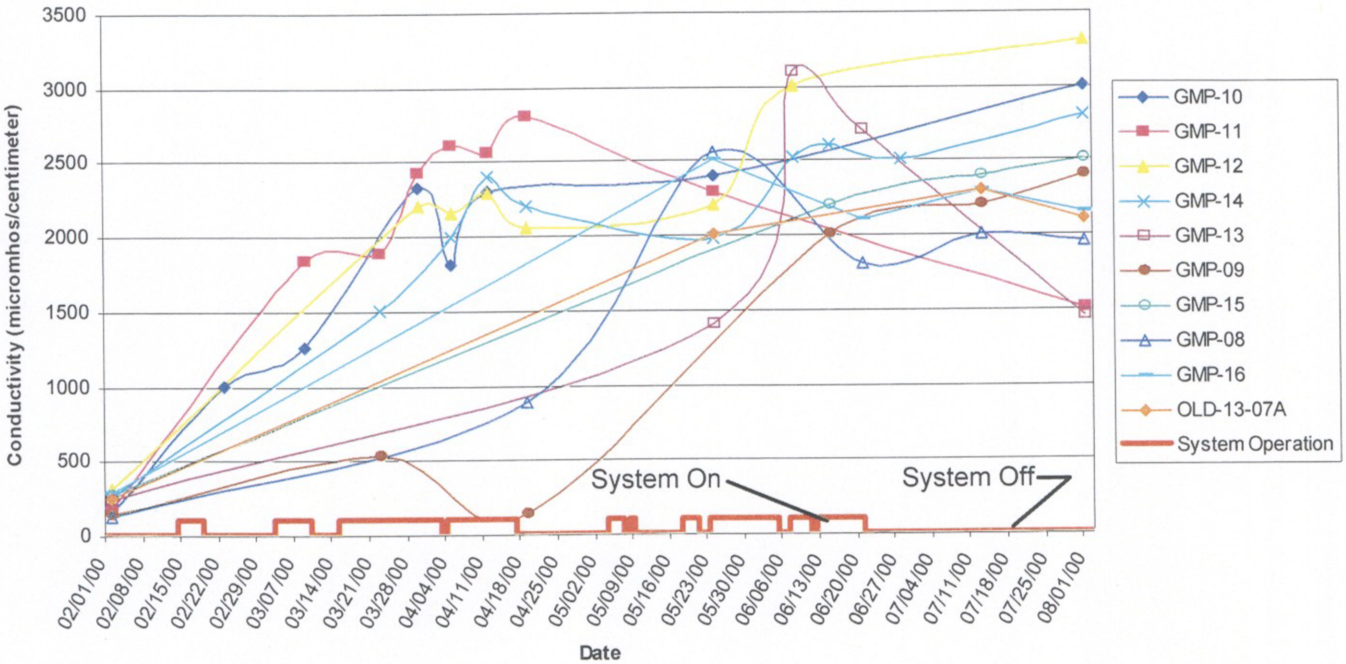

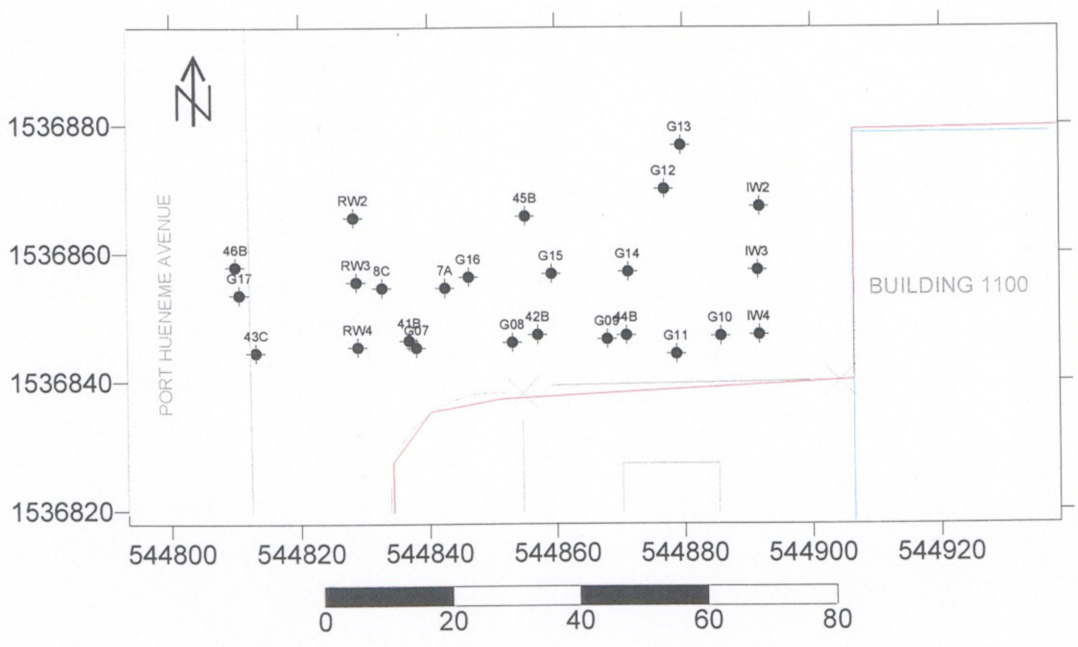

FIGURE 2-5
SHALLOW ZONE
CONDUCTIVITY DATA

GROUNDWATER TREATABILITY STUDIES
IN-SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
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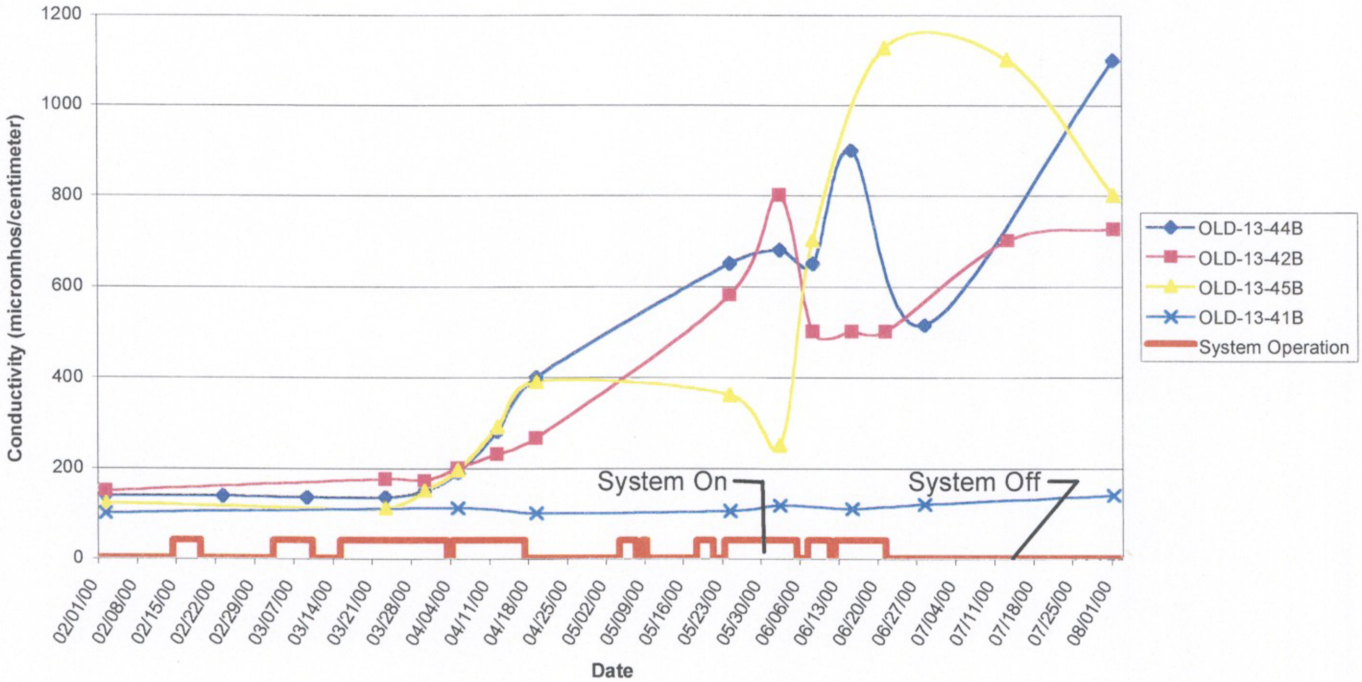

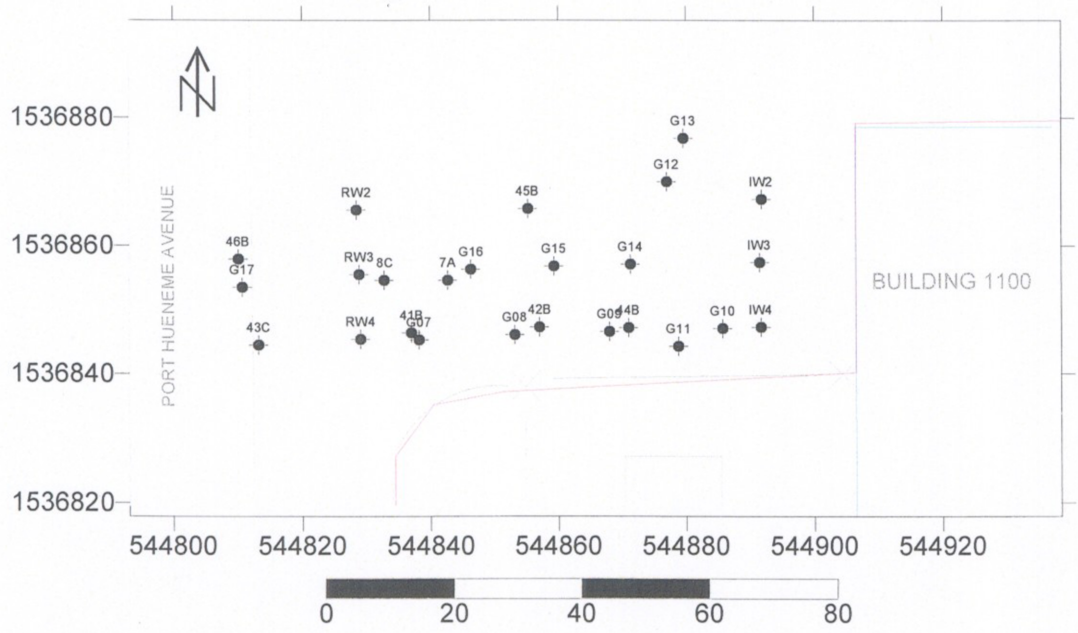

FIGURE 2-6
DEEP ZONE
CONDUCTIVITY DATA

GROUNDWATER TREATABILITY STUDIES
IN-SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

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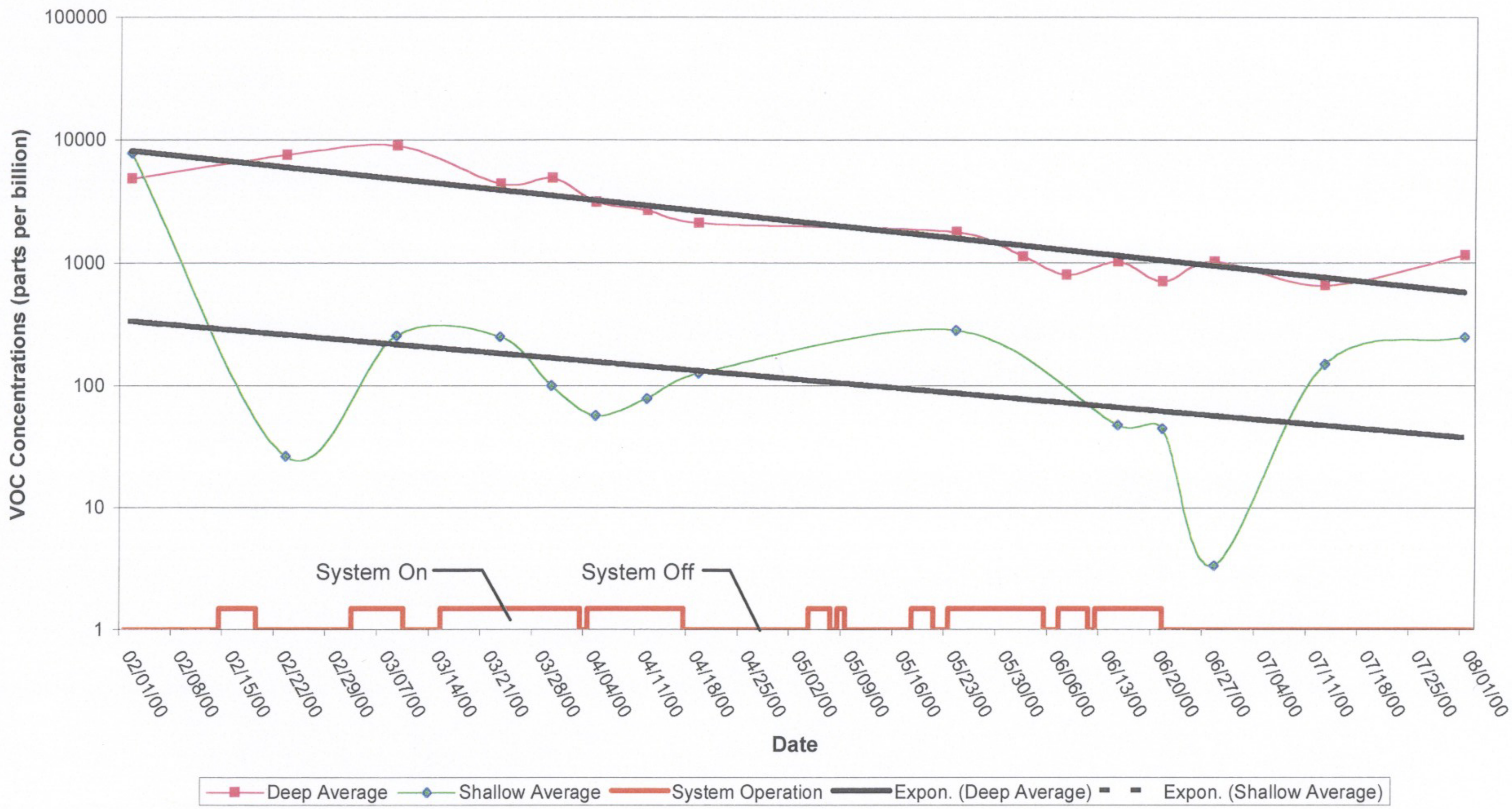

FIGURE 2-7
AVERAGE SHALLOW AND DEEP
VOC CONCENTRATIONS

GROUNDWATER TREATABILITY STUDIES
IN-SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

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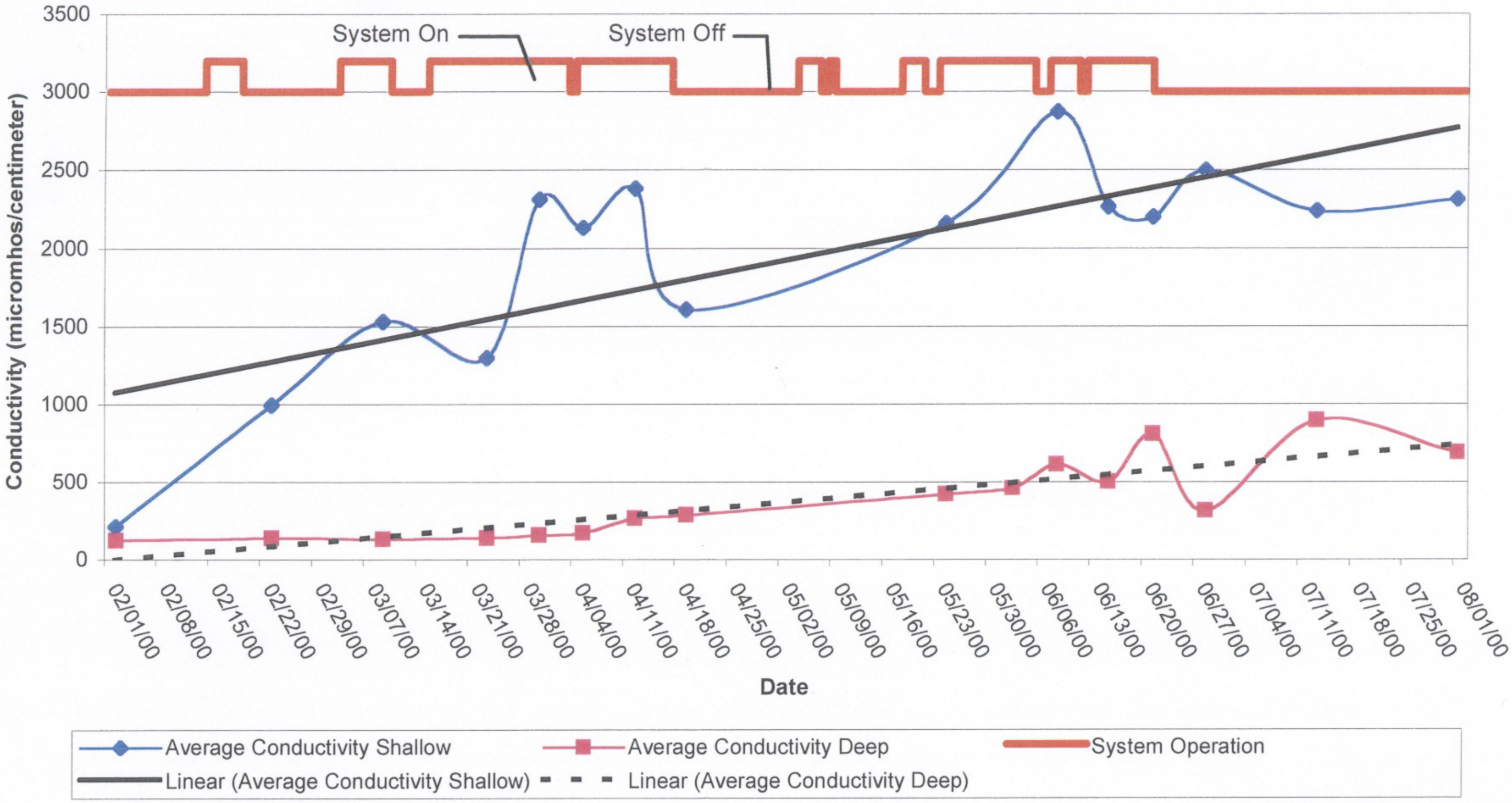

FIGURE 2-8
AVERAGE SHALLOW AND DEEP
CONDUCTIVITY DATA

GROUNDWATER TREATABILITY STUDIES
IN-SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

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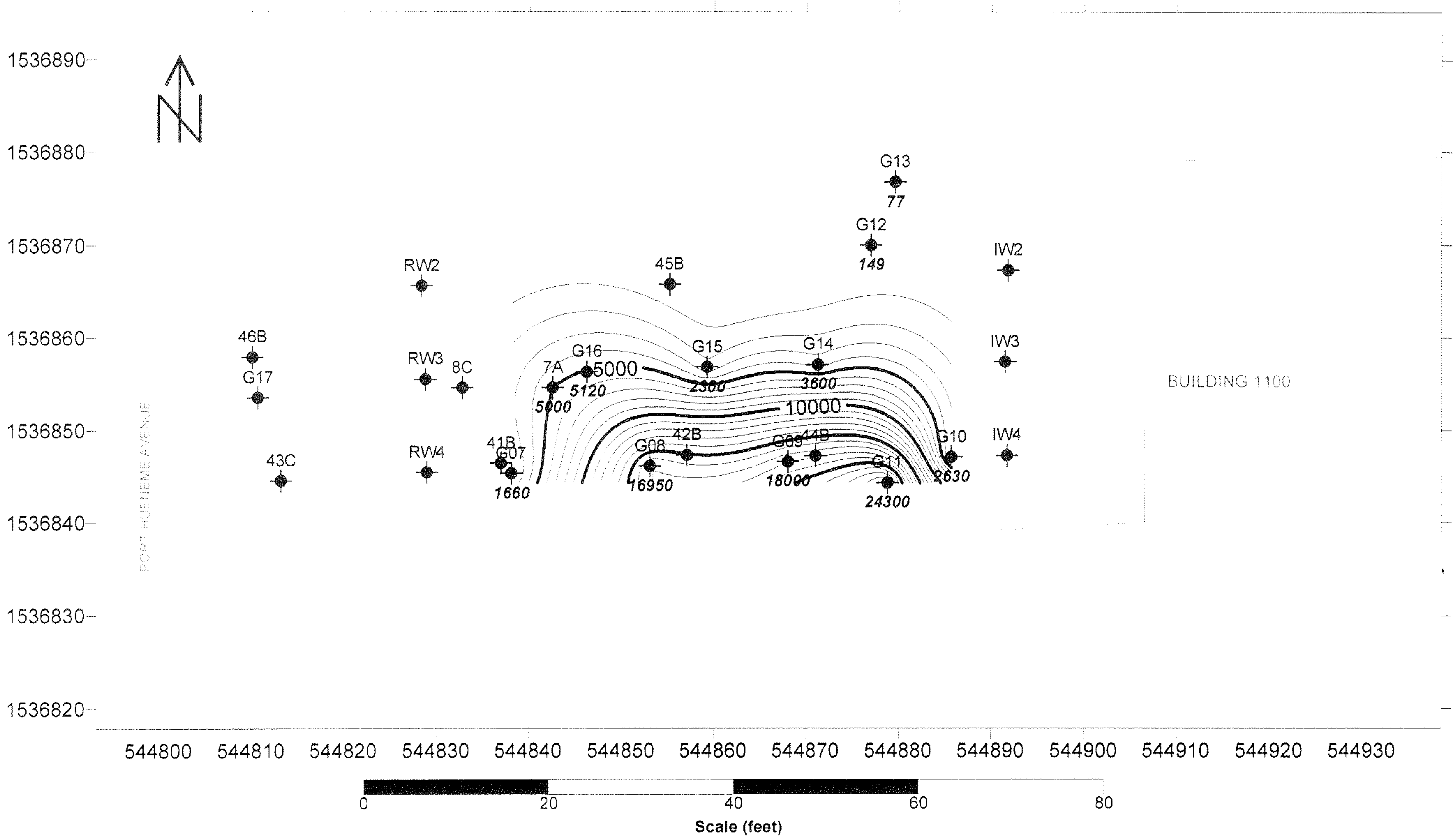

Borehole designations are shown above the symbol, and VOC concentrations (ug/L) are shown below

Note: Contour Interval 1000 micrograms per liter.

FIGURE 2-9
TOTAL SHALLOW VOC CONCENTRATIONS
FEBRUARY 2, 2000 - BASELINE

GROUNDWATER TREATABILITY STUDIES
IN-SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
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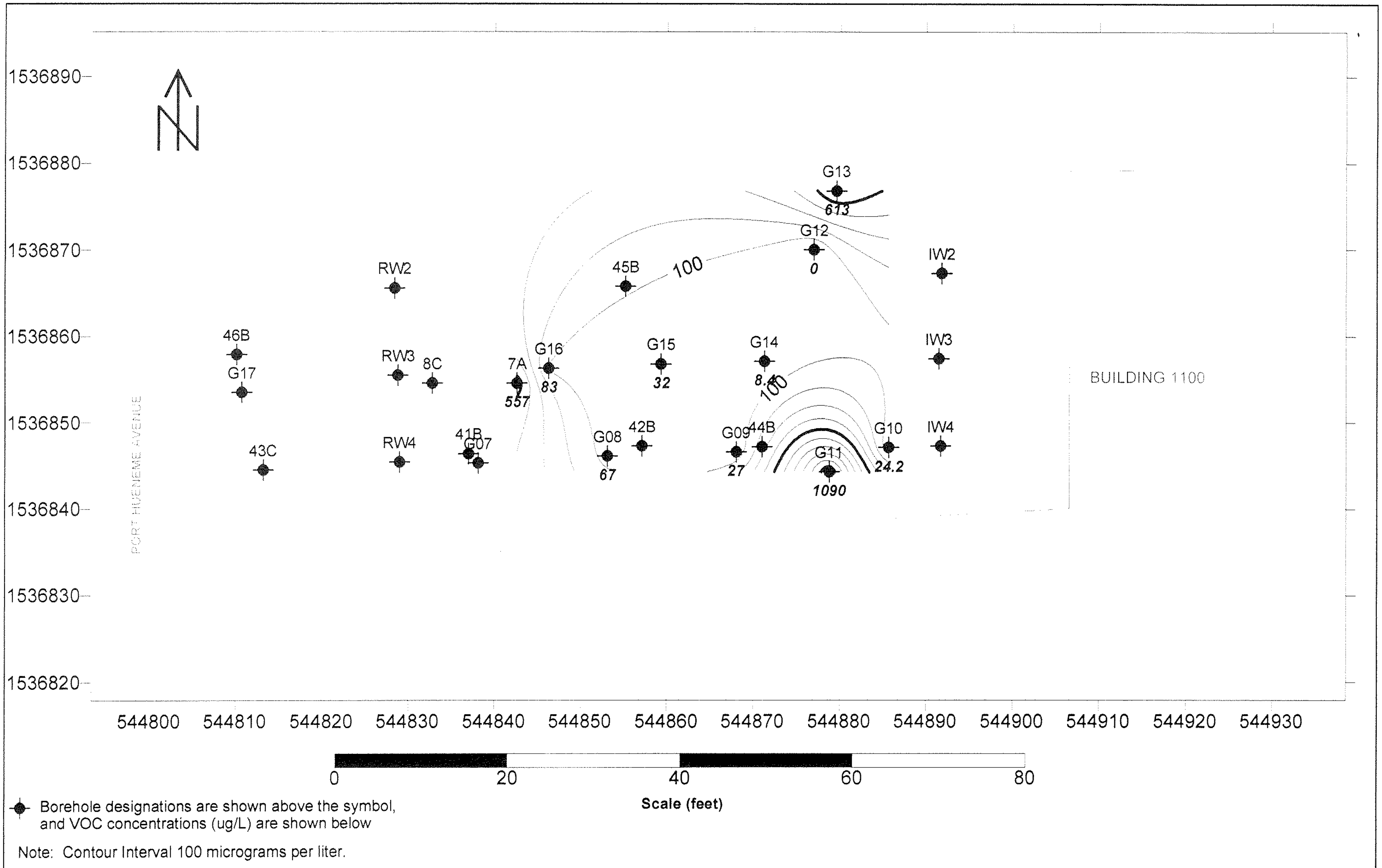

FIGURE 2-10
TOTAL SHALLOW VOC CONCENTRATIONS
AUGUST 2, 2000 - END OF PILOT STUDY

GROUNDWATER TREATABILITY STUDIES
IN-SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
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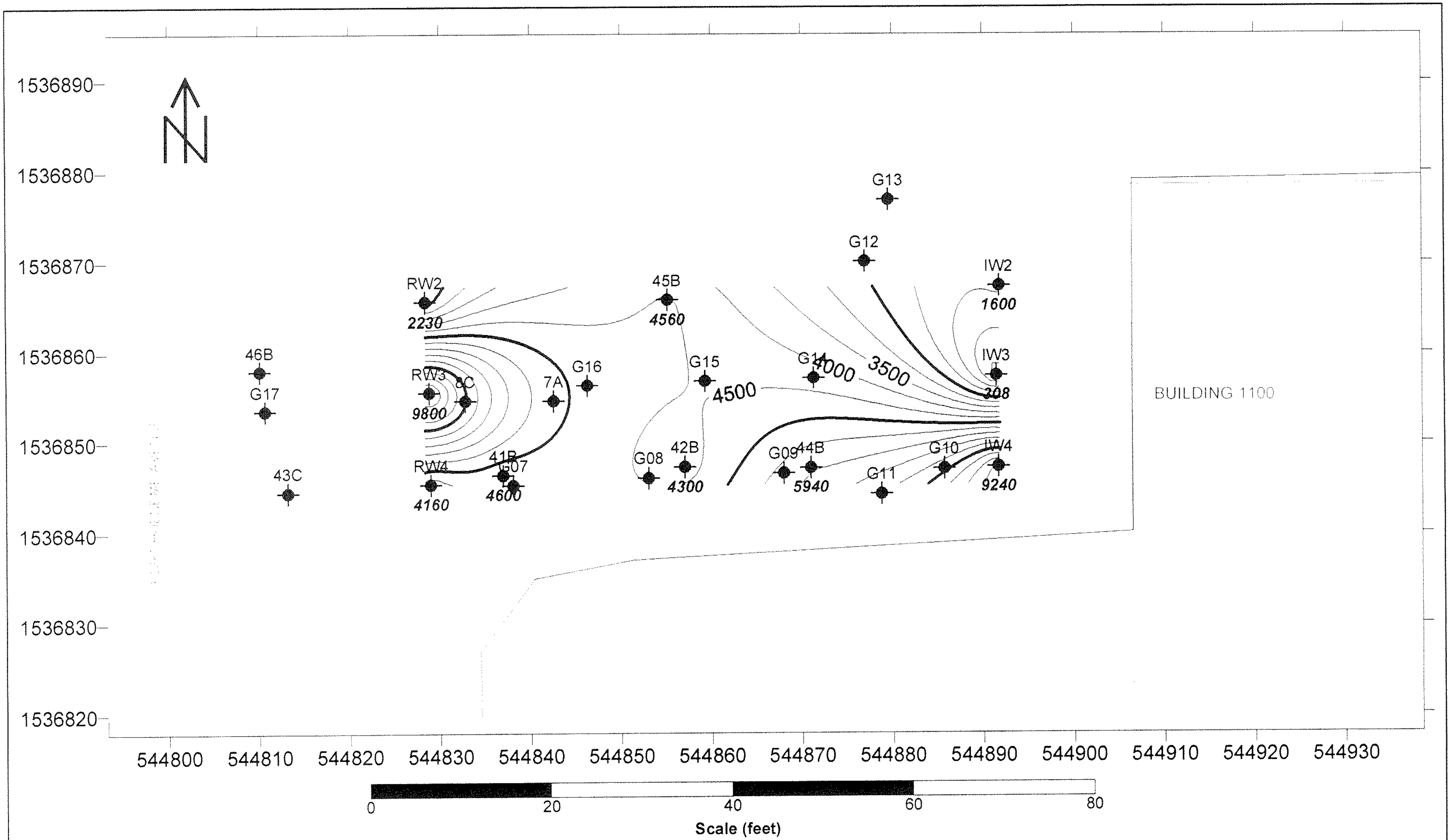


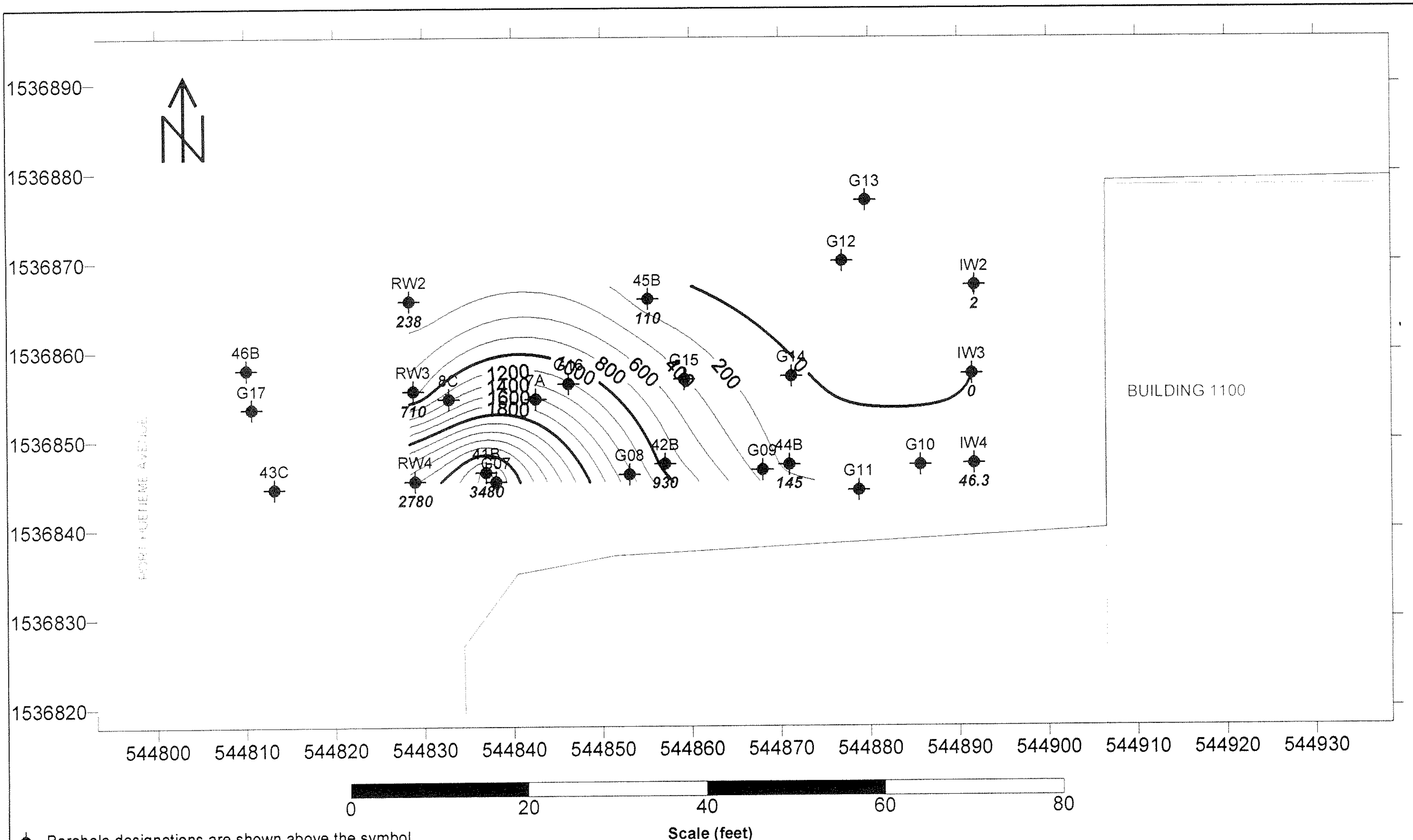
Borehole designations are shown above the symbol, and VOC concentrations (ug/L) are shown below

Note: Contour Interval 500 micrograms per liter.

FIGURE 2-11
TOTAL DEEP VOC CONCENTRATIONS
FEBRUARY 2, 2000 - BASELINE

GROUNDWATER TREATABILITY STUDIES
IN-SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
ORLANDO, FLORIDA



Borehole designations are shown above the symbol, and VOC concentrations (ug/L) are shown below

Note: Contour Interval 200 micrograms per liter.

FIGURE 2-12
TOTAL DEEP VOC CONCENTRATIONS
AUGUST 2, 2000 - END OF PILOT STUDY

GROUNDWATER TREATABILITY STUDIES
IN-SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

TABLES

Table 2-1. Baseline Groundwater Sampling
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Shallow Zone Wells

Well ID	Total Depth (BLS)	Screen Length	Screened Interval (BLS)	Halogenated VOCs	TAL Metals	Water Quality Parameters[a]	Natural Attenuation Parameters[b]
OLD-13-07A	18.5	15	3.5-18.5 ft.	X			
GMP 07	18	3	15-18 ft.	X			
GMP 08	18	3	15-18 ft.	X			
GMP 09	18	3	15-18 ft.	X	X	X	X
GMP 10	18	3	15-18 ft.	X	X	X	X
GMP-11	18	9	9-18 ft.	X			
GMP 12	18	9	9-18 ft.	X	X	X	X
GMP 13	18	9	9-18 ft.	X	X	X	X
GMP 14	18	9	9-18 ft.	X			
GMP 15	18	9	9-18 ft.	X	X	X	X
GMP 16	18	9	9-18 ft.	X			
GMP 17	18	9	9-18 ft.		X	X	X

Deep Zone Wells

Well ID	Total Depth (BLS)	Screen Length	Screened Interval (BLS)	Halogenated VOCs	TAL Metals	Water Quality Parameters[a]	Natural Attenuation Parameters[b]
OLD-13-41B	28 ft.	5 ft.	23-28 ft.	X	X	X	X
OLD-13-42B	28 ft.	5 ft.	23-28 ft.	X			
OLD-13-44B	30 ft.	10 ft.	20-30 ft.	X	X	X	X
OLD-13-45B	30 ft.	10 ft.	20-30 ft.	X	X	X	X
OLD-13-46B	30 ft.	10 ft.	20-30 ft.		X	X	X

System Wells

Well ID	Total Depth (BLS)	Screen Length	Screened Interval (BLS)	Halogenated VOCs	TAL Metals	Water Quality Parameters[a]	Natural Attenuation Parameters[b]
OLD-13-IW2	35 ft.	25 ft.	5-30 ft.	X			
OLD-13-IW3	35 ft.	25 ft.	5-30 ft.	X			
OLD-13-IW4	35 ft.	25 ft.	5-30 ft.	X			
OLD-13-RW2	35 ft.	20 ft.	10-30 ft.	X			
OLD-13-RW3	35 ft.	20 ft.	10-30 ft.	X			
OLD-13-RW4	35 ft.	20 ft.	10-30 ft.	X			

Notes:

a) Water quality parameters include Total Dissolved Solids and Color

b) Natural attenuation parameters include off-site analysis for Total Organic Carbon and light gases (RSK 175) and on-site analysis for dissolved oxygen, ferrous iron, total iron, sulfate, hydrogen sulfide, carbon dioxide, nitrite, chloride, alkalinity and hardness

BLS - Below land surface

VOCs - Volatile organic compounds

TAL - Target analyte list

Table 2-2. System Calendar
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

	February-00																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Sampling Rounds	Baseline Sampling																						1						
														5 Days															
System Operations							Set up / Start up												Recirc. Pump leak; required replacement										
Flow Rates														3.5 gpm															

	March-00																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Sampling Rounds									2														3							4	
			7 Days												19 Days																
System Operations										Power Out																					
Flow Rates			3.5 gpm												4.0 gpm																

	April-00																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Sampling Rounds					5							6							7											
				13 Days																										
System Operations																	Control panel touch pad failure; clean solids from injection wells.													
Flow Rates				4.0 gpm							3.0 gpm																			

	May-00																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Sampling Rounds																								8							
				3 Days				1 Day										3 Days					13 Days								
System Operations									High filter pressure shut down																						
Flow Rates				4.0 gpm					Vacc. Truck 5/18/00									4.0 gpm					4.0 gpm			3.0 gpm					

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Table 2-2. System Calendar
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

	Jun-00																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Sampling Rounds		9						10							11						12							13		
							4 Days					9 Days																		
System Operations																					Circulation pump failed, lightning									
Flow Rates		3.0 gpm					3.0 gpm					3.0 gpm																		

	July-00																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Sampling Rounds													14																		
System Operations	Pilot Study treatment concluded, monitoring only																														
Flow Rates																															

	August-00												
	1	2	3	4	5	6	7	8	9	10	11	12	...
Sampling Rounds		16*											
System Operations													
Flow Rates													

	January-01														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	--
Sampling Rounds					17*										
System Operations															
Flow Rates															

* There was no Sampling Round 15

Table 2-3. Performance Monitoring Groundwater Sampling
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Sampling Round	Date	Calendar Days since start	Run Days since start	Extraction Rate (GPM)	Locations Sampled	Comments
Round 1	23-Feb-00	10	5	----	GMP-10, OLD-13-44B	System not running.
Round 2	09-Mar-00	25	12	3.5	GMP-10, GMP-11, OLD-13-44B, Influent, Effluent	
Round 3	23-Mar-00	39	21	4	GMP-09, GMP-11, GMP-14, OLD-13-44B, OLD-13-45B, Influent, Effluent	
Round 4	30-Mar-00	46	28	4	GMP-10, GMP-11, GMP-12, OLD-13-42B, OLD-13-44B, OLD-13-45B, Influent, Effluent	
Round 5	05-Apr-00	52	33	4	GMP-10, GMP-11, GMP-12, GMP-14, OLD-13-42B, OLD-13-44B, OLD-13-45B, Influent, Effluent	
Round 6	12-Apr-00	59	40	3	GMP-10, GMP-11, GMP-12, GMP-14, OLD-13-41B, OLD-13-42B, OLD-13-44B, OLD-13-45B, OLD-13-46B, Influent, Effluent	
Round 7	19-Apr-00	66	44	----	GMP-08, GMP-09, GMP-11, GMP-12, GMP-14, OLD-13-41B, OLD-13-42B, OLD-13-44B, OLD-13-45B	System not running.
Round 8	24-May-00	101	53	4	GMP-08, GMP-10, GMP-11, GMP-12, GMP-13, GMP-14, GMP-16, OLD-13-41B, OLD-13-42B, OLD-13-44B, OLD-13-45B, OLD-13-07A, Influent, Effluent	
Round 9	02-Jun-00	110	62	3	OLD-13-41B, OLD-13-42B, OLD-13-44B, OLD-13-45B, Influent, Effluent	
Round 10	08-Jun-00	116	66	3	GMP-12, GMP-14, OLD-13-42B, OLD-13-44B, OLD-13-45B, Influent, Effluent	
Round 11	15-Jun-00	123	72	3	GMP-09, GMP-14, GMP-15, OLD-13-41B, OLD-13-42B, OLD-13-44B, Influent, Effluent	
Round 12	21-Jun-00	129	77	3	GMP-08, GMP-13, GMP-16, OLD-13-42B, OLD-13-45B, Influent, Effluent	
Round 13	28-Jun-00	136	77	----	GMP-14, OLD-13-41B, OLD-13-44B, Influent, Effluent	System started briefly for influent/effluent sampling
Round 14	13-Jul-00	151	77	----	GMP-08, GMP-09, GMP-15, GMP-16, OLD-13-07A, OLD-13-42B, OLD-13-45B	
Round 16*	01-Aug-00	170	77	----	IW-2, IW-3, IW-4, RW-2, RW-3, RW-4, GMP-08, GMP-09, GMP-10, GMP-11, GMP-12, GMP-13, GMP-14, GMP-16, GMP-17, OLD-13-41B, OLD-13-42B, OLD-13-44B, OLD-13-45B, OLD-13-46B, OLD-13-07A	
* There was no Round 15						

Table 2-4. Groundwater Elevations and Gradients
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

SHALLOW ZONE											
	Sampling Round			Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 10
	Date	2/7/00	2/14/00	3/9/00	3/23/00	3/30/00	4/5/00	4/12/00	4/19/00	5/24/00	6/8/00
	Extraction Rate	NA	NA	3.5 GPM	4 GPM	4 GPM	4 GPM	3 GPM	NA	4 GPM	4 GPM
Well ID	Distance										
OLD-13-26A	0			103.84	103.49	103.41	103.30	103.12	102.98	102.65	----
GMP-10	8	103.48	103.42	103.32	103.19	103.05	103.04	102.82	102.74	102.39	102.01
GMP-11	13	103.45	103.39	103.23	103.12	102.99	102.96	102.76	102.71	102.31	101.99
GMP-14	20	103.44	103.38	103.2	103.04	102.93	102.89	102.72	102.70	102.23	101.93
GMP-09	26	103.42	103.37	103.18	103.00	102.88	102.86	102.69	102.69	102.21	101.95
GMP-15	32	103.39	103.39	103.12	102.92	102.82	102.78	102.63	102.65	102.13	101.88
GMP-08	41	103.35	103.31	103.05	102.83	102.71	102.69	102.55	102.61	102.04	101.79
GMP-16	45	103.32	103.27	102.98	102.76	102.65	102.62	102.49	102.57	101.96	101.72
GMP-07	56	103.31	103.26	102.95	102.69	102.57	102.55	102.45	102.57	101.93	101.66
OLD-13-RW4	63	103.22	103.13	102.47	101.83	101.78	101.81	101.90	102.43	101.15	101.00
GMP-17	81	103.21	103.13	102.79	102.57	102.45	102.42	102.32	102.46	101.77	101.55
	Head Difference	0.17	0.16	0.37	0.50	0.48	0.49	0.37	0.17	0.46	0.35
	Gradient	0.0035	0.0033	0.0077	0.0104	0.0100	0.0102	0.0077	0.0035	0.0096	0.0073
DEEP ZONE											
	Sampling Round			Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 10
	Date	2/7/00	2/14/00	3/9/00	3/23/00	3/30/00	4/5/00	4/12/00	4/19/00	5/24/00	6/8/00
	Extraction Rate	NA	NA	3.5 GPM	4 GPM	4 GPM	4 GPM	3 GPM	NA	4 GPM	4 GPM
Well ID	Distance										
OLD-13-IW4	0	103.46	103.37	103.24	106.42	107.66	108.02	109.16	102.69	104.81	106.79
OLD-13-44B	21	103.37	103.28	103.06	102.89	102.77	102.73	102.60	102.60	102.06	101.80
OLD-13-42B	35	103	102.96	102.99	102.79	102.67	102.64	102.52	102.54	101.98	101.72
OLD-13-45B	36	103.33	103.26	102.98	102.79	102.67	102.63	102.51	102.56	101.98	101.73
OLD-13-41B	55	103.24	103.17	102.84	102.63	102.52	102.48	102.38	102.48	101.83	101.60
OLD-13-RW4	63	103.22	103.13	102.47	101.83	101.78	101.81	101.90	102.43	101.15	101.00
	Head Difference	0.13	0.11	0.22	0.26	0.25	0.25	0.22	0.12	0.23	0.2
	Gradient	0.0038	0.0032	0.0065	0.0076	0.0074	0.0074	0.0065	0.0035	0.0068	0.0059

Distance - Distance of Monitoring well from injection wells
Head Difference - Shallow Zone = GMP-10 - GMP-07 and Deep Zone = OLD-13-44B - OLD-13-41B
Gradient - Shallow Zone = Head Difference/48 feet and Deep Zone = Head Difference/34 feet

Table 2-5. Summary of VOC Concentrations and Groundwater Conductivity
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

	Date			2/23/00		3/9/00		3/23/00		3/30/00		4/5/00		4/12/00		4/19/00	
	Sampling Round	Baseline		Round 1		Round 2		Round 3		Round 4		Round 5		Round 6		Round 7	
	Run Days	0		5		12		21		28		33		40/41		44/45	
	Calendar Days	0		10		25		39		46		52		59/60		66/67	
Well ID	Travel Time	Cond.	VOCs	Cond.	VOCs	Cond.	VOCs	Cond.	VOCs	Cond.	VOCs	Cond.	VOCs	Cond.	VOCs	Cond.	VOCs
SHALLOW ZONE																	
GMP-10	10	152	2630	1000	26.6	1250	34			2325	30	1800	9	2300	7		
GMP-11	20	172	24300			1825	482	1880	110	2420	270	2600	36	2550	0	2800	0
GMP-12	30	302	149							2200	3.6	2150	0	2280	9	2050	32.4
GMP-14	45	260	3600					1500	377			1990	185	2400	300	2200	280
GMP-13	55	238	77														
GMP-09	80	130	18000					530	271							135	37.1
GMP-15	80	270	2300														
GMP-08	120	128	16950													880	412
GMP-16	120	280	5120														
OLD-13-07A	140	240	5000														
DEEP ZONE																	
OLD-13-44B	10	138	5940	138	7540	135	8930	135	8700	150	6420	190	4610	280	3900	400	1930
OLD-13-42B	25	148	4300							171	8200	199	6260	230	4020	265	4380
OLD-13-45B	25	121	4560					111	45	150	61	195	67	290	48	390	43
OLD-13-41B	50	100	4600											112	1620	100	2060

Notes: Travel Time - Estimated from groundwater model
Cond. - Conductivity of groundwater in μS/cm
VOCs - Total concentration of cis1,2 DCE, TCE and PCE in μg/L
* There was no Round 15

Table 2-5. Summary of VOC Concentrations and Groundwater Conductivity
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

	Date	5/24/00		6/2/00		6/8/00		6/15/00		6/21/00		6/28/00		7/13/00		8/1/00	
	Sampling Round	Round 8		Round 9		Round 10		Round 11		Round 12		Round 13		Round 14		Round 16*	
	Run Days	53/54		53/54													
	Calendar Days	101/102		101/102													
Well ID	Travel Time	Cond.	VOCs	Cond.	VOCs	Cond.	VOCs	Cond.	VOCs	Cond.	VOCs	Cond.	VOCs	Cond.	VOCs	Cond.	VOCs
SHALLOW ZONE																	
GMP-10	10	2400	5													3000	24.2
GMP-11	20	2280	0													1500	1090
GMP-12	30	2200	2			3000	U									3300	U
GMP-14	45	1980	100			2520	84	2600	120			2500	3.4				8.4
GMP-13	55	1400	256			3100	U			2700	U					1450	613
GMP-09	80							2000	17.3					2200	19		27
GMP-15	80							2200	7.3					2400	14.7	2500	32
GMP-08	120	2550	80							1800	48.5			2000	40	1950	67
GMP-16	120	2500	99							2100	41.6			2300	180	2150	83
OLD-13-07A	140	2000	1742											2300	524	2100	557
DEEP ZONE																	
OLD-13-44B	10	650	2120	680	1080	650	955	900	590			515	700			1100	145
OLD-13-42B	25	580	3170	800	2330	500	1410	500	1400	500	1400			700	1323	725	930
OLD-13-45B	25	360	54	250	97	700	35			1125	12.6			1100	33	800	110
OLD-13-41B	50	105	1770	118	990			110	1080			120	1356			140	3480

Notes: Travel Time - Estimated from groundwater model
Cond. - Conductivity of groundwater in µS/cm
VOCs - Total concentration of cis1,2 DCE, TCE and PCE in µg/L
* There was no Round 15

APPENDIX A

APPENDIX A

SUMMARY OF ANALYTICAL RESULTS

Appendix A-1

Summary of Groundwater Analytical Results, Shallow Zone VOCs

Table A-1. Summary of Groundwater Analytical Results
Shallow Zone VOCs
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			GMP-07		GMP-08												GMP-09	
Sample ID	FDEPGCTL		U4G07GBL		U4G08GBL		U4G08G07		U4G08G08		U4G08G12		U4GBG14		U4GGMP-8-16		U4G09GBL	
Sampling Date			2-Feb-00		2-Feb-00		19-Apr-00		24-May-00		21-Jun-00		13-Jul-00		2-Aug-00		3-Feb-00	
Volatile organics, ug/L																		
Dichlorodifluoromethane	**1400**	MC/ST	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
Chloromethane	**2.7**	MC/C	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
Vinyl chloride	1	P/C	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
Bromomethane	**9.8**	MC/ST	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
Chloroethane	12	MC/C	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
Trichlorofluoromethane	**2100**	MC/ST	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
1,1-Dichloroethene	7	P/C	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
Methylene chloride	5	P/C	75	U	1500	U	30	U	6.0	U	3.0	U	3.0	U	10	U	1200	U
trans-1,2-Dichloroethene	100	P/ST	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
1,1-Dichloroethane	70	MC/ST	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
Chloroform	**5.7**	MC/C	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
cis-1,2-Dichloroethene	70	P/ST	25	U	500	U	44		28		16		16		45		400	U
1,1,1-Trichloroethane	200	P/ST	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
Carbon tetrachloride	3	P/C	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
1,2-Dichloroethane	3	P/C	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
Trichloroethene	3	P/C	**460**		**950**	I	**58**		**12**		**7.5**		2.0		**3.0**		**8700**	
1,2-Dichloropropane	5	P/C	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
Bromodichloromethane	1	PQL/C	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
cis-1,3-Dichloropropene	**0.2**	PQL/C	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
trans-1,3-Dichloropropene			25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
1,1,2-Trichloroethane	5	P/C	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
Tetrachloroethene	3	P/C	**1200**		**16000**		**310**		**40**		**25**		**22**		**19**		**9300**	
Dibromochloromethane	**0.4**	MC/C	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
Chlorobenzene	**100**	P/ST	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
Bromoform	**4.4**	MC/C	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
1,1,2,2-Tetrachloroethane	**0.5**	PQL/C	50	U	1000	U	20	U	4.0	U	2.0	U	2.0	U	4.0	U	800	U
1,3-Dichlorobenzene	10	MC/O	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
1,4-Dichlorobenzene	75	P/C	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
1,2-Dichlorobenzene	600	P/ST	25	U	500	U	10	U	2.0	U	1.0	U	1.0	U	2.0	U	400	U
Dilution			1:25 (ALL)		1:500 (ALL)		1:10 (ALL)		1:2 (ALL)						1:2 (ALL)		1:400 (ALL)	
Total VOCs			**1660**		**16950**		**412**		**80**		**49**		**40**		**67**		**18000**	

Table A-1. Summary of Groundwater Analytical Results
Shallow Zone VOCs
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			GMP-09										GMP-10					
Sample ID	FDEPGCTL		U4G09G03		U4G09G07		U4G09G11		U4G9G14		U4GGMP-10-16		U4G10GBL		U4GG1001		U4G10G02	
Sampling Date			23-Mar-00		19-Apr-00		15-Jun-00		13-Jul-00		2-Aug-00		3-Feb-00		23-Feb-00		8-Mar-00	
Volatile organics, ug/L																		
Dichlorodifluoromethane	**1400**	MC/ST	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
Chloromethane	2.7	MC/C	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
Vinyl chloride	1	P/C	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
Bromomethane	9.8	MC/ST	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.1	I	1.0	U
Chloroethane	12	MC/C	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
Trichlorofluoromethane	**2100**	MC/ST	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
1,1-Dichloroethene	7	P/C	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
Methylene chloride	5	P/C	15	U	3.0	U	3.0	U	3.0	U	5.0	U	150	U	3.0	U	4.0	I
trans-1,2-Dichloroethene	100	P/ST	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
1,1-Dichloroethane	70	MC/ST	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
Chloroform	5.7	MC/C	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
cis-1,2-Dichloroethene	70	P/ST	**130**		4.1		5.0		11		10		**2000**		8.7		21	
1,1,1-Trichloroethane	200	P/ST	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
Carbon tetrachloride	3	P/C	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
1,2-Dichloroethane	3	P/C	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
Trichloroethene	3	P/C	**93**		**11**		2.9	I	2.0		**6.0**		**450**		**9.7**		**3.0**	I
1,2-Dichloropropane	5	P/C	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
Bromodichloromethane	1	PQL/C	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
cis-1,3-Dichloropropene	0.2	PQL/C	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
trans-1,3-Dichloropropene			5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
1,1,2-Trichloroethane	5	P/C	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
Tetrachloroethene	3	P/C	**48**		**22**		**9.4**		**6.0**		**11**		**180**		**8.2**		**10**	
Dibromochloromethane	0.4	MC/C	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
Chlorobenzene	100	P/ST	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
Bromoform	4.4	MC/C	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
1,1,2,2-Tetrachloroethane	0.5	PQL/C	10	U	2.0	U	2.0	U	2.0	U	2.0	U	100	U	2.0	U	2.0	U
1,3-Dichlorobenzene	10	MC/O	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
1,4-Dichlorobenzene	75	P/C	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
1,2-Dichlorobenzene	600	P/ST	5.0	U	1.0	U	1.0	U	1.0	U	1.0	U	50	U	1.0	U	1.0	U
Dilution			1:5 (ALL)										1:50 (ALL)					
Total VOCs			**271**		**37**		**17**		**19**		**27**		**2630**		**28**		**38**	

Table A-1. Summary of Groundwater Analytical Results
Shallow Zone VOCs
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			GMP-10										GMP-11					
Sample ID	FDEPGCTL		U4G10G04		U4G10G05		U4G10G06		U4G10G08		U4GGMP-10-16		U4G11GBL		U4G11G02		U4G11G03	
Sampling Date			30-Mar-00		5-Apr-00		13-Apr-00		24-May-00		2-Aug-00		3-Feb-00		8-Mar-00		23-Mar-00	
Volatile organics, ug/L																		
Dichlorodifluoromethane	**1400**	MC/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
Chloromethane	**2.7**	MC/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
Vinyl chloride	**1**	P/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
Bromomethane	**9.8**	MC/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
Chloroethane	**12**	MC/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
Trichlorofluoromethane	**2100**	MC/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
1,1-Dichloroethene	**7**	P/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
Methylene chloride	**5**	P/C	3.0	U	3.0	U	3.0	U	3.0	U	5.0	U	3000	U	30	U	30	U
trans-1,2-Dichloroethene	**100**	P/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
1,1-Dichloroethane	**70**	MC/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
Chloroform	**5.7**	MC/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
cis-1,2-Dichloroethene	**70**	P/ST	1.0	I	1.0	U	1.0	U	1.0	U	6.2		1000	U	**230**		10	U
1,1,1-Trichloroethane	**200**	P/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
Carbon tetrachloride	**3**	P/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
1,2-Dichloroethane	**3**	P/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
Trichloroethene	**3**	P/C	**3.0**	I	1.0	U	1.0	U	1.0	U	**3.0**		**1300**		**22**	I	10	U
1,2-Dichloropropane	**5**	P/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
Bromodichloromethane	**1**	PQL/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
cis-1,3-Dichloropropene	**0.2**	PQL/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
trans-1,3-Dichloropropene			1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
1,1,2-Trichloroethane	**5**	P/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
Tetrachloroethene	**3**	P/C	**26**		**9.0**		**7.0**		**5.0**		**15**		**23000**		**230**		**110**	
Dibromochloromethane	**0.4**	MC/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
Chlorobenzene	**100**	P/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
Bromoform	**4.4**	MC/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
1,1,2,2-Tetrachloroethane	**0.5**	PQL/C	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2000	U	20	U	20	U
1,3-Dichlorobenzene	**10**	MC/O	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
1,4-Dichlorobenzene	**75**	P/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
1,2-Dichlorobenzene	**600**	P/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1000	U	10	U	10	U
Dilution													1:1000 (ALL)		1:10 (ALL)		1:10 (ALL)	
Total VOCs			**30**		**9**		**7**		**5**		**24**		**24300**		**482**		**110**	

Table A-1. Summary of Groundwater Analytical Results
Shallow Zone VOCs
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			GMP-11												GMP-12			
Sample ID	FDEPGCTL		U4G11G04		U4G11G05		U4G11G06		U4G11G07		U4G11G08		U4GGMP-11-16		U4G12GBL		U4G12G04	
Sampling Date			30-Mar-00		5-Apr-00		13-Apr-00		20-Apr-00		24-May-00		2-Aug-00		3-Feb-00		30-Mar-00	
Volatile organics, ug/L																		
Dichlorodifluoromethane	1400	MC/ST	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
Chloromethane	2.7	MC/C	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
Vinyl chloride	1	P/C	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
Bromomethane	9.8	MC/ST	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
Chloroethane	12	MC/C	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
Trichlorofluoromethane	2100	MC/ST	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
1,1-Dichloroethene	7	P/C	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
Methylene chloride	5	P/C	15	U	6.0	U	3.0	U	3.0	U	3.0	U	50	U	3.0	U	3.0	U
trans-1,2-Dichloroethene	100	P/ST	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
1,1-Dichloroethane	70	MC/ST	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
Chloroform	5.7	MC/C	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
cis-1,2-Dichloroethene	70	P/ST	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	**350**		12		1.6	I
1,1,1-Trichloroethane	200	P/ST	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
Carbon tetrachloride	3	P/C	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
1,2-Dichloroethane	3	P/C	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
Trichloroethene	3	P/C	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	**320**	I	**7.0**		1.0	U
1,2-Dichloropropane	5	P/C	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
Bromodichloromethane	1	PQL/C	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
cis-1,3-Dichloropropene	0.2	PQL/C	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
trans-1,3-Dichloropropene			5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
1,1,2-Trichloroethane	5	P/C	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
Tetrachloroethene	3	P/C	**270**		**36**		1.0	U	1.0	U	1.0	U	**420**		**130**		2.0	I
Dibromochloromethane	0.4	MC/C	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
Chlorobenzene	100	P/ST	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
Bromoform	4.4	MC/C	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
1,1,2,2-Tetrachloroethane	0.5	PQL/C	10	U	4.0	U	2.0	U	2.0	U	2.0	U	20	U	2.0	U	2.0	U
1,3-Dichlorobenzene	10	MC/O	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
1,4-Dichlorobenzene	75	P/C	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
1,2-Dichlorobenzene	600	P/ST	5.0	U	2.0	U	1.0	U	1.0	U	1.0	U	10	U	1.0	U	1.0	U
Dilution			1:20 (PCE)		1:2 (ALL)								1:20 (TCE, PCE)		1:10 (PCE)			
			1:5 (OTHERS)										1:10 (OTHERS)					
Total VOCs			**270**		**36**		**0**		**0**		**0**		**1090**		**149**		**4**	

Table A-1. Summary of Groundwater Analytical Results
Shallow Zone VOCs
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			GMP-12												GMP-13			
Sample ID	FDEPGCTL		U4G12G05		U4G12G06		U4G12G07		U4G12G08		U4G12G10		U4GGMP-12-16		U4G13GBL		U4G13G08	
Sampling Date			5-Apr-00		13-Apr-00		20-Apr-00		25-May-00		8-Jun-00		2-Aug-00		3-Feb-00		25-May-00	
Volatile organics, ug/L																		
Dichlorodifluoromethane	1400	MC/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
Chloromethane	2.7	MC/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
Vinyl chloride	1	P/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
Bromomethane	9.8	MC/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
Chloroethane	12	MC/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
Trichlorofluoromethane	2100	MC/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
1,1-Dichloroethene	7	P/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
Methylene chloride	5	P/C	3.0	U	3.0	U	3.0	U	3.0	U	3.0	U	5.0	U	3.0	U	15	U
trans-1,2-Dichloroethene	100	P/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
1,1-Dichloroethane	70	MC/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
Chloroform	5.7	MC/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
cis-1,2-Dichloroethene	70	P/ST	1.0	U	1.0	U	7.4		1.0	U	1.0	U	1.0	U	31		**130**	
1,1,1-Trichloroethane	200	P/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
Carbon tetrachloride	3	P/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
1,2-Dichloroethane	3	P/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
Trichloroethene	3	P/C	1.0	U	1.0	U	1.0	I	1.0	U	1.0	U	1.0	U	**8.0**		**69**	
1,2-Dichloropropane	5	P/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
Bromodichloromethane	1	PQL/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
cis-1,3-Dichloropropene	0.2	PQL/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
trans-1,3-Dichloropropene			1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
1,1,2-Trichloroethane	5	P/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
Tetrachloroethene	3	P/C	1.0	U	**9.0**		**24**		**2.0**	I	1.0	U	1.0	U	**38**		**57**	
Dibromochloromethane	0.4	MC/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
Chlorobenzene	100	P/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
Bromoform	4.4	MC/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
1,1,2,2-Tetrachloroethane	0.5	PQL/C	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	10	U
1,3-Dichlorobenzene	10	MC/O	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
1,4-Dichlorobenzene	75	P/C	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
1,2-Dichlorobenzene	600	P/ST	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	5.0	U
Dilution															1:2 (PCE)		1:5 (ALL)	
Total VOCs			**0**		**9**		**32**		**2**		**0**		**0**		**77**		**256**	

Table A-1. Summary of Groundwater Analytical Results
Shallow Zone VOCs
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			GMP-13						GMP-14									
Sample ID	FDEPGCTL		U4G13G10		U4G13G12		U4GGMP-13-16		U4G14GBL		U4G14G03		U4G14G05		U4G14G06		U4G14G07	
Sampling Date			8-Jun-00		21-Jun-00		2-Aug-00		2-Feb-00		23-Mar-00		5-Apr-00		13-Apr-00		20-Apr-00	
Volatile organics, ug/L																		
Dichlorodifluoromethane	**1400**	MC/ST	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
Chloromethane	**2.7**	MC/C	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
Vinyl chloride	1	P/C	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
Bromomethane	**9.8**	MC/ST	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
Chloroethane	**12**	MC/C	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
Trichlorofluoromethane	**2100**	MC/ST	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
1,1-Dichloroethene	**7**	P/C	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
Methylene chloride	**5**	P/C	3.0	U	3.0	U	50	U	300	U	30	U	15	U	30	U	30	U
trans-1,2-Dichloroethene	**100**	P/ST	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
1,1-Dichloroethane	**70**	MC/ST	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
Chloroform	**5.7**	MC/C	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
cis-1,2-Dichloroethene	**70**	P/ST	1.0	U	1.0	U	**200**		100	U	**84**		**140**		**300**		**280**	
1,1,1-Trichloroethane	**200**	P/ST	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
Carbon tetrachloride	**3**	P/C	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
1,2-Dichloroethane	**3**	P/C	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
Trichloroethene	**3**	P/C	1.0	U	1.0	U	**93**		100	U	**83**		**45**		10	U	10	U
1,2-Dichloropropane	**5**	P/C	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
Bromodichloromethane	**1**	PQL/C	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
cis-1,3-Dichloropropene	**0.2**	PQL/C	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
trans-1,3-Dichloropropene			1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
1,1,2-Trichloroethane	**5**	P/C	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
Tetrachloroethene	**3**	P/C	1.0	U	1.0	U	**320**		**3600**		**210**		5.0	U	10	U	10	U
Dibromochloromethane	**0.4**	MC/C	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
Chlorobenzene	**100**	P/ST	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
Bromoform	**4.4**	MC/C	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
1,1,2,2-Tetrachloroethane	**0.5**	PQL/C	2.0	U	2.0	U	20	U	200	U	20	U	10	U	20	U	20	U
1,3-Dichlorobenzene	**10**	MC/O	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
1,4-Dichlorobenzene	**75**	P/C	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
1,2-Dichlorobenzene	**600**	P/ST	1.0	U	1.0	U	10	U	100	U	10	U	5.0	U	10	U	10	U
Dilution							1:10 (ALL)		1:100 (ALL)		1:10 (ALL)		1:5 (ALL)		1:10 (ALL)		1:10 (ALL)	
Total VOCs			**0**		**0**		**613**		**3600**		**377**		**185**		**300**		**280**	

Table A-1. Summary of Groundwater Analytical Results
Shallow Zone VOCs
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			GMP-14										GMP-15					
Sample ID	FDEPGCTL		U4G14G08		U4G14G10		U4G14G11		U4G14G13		U4GGMP-14-16		U4G15GBL		U4G15G11		U4G15G14	
Sampling Date			24-May-00		8-Jun-00		15-Jun-00		28-Jun-00		2-Aug-00		4-Feb-00		15-Jun-00		13-Jul-00	
Volatile organics, ug/L																		
Dichlorodifluoromethane	1400	MC/ST	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
Chloromethane	2.7	MC/C	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
Vinyl chloride	1	P/C	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
Bromomethane	9.8	MC/ST	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
Chloroethane	12	MC/C	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
Trichlorofluoromethane	2100	MC/ST	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
1,1-Dichloroethene	7	P/C	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
Methylene chloride	5	P/C	15	U	30	U	15	U	3.0	U	5.0	U	300	U	3.0	U	3.0	U
trans-1,2-Dichloroethene	100	P/ST	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
1,1-Dichloroethane	70	MC/ST	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
Chloroform	5.7	MC/C	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
cis-1,2-Dichloroethene	70	P/ST	**100**		**84**		**120**		1.1		8.4		100	U	1.9	I	5.7	
1,1,1-Trichloroethane	200	P/ST	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
Carbon tetrachloride	3	P/C	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
1,2-Dichloroethane	3	P/C	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
Trichloroethene	3	P/C	5.0	U	10	U	5.0	U	1.0	U	1.0	U	**100**	I	2.8	I	**8.0**	
1,2-Dichloropropane	5	P/C	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
Bromodichloromethane	1	PQL/C	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
cis-1,3-Dichloropropene	0.2	PQL/C	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
trans-1,3-Dichloropropene			5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
1,1,2-Trichloroethane	5	P/C	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
Tetrachloroethene	3	P/C	5.0	U	10	U	5.0	U	2.3		1.0	U	**2200**		2.6	I	1.0	
Dibromochloromethane	0.4	MC/C	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
Chlorobenzene	100	P/ST	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
Bromoform	4.4	MC/C	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
1,1,2,2-Tetrachloroethane	0.5	PQL/C	10	U	20	U	10	U	2.0	U	2.0	U	200	U	2.0	U	2.0	U
1,3-Dichlorobenzene	10	MC/O	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
1,4-Dichlorobenzene	75	P/C	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
1,2-Dichlorobenzene	600	P/ST	5.0	U	10	U	5.0	U	1.0	U	1.0	U	100	U	1.0	U	1.0	U
Dilution			1:5 (ALL)		1:10 (ALL)		1:5 (ALL)						1:100 (ALL)					
Total VOCs			**100**		**84**		**120**		3		8		**2300**		7		15	

Table A-1. Summary of Groundwater Analytical Results
Shallow Zone VOCs
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			GMP-15		GMP-16									
Sample ID	FDEPGCTL		U4GGMP-15-16		U4G16GBL		U4G16G08		U4G16G12		U4G16G14		U4GGMP-16-16	
Sampling Date			2-Aug-00		2-Feb-00		24-May-00		21-Jun-00		13-Jul-00		2-Aug-00	
Volatile organics, ug/L														
Dichlorodifluoromethane	**1400**	MC/ST	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
Chloromethane	**2.7**	MC/C	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
Vinyl chloride	**1**	P/C	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
Bromomethane	**9.8**	MC/ST	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
Chloroethane	**12**	MC/C	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
Trichlorofluoromethane	**2100**	MC/ST	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
1,1-Dichloroethene	**7**	P/C	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
Methylene chloride	**5**	P/C	5.0	U	300	U	6.0	U	3.0	U	6.0	U	10.0	U
trans-1,2-Dichloroethene	**100**	P/ST	1.0	U	100	U	2.0	U	1.0	U	**2.2**		2.0	U
1,1-Dichloroethane	**70**	MC/ST	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
Chloroform	**5.7**	MC/C	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
cis-1,2-Dichloroethene	**70**	P/ST	17		100	U	65		19		**140**		57	
1,1,1-Trichloroethane	**200**	P/ST	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
Carbon tetrachloride	**3**	P/C	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
1,2-Dichloroethane	**3**	P/C	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
Trichloroethene	**3**	P/C	**8.0**		**120**	I	**17**		**19**		**37**		**18**	
1,2-Dichloropropane	**5**	P/C	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
Bromodichloromethane	**1**	PQL/C	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
cis-1,3-Dichloropropene	**0.2**	PQL/C	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
trans-1,3-Dichloropropene			1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
1,1,2-Trichloroethane	**5**	P/C	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
Tetrachloroethene	**3**	P/C	**7.0**		**5000**		**17**		**3.6**	I	**3.0**		**8.0**	
Dibromochloromethane	**0.4**	MC/C	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
Chlorobenzene	**100**	P/ST	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
Bromoform	**4.4**	MC/C	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
1,1,2,2-Tetrachloroethane	**0.5**	PQL/C	2.0	U	200	U	4.0	U	2.0	U	4.0	U	4.0	U
1,3-Dichlorobenzene	**10**	MC/O	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
1,4-Dichlorobenzene	**75**	P/C	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
1,2-Dichlorobenzene	**600**	P/ST	1.0	U	100	U	2.0	U	1.0	U	2.0	U	2.0	U
Dilution					1:100 (ALL)		1:2 (ALL)				1:2 (ALL)		1:2 (ALL)	
Total VOCs			**32**		**5120**		**99**		**42**		**182**		**83**	

Table A-1. Summary of Groundwater Analytical Results
Shallow Zone VOCs
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			OLD-13-07A		OLD-13-07A					
Sample ID	FDEPGCTL		U4G07ABL		U4G07A08		U4G07A14		U4G7A-16	
Sampling Date			2-Feb-00		24-May-00		13-Jul-00		2-Aug-00	
Volatile organics, ug/L										
Dichlorodifluoromethane	**1400**	MC/ST	250	U	40	U	5.0	U	10	U
Chloromethane	**2.7**	MC/C	250	U	40	U	5.0	U	10	U
Vinyl chloride	**1**	P/C	250	U	40	U	**7.0**		10	U
Bromomethane	**9.8**	MC/ST	250	U	40	U	5.0	U	10	U
Chloroethane	**12**	MC/C	250	U	40	U	5.0	U	10	U
Trichlorofluoromethane	**2100**	MC/ST	250	U	40	U	5.0	U	10	U
1,1-Dichloroethene	**7**	P/C	250	U	40	U	5.0	U	10	U
Methylene chloride	**5**	P/C	750	U	120	U	**15**		50	U
trans-1,2-Dichloroethene	**100**	P/ST	250	U	40	U	5.0	U	10	U
1,1-Dichloroethane	**70**	MC/ST	250	U	40	U	5.0	U	10	U
Chloroform	**5.7**	MC/C	250	U	40	U	5.0	U	10	U
cis-1,2-Dichloroethene	**70**	P/ST	250	U	**170**		**260**		**360**	
1,1,1-Trichloroethane	**200**	P/ST	250	U	40	U	5.0	U	10	U
Carbon tetrachloride	**3**	P/C	250	U	40	U	5.0	U	10	U
1,2-Dichloroethane	**3**	P/C	250	U	40	U	5.0	U	10	U
Trichloroethene	**3**	P/C	250	U	**72**	I	**52**		**57**	
1,2-Dichloropropane	**5**	P/C	250	U	40	U	5.0	U	10	U
Bromodichloromethane	**1**	PQL/C	250	U	40	U	5.0	U	10	U
cis-1,3-Dichloropropene	**0.2**	PQL/C	250	U	40	U	5.0	U	10	U
trans-1,3-Dichloropropene			250	U	40	U	5.0	U	10	U
1,1,2-Trichloroethane	**5**	P/C	250	U	40	U	5.0	U	10	U
Tetrachloroethene	**3**	P/C	**5000**		**1500**		**190**		**140**	
Dibromochloromethane	**0.4**	MC/C	250	U	40	U	5.0	U	10	U
Chlorobenzene	**100**	P/ST	250	U	40	U	5.0	U	10	U
Bromoform	**4.4**	MC/C	250	U	40	U	5.0	U	10	U
1,1,2,2-Tetrachloroethane	**0.5**	PQL/C	500	U	80	U	10	U	20	U
1,3-Dichlorobenzene	**10**	MC/O	250	U	40	U	5.0	U	10	U
1,4-Dichlorobenzene	**75**	P/C	250	U	40	U	5.0	U	10	U
1,2-Dichlorobenzene	**600**	P/ST	250	U	40	U	5.0	U	10	U
Dilution			1:250 (ALL)		1:40 (ALL)		1:5 (ALL)		1:10 (ALL)	
Total VOCs			**5000**		**1742**		**524**		**557**	

Appendix A-2

Summary of Groundwater Analytical Results, Shallow Zone TAL Metals

Table A-2. Summary of Groundwater Analytical Results
Shallow Zone TAL Metals
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			GMP-09						GMP-10			
Sample ID	FDEPGCTL		U4H09GBL		U4HGMP-9-16		U4HGMP-9-16		U4H10GBL		U4GG1001	
Sampling Date			3-Feb-00		2-Aug-00		2-Aug-00		3-Feb-00		23-Feb-00	
Inorganics, mg/L												
Aluminum	**0.2**	S/	0.05	U	**6.4**				0.05	U	**0.76**	
Antimony	**0.006**	P/ST	0.005	U	0.006	U			0.005	U	0.005	U
Arsenic	**0.05**	P/C	0.01	U	0.01	U			0.01	U	0.01	U
Barium	**2**	P/ST	0.1	U	0.1	U			0.1	U	0.1	U
Beryllium	**0.004**	P/C	0.001	U	0.001	U			0.001	U	0.001	U
Cadmium	**0.005**	P/C	0.001	U	0.001	U			0.001	U	0.001	U
Calcium			16		6.9				27		52	
Chromium	**0.1**	P/	0.01	U	0.025				0.01	U	0.01	I
Cobalt	**0.42**	MC/ST	0.05	U	0.05	U			0.05	U	0.05	U
Copper	**1**	S/ST	0.05	U	0.05	U			0.05	U	0.05	U
Iron	**0.3**	S/	0.05	U	0.16		0.1		0.23		0.29	
Lead	**0.015**	P/ST	0.005	U	0.0054				0.005	U	0.005	U
Magnesium			**2.0**		0.5	U			**2.3**		**3.4**	
Manganese	**0.05**	S/ST	0.01	U	0.01				0.012		0.011	
Mercury	**0.002**	P/ST	0.0002	I	**0.0042**				0.00021	I	0.0005	U
Molybdenum	**0.035**	MC/ST			0.01	U						
Nickel	**0.1**	P/ST	0.01	U	0.1	U			0.01	U	0.01	U
Potassium			1.6		530				0.7		270	
Selenium	**0.05**	P/ST	0.01	U	0.01	U			0.01	U	0.01	U
Silver	**0.1**	S/ST	0.01	U	0.01	U			0.01	U	0.01	U
Sodium	**160**	P	5.8		7.4				2.5		7.1	
Thallium	**0.002**	P/	0.002	U	0.002	U			0.002	U	0.002	U
Vanadium	**0.049**	MC/ST	0.01	U	0.011				0.01	U	0.01	U
Zinc	**5**	S/ST	0.1	U	0.1	U			0.1	U	0.1	U
RSK 175, mg/L												
Methane			**0.003**		**0.0048**				**0.025**			
Ethane			0.001	U	0.001	U			0.001	U		
Ethene			0.001	U	0.001	U			0.001	U		
Water Quality, mg/L												
Alkalinity					**900**							
Alk-P			0						0			
Alk-T			4.76						6.8			
COLOR (CU)	**15**		<1						<1			
CO2			50						70			
Chloride	**250**		15		16				10			
Fe2+			0.68						0.82			
Fe Total			0.2						0.5			
Hardness			85.5						102.6			
Nitrite-N			0.048		0.01	U			0.06			
Nitrate-N			0		0.02	U			0			
Nitrate-Nitrite-N					0.02	U						
Sulfate			0.205		19				0.027			
Sulfide			0.1						0.1			
TDS	**500**		94		**1900**				100			
TOC			7.0		180				6.0			
pH	**6.5 to 8.5**		5.73		6.41		--		5.75		6.24	
Temp (degrees C)			21.9		29		--		21.8		25	
Conductivity			130		2400		--		152		1000	
Turbidity (NTUs)			3.35		--		--		2.03		26.5	
Oxygen Reduction Potential (mv)			-78.4		-277.1		--		-191.2		-105	
Dissolved Oxygen			6.6		0.18		--		0		--	

Table A-2. Summary of Groundwater Analytical Results
Shallow Zone TAL Metals
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			GMP-10				GMP-10				GMP-12	
Sample ID	FDEPGCTL		U4H10G02		U4H10G08		U4HGMP-10-16		U4HGMP-10-16		U4H12GBL	
Sampling Date			8-Mar-00		25-May-00		2-Aug-00		2-Aug-00		3-Feb-00	
Inorganics, mg/L												
Aluminum	**0.2**	S/	**4.3**		**5.1**		**0.95**				0.05	U
Antimony	**0.006**	P/ST	0.005	U	0.006	U	0.006	U			0.005	U
Arsenic	**0.05**	P/C	0.05	U	0.02	U	0.01	U			0.01	U
Barium	**2**	P/ST	0.5	U	0.2	U	0.1	U			0.1	U
Beryllium	**0.004**	P/C	0.005	U	0.002	U	0.001	U			0.001	U
Cadmium	**0.005**	P/C	0.005	U	0.002	U	0.001	U			0.001	U
Calcium			13		12		8.6				56	
Chromium	**0.1**	P/	0.05	U	0.068		0.012				0.01	U
Cobalt	**0.42**	MC/ST	0.25	U	0.1	U	0.05	U			0.05	U
Copper	**1**	S/ST	0.25	U	0.1	U	0.05	U			0.05	U
Iron	**0.3**	S/	0.28		0.1	U	0.06	U	0.05	U	0.05	U
Lead	**0.015**	P/ST	0.025	U	0.025	U	0.005	U			0.005	U
Magnesium			2.5	U	**1.1**		**0.52**				**3**	
Manganese	**0.05**	S/ST	**0.1**		**140**		**14**				0.01	U
Mercury	**0.002**	P/ST	0.0005	U	**0.0023**		0.0013				0.0002	U
Molybdenum	**0.035**	MC/ST					0.01	U				
Nickel	**0.1**	P/ST	0.05	U	0.5	U	0.1	U			0.01	U
Potassium			160		850		900				1	
Selenium	**0.05**	P/ST	0.05	U	0.05	U	0.01	U			0.01	U
Silver	**0.1**	S/ST	0.05	U	0.02	U	0.01	U			0.01	U
Sodium	**160**	P	2.7		10		9.8				3.8	
Thallium	**0.002**	P/	0.002	U	0.01	U	0.002	U			0.002	U
Vanadium	**0.049**	MC/ST	0.05	U	0.02	U	0.01	U			0.01	U
Zinc	**5**	S/ST	0.5	U	0.2	U	0.1	U			0.1	U
RSK 175, mg/L												
Methane							**0.0027**				**0.0064**	
Ethane							0.001	U			0.001	U
Ethene							0.001	U			0.001	U
Water Quality, mg/L												
Alkalinity							**1100**					
Alk-P											0	
Alk-T											12.24	
COLOR (CU)	**15**						**700**				10	
CO2											35	
Chloride	**250**						**18**				15	
Fe2+											0.83	
Fe Total												
Hardness											171	
Nitrite-N							0.01	U			0.057	
Nitrate-N							0.02	U			0	
Nitrate-Nitrite-N							0.01	U				
Sulfate							41				0.837	
Sulfide											0.1	
TDS	**500**						**2100**				180	
TOC							81				8.0	
pH	**6.5 to 8.5**		6.88		6.48		6.9		--		6.4	
Temp (degrees C)			25.8		28.6		28.6		--		22.2	
Conductivity			1250		2400		3000		--		302	
Turbidity (NTUs)			51.8		--				--		5.13	
Oxygen Reduction Potential (mv)			-171		--		350		--		83.6	
Dissolved Oxygen			--		--		0.9		--		2.9	

Table A-2. Summary of Groundwater Analytical Results
Shallow Zone TAL Metals
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			GMP-12					GMP-13			
Sample ID	FDEPGCTL		U4H12G04		U4HGMP-12-16		U4HGMP-12-16	U4H13GBL		U4HGMP-13-16	
Sampling Date			30-Mar-00		2-Aug-00		2-Aug-00	3-Feb-00		2-Aug-00	
Inorganics, mg/L											
Aluminum	**0.2**	S/	**5.8**		**0.98**			0.05	U	**0.36**	
Antimony	**0.006**	P/ST	0.005	U	0.006	U		0.005	U	0.006	U
Arsenic	**0.05**	P/C	0.01	U	**0.02**			0.01	U	0.01	U
Barium	**2**	P/ST	0.1	U	0.1	U		0.1	U	0.1	U
Beryllium	**0.004**	P/C	0.001	U	0.001	U		0.001	U	0.001	U
Cadmium	**0.005**	P/C	0.001	U	0.001	U		0.001	U	0.001	U
Calcium			23		3.2			43		2.1	
Chromium	**0.1**	P/	**0.17**		**0.11**			0.01	U	0.038	
Cobalt	**0.42**	MC/ST	0.05	U	0.05	U		0.05	U	0.05	U
Copper	**1**	S/ST	0.05	U	0.05	U		0.05	U	0.05	U
Iron	**0.3**	S/	**0.37**		0.08		0.09	0.05	U	0.1	
Lead	**0.015**	P/ST	0.005	U	0.005	U		0.005	U	0.005	U
Magnesium			**0.55**		**0.76**			**2.1**		0.5	U
Manganese	**0.05**	S/ST	0.027		**490**			0.01	U	**5.6**	
Mercury	**0.002**	P/ST	0.00064		0.00099			0.0002	U	0.00062	
Molybdenum	**0.035**	MC/ST			0.01	U				0.01	U
Nickel	**0.1**	P/ST	0.01	U	0.1	U		0.01	U	0.1	U
Potassium			810		950			0.7		410	
Selenium	**0.05**	P/ST	0.01	U	0.01	U		0.01	U	0.01	U
Silver	**0.1**	S/ST	0.01	U	0.01	U		0.01	U	0.01	U
Sodium	**160**	P	8.4		10			2.6		5.3	
Thallium	**0.002**	P/	0.002	U	0.002	U		0.002	U	0.002	U
Vanadium	**0.049**	MC/ST	**0.052**		0.01	U		0.01	U	0.01	U
Zinc	**5**	S/ST	0.1	U	0.1	U		0.1	U	0.1	U
RSK 175, mg/L											
Methane					**0.0027**			**0.016**		**0.0041**	
Ethane					0.001	U				0.001	U
Ethene					0.001	U				0.001	U
Water Quality, mg/L											
Alkalinity					720					540	
Alk-P								0			
Alk-T								8.84			
COLOR (CU)	**15**							<1		**500**	
CO2								40			
Chloride	**250**				15			10		7.5	
Fe2+								1.78			
Fe Total								0			
Hardness								153.9			
Nitrite-N					0.06			0.199		0.01	U
Nitrate-N					0.6			0		0.02	U
Nitrate-Nitrite-N					0.66					0.02	U
Sulfate					68			0.091		13	
Sulfide								0			
TDS	**500**				**3100**			160		**1300**	
TOC					46			6.0		54	
pH	**6.5 to 8.5**		7.22		6.73		--	6.25		7.13	
Temp (degrees C)			27.3		29.7		--	22.3		29.1	
Conductivity			2200		3300		--	238		1450	
Turbidity (NTUs)			18.7				--	3.66		--	
Oxygen Reduction Potential (mv)			-267.5		753.3		--	126.2		395.1	
Dissolved Oxygen			--		0.18		--	0.6		2.04	

Table A-2. Summary of Groundwater Analytical Results
Shallow Zone TAL Metals
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			GMP-13		GMP-14		GMP-15			
Sample ID	FDEPGCTL		U4HGMP-13-16		U4H14G10		U4H15GBL		U4HGMP-15-16	
Sampling Date			2-Aug-00		8-Jun-00		4-Feb-00		2-Aug-00	
Inorganics, mg/L										
Aluminum	**0.2**	S/			**5.7**		0.05	U	**3.2**	
Antimony	**0.006**	P/ST			0.006	U	0.005	U	0.006	U
Arsenic	**0.05**	P/C			0.01	U	0.01	U	0.01	U
Barium	**2**	P/ST			0.1	U	0.1	U	0.1	U
Beryllium	**0.004**	P/C			0.001	U	0.001	U	0.001	U
Cadmium	**0.005**	P/C			0.001	U	0.001	U	0.001	U
Calcium					12		47		14	
Chromium	**0.1**	P/			**0.1**		0.01	U	0.017	
Cobalt	**0.42**	MC/ST			0.05	U	0.05	U	0.05	U
Copper	**1**	S/ST			0.05	U	0.05	U	0.05	U
Iron	**0.3**	S/	0.05		0.19		0.05	U	0.15	
Lead	**0.015**	P/ST			0.005	U	0.005	U	0.005	U
Magnesium					0.5	U	**3.4**		**0.68**	
Manganese	**0.05**	S/ST			**1.7**		0.01	U	**0.021**	
Mercury	**0.002**	P/ST			0.001		0.0002	U	**0.0034**	
Molybdenum	**0.035**	MC/ST							0.01	U
Nickel	**0.1**	P/ST			0.1	U	0.01	U	0.1	U
Potassium					620		1.2		640	
Selenium	**0.05**	P/ST			0.01	U	0.01	U	0.01	U
Silver	**0.1**	S/ST			0.01	U	0.01	U	0.01	U
Sodium	**160**	P					6.5		8.8	
Thallium	**0.002**	P/			0.002	U	0.002	U	0.002	U
Vanadium	**0.049**	MC/ST			0.04		0.01		0.024	
Zinc	**5**	S/ST			0.1	U	0.1	U	0.1	U
RSK 175, mg/L										
Methane							**0.008**		**0.011**	
Ethane							0.001	U	0.001	U
Ethene							0.001	U	0.001	U
Water Quality, mg/L										
Alkalinity									920	
Alk-P							0			
Alk-T							8.16			
COLOR (CU)	**15**						10			
CO2							70			
Chloride	**250**						15		15	
Fe2+							0.03			
Fe Total							0.1			
Hardness							153.9			
Nitrite-N							0.16		0.01	U
Nitrate-N							0		0.02	U
Nitrate-Nitrite-N									0.02	U
Sulfate							0.286		17	
Sulfide							0.1			
TDS	**500**						150		**1900**	
TOC							8.0		140.0	
pH	**6.5 to 8.5**				6.16		6.35		6.28	
Temp (degrees C)					22.2		23.6		28.5	
Conductivity					260		268		2500	
Turbidity (NTUs)					0.9		26.9			
Oxygen Reduction Potential (mv)					-99.2		-67.4		-253.4	
Dissolved Oxygen							0		0.09	

Table A-2. Summary of Groundwater Analytical Results
Shallow Zone TAL Metals
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			GMP-15		GMP-17					
Sample ID	FDEPGCTL		U4HGMP-15-16		U4H17GBL		U4HGMP-17-16		U4HGMP-17-16	
Sampling Date			2-Aug-00		9-Feb-00		2-Aug-00		2-Aug-00	
Inorganics, mg/L										
Aluminum	**0.2**	S/			0.05	U	0.05	U		
Antimony	**0.006**	P/ST			0.005	U	0.006	U		
Arsenic	**0.05**	P/C			0.01	U	0.01	U		
Barium	**2**	P/ST			0.1	U	0.1	U		
Beryllium	**0.004**	P/C			0.001	U	0.001	U		
Cadmium	**0.005**	P/C			0.001	U	0.001	U		
Calcium					30		69			
Chromium	**0.1**	P/			0.01	U	0.01	U		
Cobalt	**0.42**	MC/ST			0.05	U	0.05	U		
Copper	**1**	S/ST			0.05	U	0.05	U		
Iron	**0.3**	S/	0.09		0.05	U	0.05	U	0.05	U
Lead	**0.015**	P/ST			0.005	U	0.005	U		
Magnesium					**5.1**		**12**			
Manganese	**0.05**	S/ST			0.01	U	0.01	U		
Mercury	**0.002**	P/ST			0.0002	U	0.00035			
Molybdenum	**0.035**	MC/ST					0.01	U		
Nickel	**0.1**	P/ST			0.01	U	0.01	U		
Potassium					1.8		2.0			
Selenium	**0.05**	P/ST			0.01	U	0.01	U		
Silver	**0.1**	S/ST			0.01	U	0.01	U		
Sodium	**160**	P			7.2		6.9			
Thallium	**0.002**	P/			0.002	U	0.002	U		
Vanadium	**0.049**	MC/ST			**0.02**		0.01	U		
Zinc	**5**	S/ST			0.1	U	0.1	U		
RSK 175, mg/L										
Methane					0.0039		0.004			
Ethane					0.001	U	0.001	U		
Ethene					0.001	U	0.001	U		
Water Quality, mg/L										
Alkalinity										
Alk-P					0					
Alk-T					8.16					
COLOR (CU)	**15**				10					
CO2					30					
Chloride	**250**				20					
Fe2+					0					
Fe Total					0					
Hardness					114.9					
Nitrite-N					0.005		0.01	U		
Nitrate-N					0		0.02	U		
Nitrate-Nitrite-N							0.02	U		
Sulfate					0.021		11			
Sulfide					0					
TDS	**500**				150					
TOC					6.0					
pH	**6.5 to 8.5**		--		6.26		5.65		--	
Temp (degrees C)			--		22.8		27.4		--	
Conductivity			--		205		440		--	
Turbidity (NTUs)			--		0.64		7.7		--	
Oxygen Reduction Potential (mv)			--		-53.8		-58.4		--	
Dissolved Oxygen			--		0.3		0.81		--	

Table A-2. Summary of Groundwater Analytical Results
Shallow Zone TAL Metals
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			GMP-17	
Sample ID	FDEPGCTL		U4HGMP-17-17	
Sampling Date			5-Jan-01	
Inorganics, mg/L				
Aluminum	**0.2**	S/	**1.0**	
Antimony	**0.006**	P/ST	0.006	U
Arsenic	**0.05**	P/C	0.01	U
Barium	**2**	P/ST	0.1	U
Beryllium	**0.004**	P/C	0.001	U
Cadmium	**0.005**	P/C	0.001	U
Calcium			18	
Chromium	**0.1**	P/	0.016	
Cobalt	**0.42**	MC/ST	0.05	U
Copper	**1**	S/ST	0.05	U
Iron	**0.3**	S/	0.05	U
Lead	**0.015**	P/ST	0.005	U
Magnesium			**2.8**	
Manganese	**0.05**	S/ST	0.01	U
Mercury	**0.002**	P/ST	0.00079	
Molybdenum	**0.035**	MC/ST	0.01	U
Nickel	**0.1**	P/ST	0.01	U
Potassium			370	
Selenium	**0.05**	P/ST	0.01	U
Silver	**0.1**	S/ST	0.01	U
Sodium	**160**	P	5.3	
Thallium	**0.002**	P/	0.002	U
Vanadium	**0.049**	MC/ST	0.01	U
Zinc	**5**	S/ST	0.1	U
RSK 175, mg/L				
Methane				
Ethane				
Ethene				
Water Quality, mg/L				
Alkalinity				
Alk-P				
Alk-T				
COLOR (CU)	**15**		**500**	
CO2				
Chloride	**250**		11	
Fe2+				
Fe Total				
Hardness				
Nitrite-N				
Nitrate-N				
Nitrate-Nitrite-N				
Sulfate				
Sulfide				
TDS	**500**		**750**	
TOC				
pH	**6.5 to 8.5**		6.63	
Temp (degrees C)			22.8	
Conductivity			1200	
Turbidity (NTUs)			18	
Oxygen Reduction Potential (mv)			189.9	
Dissolved Oxygen			0.2	

Appendix A-3

Summary of Groundwater Analytical Results, Deep Zone VOCs

Table A-3. Summary of Groundwater Analytical Results
Deep Zone VOCs
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			OLD-13-41B														
Sample ID	FDEPGCTL		U4G41BBL		4G41B06	U4G41B07		U4G41B08		U4G41B09		U4G41B11		U4G41B13		U4GOLD-13-41B-16	
Sampling Date			02/04/00		04/13/00	04/19/00		05/24/00		06/02/00		06/15/00		06/28/00		08/02/00	
Volatile organics, ug/L																	
Dichlorodifluoromethane	**1400**	MC/ST	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
Chloromethane	**2.7**	MC/C	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
Vinyl chloride	**1**	P/C	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
Bromomethane	**9.8**	MC/ST	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
Chloroethane	**12**	MC/C	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
Trichlorofluoromethane	**2100**	MC/ST	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
1,1-Dichloroethene	**7**	P/C	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
Methylene chloride	**5**	P/C	300	U	75	150	U	120	U	300	U	75	U	75	U	250	U
trans-1,2-Dichloroethene	**100**	P/ST	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
1,1-Dichloroethane	**70**	MC/ST	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
Chloroform	**5.7**	MC/C	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
cis-1,2-Dichloroethene	**70**	P/ST	100	U	**120**	**120**	I	**110**	I	**110**	I	**230**		**680**		**1100**	
1,1,1-Trichloroethane	**200**	P/ST	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
Carbon tetrachloride	**3**	P/C	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
1,2-Dichloroethane	**3**	P/C	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
Trichloroethene	**3**	P/C	**1300**		**900**	**1300**		**1400**		**750**		**740**		**580**		**1900**	
1,2-Dichloropropane	**5**	P/C	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
Bromodichloromethane	**1**	PQL/C	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
cis-1,3-Dichloropropene	**0.2**	PQL/C	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
trans-1,3-Dichloropropene			100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
1,1,2-Trichloroethane	**5**	P/C	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
Tetrachloroethene	**3**	P/C	**3300**		**600**	**640**		**260**		**130**	I	**110**		**96**		**480**	
Dibromochloromethane	**0.4**	MC/C	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
Chlorobenzene	**100**	P/ST	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
Bromoform	**4.4**	MC/C	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
1,1,2,2-Tetrachloroethane	**0.5**	PQL/C	200	U	50	100	U	80	U	200	U	50	U	50	U	100	U
1,3-Dichlorobenzene	**10**	MC/O	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
1,4-Dichlorobenzene	**75**	P/C	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
1,2-Dichlorobenzene	**600**	P/ST	100	U	25	50	U	40	U	100	U	25	U	25	U	50	U
Dilution			1:100 (ALL)		:25 (ALL)	1:50 (ALL)		1:40 (ALL)		1:100 (ALL)		1:25 (ALL)		1:25 (ALL)		1:50 (ALL)	
Total VOCs			**4600**		**1620**	**2060**		**1770**		**990**		**1080**		**1356**		**3480**	

Table A-3. Summary of Groundwater Analytical Results
Deep Zone VOCs
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			OLD-13-42B															
Sample ID	FDEPGCTL		U4G42BBL		U4G42B04		U4G42B05		U4G42B06		U4G42B07		U4G42B08		U4G42B09		U4G42B10	
Sampling Date			02/04/00		03/30/00		04/05/00		04/12/00		04/19/00		05/24/00		06/02/00		06/08/00	
Volatile organics, ug/L																		
Dichlorodifluoromethane	**1400**	MC/ST	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
Chloromethane	**2.7**	MC/C	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
Vinyl chloride	**1**	P/C	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
Bromomethane	**9.8**	MC/ST	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
Chloroethane	**12**	MC/C	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
Trichlorofluoromethane	**2100**	MC/ST	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
1,1-Dichloroethene	**7**	P/C	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
Methylene chloride	**5**	P/C	300	U	300	U	300	U	300	U	150	U	300	U	300	U	150	U
trans-1,2-Dichloroethene	**100**	P/ST	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
1,1-Dichloroethane	**70**	MC/ST	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
Chloroform	**5.7**	MC/C	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
cis-1,2-Dichloroethene	**70**	P/ST	**700**		**1400**		**960**		**620**		**680**		**2100**		**1600**		**920**	
1,1,1-Trichloroethane	**200**	P/ST	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
Carbon tetrachloride	**3**	P/C	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
1,2-Dichloroethane	**3**	P/C	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
Trichloroethene	**3**	P/C	**1900**		**4300**		**3400**		**2200**		**2500**		**940**		**730**		**490**	
1,2-Dichloropropane	**5**	P/C	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
Bromodichloromethane	**1**	PQL/C	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
cis-1,3-Dichloropropene	**0.2**	PQL/C	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
trans-1,3-Dichloropropene			100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
1,1,2-Trichloroethane	**5**	P/C	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
Tetrachloroethene	**3**	P/C	**1700**		**2500**		**1900**		**1200**		**1200**		**130**	I	100	U	50	U
Dibromochloromethane	**0.4**	MC/C	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
Chlorobenzene	**100**	P/ST	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
Bromoform	**4.4**	MC/C	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
1,1,2,2-Tetrachloroethane	**0.5**	PQL/C	200	U	200	U	200	U	200	U	100	U	200	U	200	U	100	U
1,3-Dichlorobenzene	**10**	MC/O	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
1,4-Dichlorobenzene	**75**	P/C	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
1,2-Dichlorobenzene	**600**	P/ST	100	U	100	U	100	U	100	U	50	U	100	U	100	U	50	U
Dilution			1:100 (ALL)		1:100 (ALL)		1:500 (TCE)		1:100 (ALL)		1:50 (ALL)		1:100 (ALL)		1:100 (ALL)		1:50 (ALL)	
							:100 (OTHERS											
Total VOCs			**4300**		**8200**		**6260**		**4020**		**4380**		**3170**		**2330**		**1410**	

Table A-3. Summary of Groundwater Analytical Results
Deep Zone VOCs
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			OLD-13-42B								OLD-13-44B							
Sample ID	FDEPGCTL		U4G42B11		U4G42B12		U4G42B14		U4GGMB-42B-16		U4G44BBL		U4G44B01		U4G44B02		U4G44B03	
Sampling Date			06/15/00		06/21/00		07/13/00		08/02/00		02/03/00		02/23/00		03/08/00		03/23/00	
Volatile organics, ug/L																		
Dichlorodifluoromethane	**1400**	MC/ST	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
Chloromethane	**2.7**	MC/C	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
Vinyl chloride	**1**	P/C	40	U	40	U	**31**		**26**		25	U	100	U	100	U	100	U
Bromomethane	**9.8**	MC/ST	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
Chloroethane	**12**	MC/C	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
Trichlorofluoromethane	**2100**	MC/ST	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
1,1-Dichloroethene	**7**	P/C	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
Methylene chloride	**5**	P/C	120	U	120	U	30	U	100	U	75	U	300	U	300	U	300	U
trans-1,2-Dichloroethene	**100**	P/ST	40	U	40	U	**12**		20	U	25	U	100	U	100	U	100	U
1,1-Dichloroethane	**70**	MC/ST	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
Chloroform	**5.7**	MC/C	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
cis-1,2-Dichloroethene	**70**	P/ST	**860**		**700**		**1000**		**830**		**1100**		**1800**		**630**		**700**	
1,1,1-Trichloroethane	**200**	P/ST	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
Carbon tetrachloride	**3**	P/C	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
1,2-Dichloroethane	**3**	P/C	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
Trichloroethene	**3**	P/C	**540**		**700**		**280**		**74**		**4700**		**5400**		**5800**		**5600**	
1,2-Dichloropropane	**5**	P/C	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
Bromodichloromethane	**1**	PQL/C	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
cis-1,3-Dichloropropene	**0.2**	PQL/C	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
trans-1,3-Dichloropropene			40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
1,1,2-Trichloroethane	**5**	P/C	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
Tetrachloroethene	**3**	P/C	40	U	40	U	10	U	20	U	**140**		**340**		**2500**		**2400**	
Dibromochloromethane	**0.4**	MC/C	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
Chlorobenzene	**100**	P/ST	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
Bromoform	**4.4**	MC/C	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
1,1,2,2-Tetrachloroethane	**0.5**	PQL/C	80	U	80	U	20	U	40	U	50	U	200	U	200	U	200	U
1,3-Dichlorobenzene	**10**	MC/O	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
1,4-Dichlorobenzene	**75**	P/C	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
1,2-Dichlorobenzene	**600**	P/ST	40	U	40	U	10	U	20	U	25	U	100	U	100	U	100	U
Dilution			1:40 (ALL)		1:40 (ALL)		1:10 (ALL)		1:20 (ALL)		1:100 (TCE)		1:100 (ALL)		1:100 (ALL)		1:100 (ALL)	
											:25 (OTHERS)							
Total VOCs			**1400**	**0**	**1400**		**1323**		**930**		**5940**		**7540**		**8930**		**8700**	

Table A-3. Summary of Groundwater Analytical Results
Deep Zone VOCs
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			OLD-13-44B																	
Sample ID	FDEPGCTL		U4G44B04		U4G44B05		U4G44B06		U4G44B07		U4G44B08		U4G44B09		U4G44B10		U4G44B11		U4G44B13	
Sampling Date			03/30/00		04/05/00		04/12/00		04/19/00		05/24/00		06/02/00		06/08/00		06/15/00		06/28/00	
Volatile organics, ug/L																				
Dichlorodifluoromethane	1400	MC/ST	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	36	
Chloromethane	2.7	MC/C	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
Vinyl chloride	1	P/C	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
Bromomethane	9.8	MC/ST	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
Chloroethane	12	MC/C	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
Trichlorofluoromethane	2100	MC/ST	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
1,1-Dichloroethene	7	P/C	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
Methylene chloride	5	P/C	300	U	300	U	150	U	**92**	I	120	U	300	U	150	U	75	U	60	U
trans-1,2-Dichloroethene	100	P/ST	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
1,1-Dichloroethane	70	MC/ST	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
Chloroform	5.7	MC/C	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
cis-1,2-Dichloroethene	70	P/ST	**820**		**920**		**1300**		**680**		**420**		**370**		**450**		**340**		**370**	
1,1,1-Trichloroethane	200	P/ST	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
Carbon tetrachloride	3	P/C	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
1,2-Dichloroethane	3	P/C	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
Trichloroethene	3	P/C	**3900**		**2900**		**2100**		**1000**		**1500**		**710**		**440**		**200**		**280**	
1,2-Dichloropropane	5	P/C	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
Bromodichloromethane	1	PQL/C	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
cis-1,3-Dichloropropene	0.2	PQL/C	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
trans-1,3-Dichloropropene			100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
1,1,2-Trichloroethane	5	P/C	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
Tetrachloroethene	3	P/C	**1700**		**790**		**500**		**250**		**200**		100	U	**65**	I	**50**	I	**50**	
Dibromochloromethane	0.4	MC/C	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
Chlorobenzene	100	P/ST	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
Bromoform	4.4	MC/C	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
1,1,2,2-Tetrachloroethane	0.5	PQL/C	200	U	200	U	100	U	50	U	80	U	200	U	100	U	50	U	40	U
1,3-Dichlorobenzene	10	MC/O	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
1,4-Dichlorobenzene	75	P/C	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
1,2-Dichlorobenzene	600	P/ST	100	U	100	U	50	U	25	U	40	U	100	U	50	U	25	U	20	U
Dilution			1:100 (ALL)		1:100 (ALL)		1:50 (ALL)		1:25 (ALL)		1:40 (ALL)		1:100 (ALL)		1:50 (ALL)		1:25 (ALL)		1:20 (ALL)	
Total VOCs			**6420**		**4610**		**3900**		**2022**		**2120**		**1080**		**955**		**590**		**736**	

Table A-3. Summary of Groundwater Analytical Results
Deep Zone VOCs
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			OLD-13-44B		OLD-13-45B											
Sample ID	FDEPGCTL		U4GGMB-44B-16		U4G45BBL		U4G45B03		U4G45B04		U4G45B05		U4G45B06		U4G45B07	
Sampling Date			08/02/00		02/04/00		03/23/00		03/30/00		04/05/00		04/12/00		04/19/00	
Volatile organics, ug/L																
Dichlorodifluoromethane	**1400**	MC/ST	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Chloromethane	**2.7**	MC/C	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Vinyl chloride	**1**	P/C	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Bromomethane	**9.8**	MC/ST	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Chloroethane	**12**	MC/C	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Trichlorofluoromethane	**2100**	MC/ST	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,1-Dichloroethene	**7**	P/C	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Methylene chloride	**5**	P/C	25	U	150	U	3.0	U	5.0		3.0	U	3.0	U	3.0	U
trans-1,2-Dichloroethene	**100**	P/ST	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,1-Dichloroethane	**70**	MC/ST	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Chloroform	**5.7**	MC/C	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
cis-1,2-Dichloroethene	**70**	P/ST	68		**1500**		24		31		26		16		16	
1,1,1-Trichloroethane	**200**	P/ST	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Carbon tetrachloride	**3**	P/C	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,2-Dichloroethane	**3**	P/C	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Trichloroethene	**3**	P/C	**64**		**2200**		**12**		**17**		**31**		**26**		**21**	
1,2-Dichloropropane	**5**	P/C	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Bromodichloromethane	**1**	PQL/C	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
cis-1,3-Dichloropropene	**0.2**	PQL/C	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
trans-1,3-Dichloropropene			5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,1,2-Trichloroethane	**5**	P/C	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Tetrachloroethene	**3**	P/C	**13**		**860**		**9.0**		**13**		**10**		**6.0**		**6.0**	
Dibromochloromethane	**0.4**	MC/C	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Chlorobenzene	**100**	P/ST	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Bromoform	**4.4**	MC/C	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,1,2,2-Tetrachloroethane	**0.5**	PQL/C	10	U	200	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U
1,3-Dichlorobenzene	**10**	MC/O	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,4-Dichlorobenzene	**75**	P/C	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,2-Dichlorobenzene	**600**	P/ST	5.0	U	100	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Dilution			1:5 (ALL)		1:100 (ALL)						1:2 (TCE)					
Total VOCs			**145**		**4560**		**45**		**66**		**67**		**48**		**43**	

Table A-3. Summary of Groundwater Analytical Results
Deep Zone VOCs
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			OLD-13-45B											
Sample ID	FDEPGCTL		U4G45B08		U4G45B09		U4G45B10		U4G45B12		U4G45B14		U4GOLD-13-45B-16	
Sampling Date			05/24/00		06/02/00		06/08/00		06/21/00		07/13/00		08/02/00	
Volatile organics, ug/L														
Dichlorodifluoromethane	**1400**	MC/ST	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
Chloromethane	**2.7**	MC/C	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
Vinyl chloride	**1**	P/C	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
Bromomethane	**9.8**	MC/ST	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
Chloroethane	**12**	MC/C	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
Trichlorofluoromethane	**2100**	MC/ST	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
1,1-Dichloroethene	**7**	P/C	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
Methylene chloride	**5**	P/C	3.0	U	30	U	3.0	U	3.0	U	3.0	U	25	U
trans-1,2-Dichloroethene	**100**	P/ST	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
1,1-Dichloroethane	**70**	MC/ST	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
Chloroform	**5.7**	MC/C	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
cis-1,2-Dichloroethene	**70**	P/ST	14		27	I	10		6.9		26		**100**	
1,1,1-Trichloroethane	**200**	P/ST	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
Carbon tetrachloride	**3**	P/C	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
1,2-Dichloroethane	**3**	P/C	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
Trichloroethene	**3**	P/C	**34**		**57**		**21**		**5.7**		**7.0**		**10.0**	
1,2-Dichloropropane	**5**	P/C	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
Bromodichloromethane	**1**	PQL/C	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
cis-1,3-Dichloropropene	**0.2**	PQL/C	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
trans-1,3-Dichloropropene			1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
1,1,2-Trichloroethane	**5**	P/C	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
Tetrachloroethene	**3**	P/C	**6.0**		**13**	I	**4.0**		1.0	U	1.0	U	5.0	U
Dibromochloromethane	**0.4**	MC/C	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
Chlorobenzene	**100**	P/ST	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
Bromoform	**4.4**	MC/C	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
1,1,2,2-Tetrachloroethane	**0.5**	PQL/C	2.0	U	20	U	2.0	U	2.0	U	2.0	U	10	U
1,3-Dichlorobenzene	**10**	MC/O	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
1,4-Dichlorobenzene	**75**	P/C	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
1,2-Dichlorobenzene	**600**	P/ST	1.0	U	10	U	1.0	U	1.0	U	1.0	U	5.0	U
Dilution					1:10 (ALL)								1:5 (ALL)	
Total VOCs			**54**		**97**		**35**		**13**		**33**		**110**	

Appendix A-4

Summary of Groundwater Analytical Results, Deep Zone TAL Metals

Table A-4. Summary of Groundwater Analytical Results
Deep Zone TAL Metals
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			OLD-13-41B									
Sample ID	FDEPGCTL		U4H41BBL		U4H41B06		U4H41B13		U4GOLD-13-41B-16		U4HOLD-13-41B-16	
Sampling Date			4-Feb-00		13-Apr-00		28-Jun-00		2-Aug-00		2-Aug-00	
Inorganics, mg/L												
Aluminum	**0.2**	S/	0.067		0.087		**0.2**		**0.56**			
Antimony	**0.006**	P/ST	0.005	U	0.005	U	0.006	U	0.006	U		
Arsenic	**0.05**	P/C	0.01	U	0.01	U	0.01	U	0.01	U		
Barium	**2**	P/ST	0.1	U	0.1	U	0.1	U	0.1	U		
Beryllium	**0.004**	P/C	0.001	U	0.001	U	0.001	U	0.001	U		
Cadmium	**0.005**	P/C	0.001	U	0.001	U	0.001	U	0.001	U		
Calcium			3.4		4.4		5.1		3.9			
Chromium	**0.1**	P/	0.01	U	0.01	U	0.01	U	0.01	U		
Cobalt	**0.42**	MC/ST	0.05	U	0.05	U	0.05	U	0.05	U		
Copper	**1**	S/ST	0.05	U	0.05	U	0.05	U	0.05	U		
Iron	**0.3**	S/	0.072		0.13		0.1		**1.1**		0.11	
Lead	**0.015**	P/ST	0.005	U	0.005	U	0.005	U	0.005	U		
Magnesium			1.2		1.5		1.9		1.6			
Manganese	**0.05**	S/ST	0.01	U	0.01	U	0.01	U	0.015			
Mercury	**0.002**	P/ST	0.0002	U	0.00021	I	0.0002	U	0.0002	U		
Molybdenum	**0.035**	MC/ST							0.01	U		
Nickel	**0.1**	P/ST	0.01	U	0.01	U	0.01	U	0.1	U		
Potassium			1		NA		4.5		6.5			
Selenium	**0.05**	P/ST	0.01	U	0.01	U	0.01	U	0.01	U		
Silver	**0.1**	S/ST	0.01	U	0.01	U	0.01	U	0.01	U		
Sodium	**160**	P	11		NA		11		12			
Thallium	**0.002**	P/	0.002	U	0.002	U	0.002	U	0.002	U		
Vanadium	**0.049**	MC/ST	0.01	U	0.01	U	0.01	U	0.01	U		
Zinc	**5**	S/ST	0.1	U	0.1	U	0.1	U	0.1	U		
RSK 175, mg/L												
Methane			**0.026**						**0.017**			
Ethane			0.001	U					0.001	U		
Ethene			0.001	U					0.001	U		
Water Quality, mg/L												
Alkalinity									2.0	U		
Alk-P			0									
Alk-T			0.68									
COLOR (CU)	**15**		<1						**80**			
CO2			70									
Chloride	**250**		20						13			
Fe2+			0.04									
Fe Total			0.5									
Hardness			51.3									
Nitrite-N			0.15						0.01	U		
Nitrate-N			0						0.02	U		
Nitrate-Nitrite-N									0.02	U		
Sulfate			0.283						5.0			
Sulfide			0.3									
TDS	**500**		76						210			
TOC			6						200			
pH	**6.5 to 8.5**		5.22		4.95		4.71		4.62		--	
Temp (degrees C)			22.6		24.1		26		27		--	
Conductivity			100		112		120		140		--	
Turbidity (NTUs)			9.19		1.56		3.55		24.3		--	
Oxygen Reduction Potential (mv)			-107.3		-135.2		-140		-62.7		--	
Dissolved Oxygen			0.1		--		--		0.64		--	

Table A-4. Summary of Groundwater Analytical Results
Deep Zone TAL Metals
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			OLD-13-42B	OLD-13-42B	OLD-13-44B			
Sample ID	FDEPGCTL		U4GGMB-44B-16	U4HGMB-44B-16	U4H44BBL	U4G44B01	U4H44B02	U4GGMP-44B-16
Sampling Date			2-Aug-00	2-Aug-00	3-Feb-00	23-Feb-00	8-Mar-00	2-Aug-00
Inorganics, mg/L								
Aluminum	**0.2**	S/	0.18		0.05 U	0.072	0.099	**7.2**
Antimony	**0.006**	P/ST	0.006 U		0.005 U	0.005 U	0.005 U	0.006 U
Arsenic	**0.05**	P/C	0.01 U		0.01 U	0.01 U	0.01 U	0.01 U
Barium	**2**	P/ST	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U
Beryllium	**0.004**	P/C	0.001 U		0.001 U	0.001 U	0.001 U	0.001 U
Cadmium	**0.005**	P/C	0.001 U		0.001 U	0.001 U	0.001 U	0.001 U
Calcium			11		6.7	7.1	8.3	7.6
Chromium	**0.1**	P/	0.01 U		0.01 U	0.01 U	0.01 U	0.029
Cobalt	**0.42**	MC/ST	0.05 U		0.05 U	0.05 U	0.05 U	0.05 U
Copper	**1**	S/ST	0.05 U		0.05 U	0.05 U	0.05 U	0.05 U
Iron	**0.3**	S/	**0.71**	**0.59**	**2.4**	**1.7**	**1.7**	**1.2**
Lead	**0.015**	P/ST	0.005 U		0.005 U	0.005 U	0.005 U	0.005 U
Magnesium			2		1.4	1.7	2.2	1.1
Manganese	**0.05**	S/ST	**0.19**		0.018	0.019	0.02	0.039
Mercury	**0.002**	P/ST	0.0006		0.0002 U	0.0005 U	0.0005 U	0.00023
Molybdenum	**0.035**	MC/ST	0.01 U					0.01 U
Nickel	**0.1**	P/ST	0.1 U		0.01 U	0.01 U	0.01 U	0.1 U
Potassium			56		1	1.2	1.2	310
Selenium	**0.05**	P/ST	0.01 U		0.01 U	0.01 U	0.01 U	**0.015**
Silver	**0.1**	S/ST	0.01 U		0.01 U	0.01 U	0.01 U	0.01 U
Sodium	**160**	P	61		15	13	12	20
Thallium	**0.002**	P/	0.002 U		0.002 U	0.002 U	0.002 U	0.002 U
Vanadium	**0.049**	MC/ST	0.01 U		0.01 U	0.01 U	0.01 U	**0.069**
Zinc	**5**	S/ST	0.1 U		0.1 U	0.1 U	0.1 U	0.1 U
RSK 175, mg/L								
Methane			**0.026**		0.02			0.0082
Ethane			0.001 U		0.001 U			0.001 U
Ethene			0.001 U		0.001 U			0.0001 U
Water Quality, mg/L								
Alkalinity			180					340
Alk-P					0			
Alk-T					4.08			
COLOR (CU)	**15**		**100**		40			**600**
CO2					60			
Chloride	**250**		14		20			14
Fe2+					1.44			
Fe Total					2.5			
Hardness					51.3			
Nitrite-N			0.01 U		0.037			0.01 U
Nitrate-N			0.02 U		0			0.02 U
Nitrate-Nitrite-N			0.02 U					0.02 U
Sulfate			35		0.29			9
Sulfide					0.5			
TDS	**500**		470		98			**1500**
TOC			26		8			140
pH	**6.5 to 8.5**		5.42	--	5.61	5.36	5.39	5.51
Temp (degrees C)			26.6	--	22.6	24.5	24.2	26.9
Conductivity			725	--	138	138	135	1100
Turbidity (NTUs)			--	--	20.8	12.16	10.24	--
Oxygen Reduction Potential (mv)			-27.5	--	-158.8	-176.1	-70.5	-116
Dissolved Oxygen			1.7	--	5.1	--	--	0.36

Table A-4. Summary of Groundwater Analytical Results
Deep Zone TAL Metals
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			OLD-13-44B		OLD-13-45B				OLD-13-46B					
Sample ID	FDEPGCTL		U4HGMP-44B-16		U4H45BBL		U4H45B04		U4H46BBL		U4H46B06		U4HOLD-13-46B-16	
Sampling Date			2-Aug-00		4-Feb-00		30-Mar-00		9-Feb-00		13-Apr-00		2-Aug-00	
Inorganics, mg/L														
Aluminum	**0.2**	S/			0.05	U	**1.3**		0.078		0.19		0.05	
Antimony	**0.006**	P/ST			0.005	U	0.005	U	0.005	U	0.005	U	0.006	U
Arsenic	**0.05**	P/C			0.01	U	0.01	U	0.01	U	0.01	U	0.01	U
Barium	**2**	P/ST			0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Beryllium	**0.004**	P/C			0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
Cadmium	**0.005**	P/C			0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
Calcium					5.1		4.2		9.3		8.8		26	
Chromium	**0.1**	P/			0.01	U	0.01	U	0.01	U	0.01	U	0.01	U
Cobalt	**0.42**	MC/ST			0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
Copper	**1**	S/ST			0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
Iron	**0.3**	S/	**1.2**		**0.94**		**0.59**		**3.7**		**2.1**		**1.9**	
Lead	**0.015**	P/ST			0.005	U	0.005	U	0.005	U	0.005	U	0.005	U
Magnesium					1.4		1.4		1.4		1.4		3.3	
Manganese	**0.05**	S/ST			0.01	U	0.01	U	0.028		0.012		0.019	
Mercury	**0.002**	P/ST			0.0002	U	0.0002	I	0.0002	U	0.0002	U	0.0002	U
Molybdenum	**0.035**	MC/ST											0.01	U
Nickel	**0.1**	P/ST			0.01	U	0.01	U	0.01	U	0.01	U	0.01	U
Potassium					1		21		1.2		NA		6.5	
Selenium	**0.05**	P/ST			0.01	U	**0.01**	I	0.01	U	0.01	U	0.01	U
Silver	**0.1**	S/ST			0.01	U	0.01	U	0.01	U	0.01	U	0.01	U
Sodium	**160**	P			12		10		9.7		NA		11	
Thallium	**0.002**	P/			0.002	U	0.002	U	0.002	U	0.002	U	0.002	U
Vanadium	**0.049**	MC/ST			0.01	U	0.013		0.01	U	0.01	U	0.01	U
Zinc	**5**	S/ST			0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
RSK 175, mg/L														
Methane					0.024				0.012				0.012	
Ethane					0.001	U			0.001	U			0.001	U
Ethene					0.001	U			0.001	U			0.001	U
Water Quality, mg/L														
Alkalinity														
Alk-P					0				0					
Alk-T					2.72				3.4					
COLOR (CU)	**15**				30				25					
CO2					65				55					
Chloride	**250**				20				25					
Fe2+					0.54				2.76					
Fe Total					1.4				3					
Hardness					34.2				51.3					
Nitrite-N					0.102				0.037				0.01	U
Nitrate-N					0				0				0.02	U
Nitrate-Nitrite-N													0.02	U
Sulfate					0.273				0.334				18	
Sulfide					0.5				0.5					
TDS	**500**				76				80					
TOC					6				6					
pH	**6.5 to 8.5**		--		5.54		5.35		5.62		5.39		5.37	
Temp (degrees C)			--		23.8		25.4		23.7		23.9		26	
Conductivity			--		121		150		132		135		230	
Turbidity (NTUs)			--		19.9		12.1		25.1		5.71		6.88	
Oxygen Reduction Potential (mv)			--		-155.6		-146.9		-186.1		-130.6		-98.5	
Dissolved Oxygen			--		5.3		--		8.4		--		0.55	

Table A-4. Summary of Groundwater Analytical Results
Deep Zone TAL Metals
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			OLD-13-46B			
Sample ID	FDEPGCTL		4HOLD-13-46B-16		U4HOLD-13-46B-17	
Sampling Date			2-Aug-00		5-Jan-01	
Inorganics, mg/L						
Aluminum	**0.2**	S/			**1.4**	
Antimony	**0.006**	P/ST			0.006	U
Arsenic	**0.05**	P/C			0.01	U
Barium	**2**	P/ST			0.1	U
Beryllium	**0.004**	P/C			0.001	U
Cadmium	**0.005**	P/C			0.001	U
Calcium					30	
Chromium	**0.1**	P/			0.01	U
Cobalt	**0.42**	MC/ST			0.05	U
Copper	**1**	S/ST			0.05	U
Iron	**0.3**	S/	**1.8**		**0.75**	
Lead	**0.015**	P/ST			0.005	U
Magnesium					4.5	
Manganese	**0.05**	S/ST			0.012	
Mercury	**0.002**	P/ST			0.0002	U
Molybdenum	**0.035**	MC/ST			0.01	U
Nickel	**0.1**	P/ST			0.01	U
Potassium					64	
Selenium	**0.05**	P/ST			0.01	U
Silver	**0.1**	S/ST			0.01	U
Sodium	**160**	P			15	
Thallium	**0.002**	P/			0.002	U
Vanadium	**0.049**	MC/ST			0.027	
Zinc	**5**	S/ST			0.1	U
RSK 175, mg/L						
Methane						
Ethane						
Ethene						
Water Quality, mg/L						
Alkalinity						
Alk-P						
Alk-T						
COLOR (CU)	**15**				**250**	
CO2						
Chloride	**250**				16	
Fe2+						
Fe Total						
Hardness						
Nitrite-N						
Nitrate-N						
Nitrate-Nitrite-N						
Sulfate						
Sulfide						
TDS	**500**				250	
TOC						
pH	**6.5 to 8.5**		--		5.38	
Temp (degrees C)			--		22.5	
Conductivity			--		410	
Turbidity (NTUs)			--		4.38	
Oxygen Reduction Potential (mv)			--		10.39	
Dissolved Oxygen			--		0.2	

Appendix A-5

Summary of Groundwater Analytical Results, Recovery Well and Injection Well VOC Concentrations

Table A-5. Summary of Groundwater Analytical Results
Recovery Well and Injection Well VOC Concentrations
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			RW 4				RW 3			
Sample ID	FDEPGCTL		U4GRW4BL		U4GRW4BL		U4GRW3BL		U4GRW-3-16	
Sampling Date			3-Feb-00		2-Aug-00		3-Feb-00		2-Aug-00	
Volatile organics, ug/L										
Dichlorodifluoromethane	**1400**	MC/ST	100	U	50	U	250	U	10	U
Chloromethane	**2.7**	MC/C	100	U	50	U	250	U	10	U
Vinyl chloride	**1**	P/C	100	U	**60**		250	U	10	U
Bromomethane	**9.8**	MC/ST	100	U	50	U	250	U	10	U
Chloroethane	**12**	MC/C	100	U	50	U	250	U	10	U
Trichlorofluoromethane	**2100**	MC/ST	100	U	50	U	250	U	10	U
1,1-Dichloroethene	**7**	P/C	100	U	50	U	250	U	10	U
Methylene chloride	**5**	P/C	300	U	250	U	750	U	50	U
trans-1,2-Dichloroethene	**100**	P/ST	100	U	50	U	250	U	10	U
1,1-Dichloroethane	**70**	MC/ST	100	U	50	U	250	U	10	U
Chloroform	**5.7**	MC/C	100	U	50	U	250	U	10	U
cis-1,2-Dichloroethene	**70**	P/ST	**240**	I	**1200**		**400**	I	**270**	
1,1,1-Trichloroethane	**200**	P/ST	100	U	50	U	250	U	10	U
Carbon tetrachloride	**3**	P/C	100	U	50	U	250	U	10	U
1,2-Dichloroethane	**3**	P/C	100	U	50	U	250	U	10	U
Trichloroethene	**3**	P/C	**520**		**1300**		**1000**		**150**	
1,2-Dichloropropane	**5**	P/C	100	U	50	U	250	U	10	U
Bromodichloromethane	**1**	PQL/C	100	U	50	U	250	U	10	U
cis-1,3-Dichloropropene	**0.2**	PQL/C	100	U	50	U	250	U	10	U
trans-1,3-Dichloropropene			100	U	50	U	250	U	10	U
1,1,2-Trichloroethane	**5**	P/C	100	U	50	U	250	U	10	U
Tetrachloroethene	**3**	P/C	**3400**		**220**		**8400**		**290**	
Dibromochloromethane	**0.4**	MC/C	100	U	50	U	250	U	10	U
Chlorobenzene	**100**	P/ST	100	U	50	U	250	U	10	U
Bromoform	**4.4**	MC/C	100	U	50	U	250	U	10	U
1,1,2,2-Tetrachloroethane	**0.5**	PQL/C	200	U	100	U	500	U	20	U
1,3-Dichlorobenzene	**10**	MC/O	100	U	50	U	250	U	10	U
1,4-Dichlorobenzene	**75**	P/C	100	U	50	U	250	U	10	U
1,2-Dichlorobenzene	**600**	P/ST	100	U	50	U	250	U	10	U
Dilution			1:100 (ALL)		1:50 (ALL)		1:500 (PCE)		1:10 (ALL)	
							1:250 (OTHERS)			
pH			6.32		6.59		6.33		6.37	
Temp (degrees C)			22.8		27.8		23		28.4	
Conductivity			218		1400		222		2100	
Turbidity (NTUs)			8.02		44.9		11.67		16.8	
Oxygen Reduction Potential (mv)			-172.9		-102.3		-168.1		-216.7	
Dissolved Oxygen			--		0.45		--		0.61	
TOTAL VOCs			**4160**		**2780**		**9800**		**710**	

Table A-5. Summary of Groundwater Analytical Results
Recovery Well and Injection Well VOC Concentrations
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			RW 2				IW 4			
Sample ID	FDEPGCTL		U4GRW2BL		U4GRW-2-16		U4GIW4BL		U4GIW-4-16	
Sampling Date			3-Feb-00		2-Aug-00		2-Feb-00		2-Aug-00	
Volatile organics, ug/L										
Dichlorodifluoromethane	**1400**	MC/ST	25	U	10	U	200.0	U	1.0	U
Chloromethane	**2.7**	MC/C	25	U	10	U	200.0	U	1.0	U
Vinyl chloride	**1**	P/C	25	U	10	U	200.0	U	1.0	U
Bromomethane	**9.8**	MC/ST	25	U	10	U	200.0	U	1.0	U
Chloroethane	**12**	MC/C	25	U	10	U	200.0	U	1.0	U
Trichlorofluoromethane	**2100**	MC/ST	25	U	10	U	200.0	U	1.0	U
1,1-Dichloroethene	**7**	P/C	25	U	10	U	200.0	U	1.0	U
Methylene chloride	**5**	P/C	75	U	50	U	600	U	5.0	U
trans-1,2-Dichloroethene	**100**	P/ST	25	U	10	U	200.0	U	1.0	U
1,1-Dichloroethane	**70**	MC/ST	25	U	10	U	200.0	U	1.0	U
Chloroform	**5.7**	MC/C	25	U	10	U	200.0	U	1.0	U
cis-1,2-Dichloroethene	**70**	P/ST	**160**		**190**		**540**	I	1.3	
1,1,1-Trichloroethane	**200**	P/ST	25	U	10	U	200.0	U	1.0	U
Carbon tetrachloride	**3**	P/C	25	U	10	U	200.0	U	1.0	U
1,2-Dichloroethane	**3**	P/C	25	U	10	U	200.0	U	1.0	U
Trichloroethene	**3**	P/C	**470**		**21**		**300**	I	2.0	
1,2-Dichloropropane	**5**	P/C	25	U	10	U	200.0	U	1.0	U
Bromodichloromethane	**1**	PQL/C	25	U	10	U	200.0	U	1.0	U
cis-1,3-Dichloropropene	**0.2**	PQL/C	25	U	10	U	200.0	U	1.0	U
trans-1,3-Dichloropropene			25	U	10	U	200.0	U	1.0	U
1,1,2-Trichloroethane	**5**	P/C	25	U	10	U	200.0	U	1.0	U
Tetrachloroethene	**3**	P/C	**1600**		**27**		**8400**		**43.0**	
Dibromochloromethane	**0.4**	MC/C	25	U	10	U	200.0	U	1.0	U
Chlorobenzene	**100**	P/ST	25	U	10	U	200.0	U	1.0	U
Bromoform	**4.4**	MC/C	25	U	10	U	200.0	U	1.0	U
1,1,2,2-Tetrachloroethane	**0.5**	PQL/C	50	U	20	U	400	U	2.0	U
1,3-Dichlorobenzene	**10**	MC/O	25	U	10	U	200.0	U	1.0	U
1,4-Dichlorobenzene	**75**	P/C	25	U	10	U	200.0	U	1.0	U
1,2-Dichlorobenzene	**600**	P/ST	25	U	10	U	200.0	U	1.0	U
Dilution			1:50 (PCE)		1:10 (ALL)		1:200 (ALL)			
			1:25 (OTHERS)							
pH			6.29		6.38		6.37		6.88	
Temp (degrees C)			23.9		27.8		22.2		30.6	
Conductivity			258		2250		235		2950	
Turbidity (NTUs)			2.47		10.2		8.86		--	
Oxygen Reduction Potential (mv)			-209.3		-227.9		-186.1		709.4	
Dissolved Oxygen			--		0.16		--		2.1	
TOTAL VOCs			**2230**		**238**		**9240**		**46**	

Table A-5. Summary of Groundwater Analytical Results
Recovery Well and Injection Well VOC Concentrations
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			IW 3				IW 2			
Sample ID	FDEPGCTL		U4GIW3BL		U4GIW-3-16		U4GIW2BL		U4GIW-2-16	
Sampling Date			2-Feb-00		2-Aug-00		2-Feb-00		2-Aug-00	
Volatile organics, ug/L										
Dichlorodifluoromethane	**1400**	MC/ST	5.0	U	1.0	U	50	U	1.0	U
Chloromethane	**2.7**	MC/C	5.0	U	1.0	U	50	U	1.0	U
Vinyl chloride	**1**	P/C	5.0	U	1.0	U	50	U	1.0	U
Bromomethane	**9.8**	MC/ST	5.0	U	1.0	U	50	U	1.0	U
Chloroethane	**12**	MC/C	5.0	U	1.0	U	50	U	1.0	U
Trichlorofluoromethane	**2100**	MC/ST	5.0	U	1.0	U	50	U	1.0	U
1,1-Dichloroethene	**7**	P/C	5.0	U	1.0	U	50	U	1.0	U
Methylene chloride	**5**	P/C	15	U	5.0	U	150	U	5.0	U
trans-1,2-Dichloroethene	**100**	P/ST	5.0	U	1.0	U	50	U	1.0	U
1,1-Dichloroethane	**70**	MC/ST	5.0	U	1.0	U	50	U	1.0	U
Chloroform	**5.7**	MC/C	5.0	U	1.0	U	50	U	1.0	U
cis-1,2-Dichloroethene	**70**	P/ST	**130**		1.0	U	**50**	U	1.0	U
1,1,1-Trichloroethane	**200**	P/ST	5.0	U	1.0	U	50	U	1.0	U
Carbon tetrachloride	**3**	P/C	5.0	U	1.0	U	50	U	1.0	U
1,2-Dichloroethane	**3**	P/C	5.0	U	1.0	U	50	U	1.0	U
Trichloroethene	**3**	P/C	**110**		1.0	U	**50**	U	1.0	U
1,2-Dichloropropane	**5**	P/C	5.0	U	1.0	U	50	U	1.0	U
Bromodichloromethane	**1**	PQL/C	5.0	U	1.0	U	50	U	1.0	U
cis-1,3-Dichloropropene	**0.2**	PQL/C	5.0	U	1.0	U	50	U	1.0	U
trans-1,3-Dichloropropene			5.0	U	1.0	U	50	U	1.0	U
1,1,2-Trichloroethane	**5**	P/C	5.0	U	1.0	U	50	U	1.0	U
Tetrachloroethene	**3**	P/C	**68**		1.0	U	**1600**		2.0	
Dibromochloromethane	**0.4**	MC/C	5.0	U	1.0	U	50	U	1.0	U
Chlorobenzene	**100**	P/ST	5.0	U	1.0	U	50	U	1.0	U
Bromoform	**4.4**	MC/C	5.0	U	1.0	U	50	U	1.0	U
1,1,2,2-Tetrachloroethane	**0.5**	PQL/C	10	U	2.0	U	100	U	2.0	U
1,3-Dichlorobenzene	**10**	MC/O	5.0	U	1.0	U	50	U	1.0	U
1,4-Dichlorobenzene	**75**	P/C	5.0	U	1.0	U	50	U	1.0	U
1,2-Dichlorobenzene	**600**	P/ST	5.0	U	1.0	U	50	U	1.0	U
Dilution			1:5 (ALL)				1:50 (ALL)			
pH			6.2		6.99		6.49		6.92	
Temp (degrees C)			23.1		28.8		22.2		29	
Conductivity			265		2500		279		2650	
Turbidity (NTUs)			6.11		--		9.92		--	
Oxygen Reduction Potential (mv)			-214.1		698.1		-115.1		724.1	
Dissolved Oxygen			--		2.1		--		2.1	
TOTAL VOCs			**308**		**0**		**1600**		**2**	

Appendix A-6

Summary of Drum Analytical Results

Table A-6. Summary of Drum Analytical Results
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Lot ID			F0322		F7204		F0931		F0929		F0928	
Sample ID	FDEPGCTL		U4ZF0322		U4ZF7204		U4ZF0931		U4ZF0929		U4ZF0928	
Sampling Date			9-Feb-00		9-Feb-00		9-Feb-00		9-Feb-00		9-Feb-00	
Inorganics, mg/L												
Aluminum	**0.2**	S/	**1.5**		**1.6**		**1.5**		**1.5**		**1.5**	
Antimony	**0.006**	P/ST	0.006	U	0.006	U	0.006	U	0.006	U	0.006	U
Arsenic	**0.05**	P/C	0.012		0.01	U	0.01		0.011		0.011	
Barium	**2**	P/ST	0.1	U	0.1	U	0.1		0.1	U	0.1	U
Beryllium	**0.004**	P/C	0.001	U	0.001	U	0.002	I	0.001	U	0.001	U
Cadmium	**0.005**	P/C	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
Calcium			0.6		0.56		0.5	U	0.5	U	0.56	
Chromium	**0.1**	P/	0.039		0.029		0.05		0.038		0.042	
Cobalt	**0.42**	MC/ST	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U
Copper	**1**	S/ST	0.05	U	0.05		0.05	U	0.05	U	0.05	U
Iron	**0.3**	S/	0.19		0.12		0.14		0.13		0.14	
Lead	**0.015**	P/ST	0.006		0.006		0.006		0.006		0.006	
Magnesium			0.77		0.83		0.83		0.79		0.79	
Manganese	**0.05**	S/ST	**1100**		**1200**		**1200**		**1100**		**1100**	
Mercury	**0.002**	P/ST	0.00021	I	0.00022	I	0.00022	I	0.0002	U	0.0002	U
Nickel	**0.1**	P/ST	0.077		0.08		0.083		0.077		0.076	
Potassium			720		780		850		780		760	
Selenium	**0.05**	P/ST	**0.33**		**0.34**		**0.33**		**0.32**		**0.31**	
Silver	**0.1**	S/ST	0.01	U	0.01	U	0.01	U	0.01	U	0.01	U
Sodium	**160**	P	2		1.1		1.7		1.8		1.9	
Thallium	**0.002**	P/	**0.22**		**0.28**		**0.29**		**0.26**		**0.28**	
Vanadium	**0.049**	MC/ST	0.048		0.034		0.045		0.048		0.044	
Zinc	**5**	S/ST	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Drum samples analyzed at 4 grams per liter aqueous solution												
Thallium and selenium results believed to be biased high due to manganese and dissolved solids interferences.												

Appendix A-7

Summary of On Site Laboratory Analytical Results for Influent and Effluent

Table A-7. Summary of On Site Laboratory Analytical Results for Influent and Effluent
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Sample Source			SYSTEM INFLUENT										MIXING TANK 1									
Sample ID	FDEPGCTL		INF01		INF02		INF03		INF04		INF05		MX101		MX102		MX103		MX104		MX105	
Sample Date			02/11/00		02/11/00		02/11/00		02/11/00		02/11/00		02/11/00		02/11/00		02/11/00		02/11/00		02/11/00	
Sample Time			9:50		11:10		12:15		16:00		18:30		14:25		16:05		18:20		19:30		20:29	
Volatile organics, ug/L																						
1,1-Dichloroethene	7	P/C	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Methylene Chloride	5	P/C	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
t-1,2-Dichloroethene	100	P/ST	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
1,1-Dichloroethane	70	MC/ST	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
c-1,2-Dichloroethene	70	P/ST	**450**		**380**		**350**		**320**		**320**		1	U	1	U	1	U	1	U	1	U
Chloroform	5.7	MC/C	1	U	1	U	1	U	1	U	1	U	1.2		1		1	U	1	U	1	U
1,1,1-Trichloroethane	200	P/ST	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Carbon Tetrachloride	3	P/C	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Trichloroethene	3	P/C	**1200**		**970**		**780**		**750**		**780**		1	U	1	U	1	U	1	U	1	U
1,1,2-Trichloroethane	5	P/C	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U	1	U
Tetrachloroethene	3	P/C	**3000**		**2900**		**2900**		**2800**		**3500**		**15**		**96**		**80**		**75**		**84**	
Dilution			1:500		1:100		1:100		1:100		1:100		1:2		1:2		1:2		1:2		1:2	

Table A-7. Summary of On Site Laboratory Analytical Results for Influent and Effluent Groundwater Treatability Studies In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Sample Source			MIXING TANK 2							
Sample ID	FDEPGCTL		MX201		MX202		MX203		MX204	
Sample Date			02/11/00		02/11/00		02/11/00		02/11/00	
Sample Time			17:05		18:05		19:19		20:15	
Volatile organics, ug/L										
1,1-Dichloroethene	**7**	P/C	1	U	1	U	1	U	1	U
Methylene Chloride	**5**	P/C	1	U	1	U	1	U	1	U
t-1,2-Dichloroethene	**100**	P/ST	1	U	1	U	1	U	1	U
1,1-Dichloroethane	**70**	MC/ST	1	U	1	U	1	U	1	U
c-1,2-Dichloroethene	**70**	P/ST	1	U	1	U	1	U	1	U
Chloroform	**5.7**	MC/C	2.4		1	U	1	U	1	U
1,1,1-Trichloroethane	**200**	P/ST	1	U	1	U	1	U	1	U
Carbon Tetrachloride	**3**	P/C	1	U	1	U	1	U	1	U
Trichloroethene	**3**	P/C	1	U	1	U	1	U	1	U
1,1,2-Trichloroethane	**5**	P/C	1	U	1	U	1	U	1	U
Tetrachloroethene	**3**	P/C	**9.7**		**17**		1.5		**3.8**	
Dilution			1:2		1:2		1:2		1:2	

Appendix A-8

Summary of Groundwater Analytical Results, Influent and Effluent VOC Concentrations

Table A-8. Summary of Groundwater Analytical Results
Influent and Effluent VOC Concentrations
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID			INF																			
Sample ID	FDEPGCTL		U4GINF02		U4GINF03		U4GINF04		U4GINF05		U4GINF06		U4GINF08		U4GINF09		U4GINF10		U4GINF11		U4GINF12	
Sampling Date			8-Mar-00		23-Mar-00		30-Mar-00		5-Apr-00		12-Apr-00		24-May-00		2-Jun-00		8-Jun-00		15-Jun-00		21-Jun-00	
Volatile organics, ug/L																						
Dichlorodifluoromethane	**1400**	MC/ST	100	U	100	U	100	U	100	U	41		100	U	100	U	50	U	25	U	25	U
Chloromethane	**2.7**	MC/C	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
Vinyl chloride	**1**	P/C	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
Bromomethane	**9.8**	MC/ST	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
Chloroethane	**12**	MC/C	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
Trichlorofluoromethane	**2100**	MC/ST	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
1,1-Dichloroethene	**7**	P/C	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
Methylene chloride	**5**	P/C	300	U	300	U	300	U	300	U	30	U	300	U	300	U	150	U	75	U	75	U
trans-1,2-Dichloroethene	**100**	P/ST	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
1,1-Dichloroethane	**70**	MC/ST	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
Chloroform	**5.7**	MC/C	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
cis-1,2-Dichloroethene	**70**	P/ST	100	U	100	U	100	U	**130**	I	**140**		**240**	I	**220**	I	**160**	I	**160**		**200**	
1,1,1-Trichloroethane	**200**	P/ST	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
Carbon tetrachloride	**3**	P/C	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
1,2-Dichloroethane	**3**	P/C	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
Trichloroethene	**3**	P/C	**280**	I	**260**	I	**380**	I	**340**	I	**340**	I	**310**	I	**330**	I	**160**	I	**140**		**250**	
1,2-Dichloropropane	**5**	P/C	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
Bromodichloromethane	**1**	PQL/C	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
cis-1,3-Dichloropropene	**0.2**	PQL/C	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
trans-1,3-Dichloropropene			100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
1,1,2-Trichloroethane	**5**	P/C	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
Tetrachloroethene	**3**	P/C	**2200**		**2500**		**3800**		**2800**		**2700**		**1900**		**1300**		**640**		**560**		**690**	
Dibromochloromethane	**0.4**	MC/C	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
Chlorobenzene	**100**	P/ST	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
Bromoform	**4.4**	MC/C	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
1,1,2,2-Tetrachloroethane	**0.5**	PQL/C	200	U	200	U	200	U	200	U	20	U	200	U	200	U	100	U	50	U	50	U
1,3-Dichlorobenzene	**10**	MC/O	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
1,4-Dichlorobenzene	**75**	P/C	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U
1,2-Dichlorobenzene	**600**	P/ST	100	U	100	U	100	U	100	U	10	U	100	U	100	U	50	U	25	U	25	U

Table A-8. Summary of Groundwater Analytical Results
Influent and Effluent VOC Concentrations
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Sample ID	FDEPGCTL		U4GINF02	U4GINF03	U4GINF04	U4GINF05	U4GINF06	U4GINF08	U4GINF09	U4GINF10	U4GINF11	U4GINF12
Sampling Date			8-Mar-00	23-Mar-00	30-Mar-00	5-Apr-00	12-Apr-00	24-May-00	2-Jun-00	8-Jun-00	15-Jun-00	21-Jun-00
Dilution			1:100 (ALL)	1:100 (ALL)	1:100 (ALL)	1:100 (ALL)	1:10/1:100	1:100 (ALL)	1:100 (ALL)	1:50 (ALL)	1:25 (ALL)	1:25 (ALL)

Table A-8. Summary of Groundwater Analytical Results
Influent and Effluent VOC Concentrations
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID					EFF																	
Sample ID	FDEPGCTL		U4GINF13		U4GEFF02		U4GEFF03		U4GEFF04		U4GEFF05		U4GEFF06		U4GEFF08		U4GEFF09		U4GEFF10		U4GEFF11	
Sampling Date			28-Jun-00		8-Mar-00		23-Mar-00		30-Mar-00		5-Apr-00		12-Apr-00		24-May-00		2-Jun-00		8-Jun-00		15-Jun-00	
Volatile organics, ug/L																						
Dichlorodifluoromethane	1400	MC/ST	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Chloromethane	2.7	MC/C	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Vinyl chloride	1	P/C	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Bromomethane	9.8	MC/ST	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Chloroethane	12	MC/C	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Trichlorofluoromethane	2100	MC/ST	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,1-Dichloroethene	7	P/C	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Methylene chloride	5	P/C	75	U	3.0	U	3.0	U	3.0	U	3.0	U	3.0	U	3.0	U	3.0	U	3.0	U	3.0	U
trans-1,2-Dichloroethene	100	P/ST	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,1-Dichloroethane	70	MC/ST	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Chloroform	5.7	MC/C	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
cis-1,2-Dichloroethene	70	P/ST	**180**		1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,1,1-Trichloroethane	200	P/ST	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Carbon tetrachloride	3	P/C	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,2-Dichloroethane	3	P/C	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Trichloroethene	3	P/C	**170**		1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,2-Dichloropropane	5	P/C	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Bromodichloromethane	1	PQL/C	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
cis-1,3-Dichloropropene	0.2	PQL/C	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
trans-1,3-Dichloropropene			25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,1,2-Trichloroethane	5	P/C	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Tetrachloroethene	3	P/C	**470**		1.0	U	2.0	I	1.0	U	**3.0**	I	1.0	U	1.0	U	**4.0**	I	1.0	U	1.0	U
Dibromochloromethane	0.4	MC/C	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Chlorobenzene	100	P/ST	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
Bromoform	4.4	MC/C	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,1,2,2-Tetrachloroethane	0.5	PQL/C	50	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U	2.0	U
1,3-Dichlorobenzene	10	MC/O	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,4-Dichlorobenzene	75	P/C	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U
1,2-Dichlorobenzene	600	P/ST	25	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U	1.0	U

Table A-8. Summary of Groundwater Analytical Results
Influent and Effluent VOC Concentrations
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Sample ID	FDEPGCTL		U4GINF13	U4GEFF02	U4GEFF03	U4GEFF04	U4GEFF05	U4GEFF06	U4GEFF08	U4GEFF09	U4GEFF10	U4GEFF11
Sampling Date			28-Jun-00	8-Mar-00	23-Mar-00	30-Mar-00	5-Apr-00	12-Apr-00	24-May-00	2-Jun-00	8-Jun-00	15-Jun-00
Dilution			1:25 (ALL)									

Table A-8. Summary of Groundwater Analytical Results
Influent and Effluent VOC Concentrations
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID						
Sample ID	FDEPGCTL		U4GEFF12		U4GEFF13	
Sampling Date			21-Jun-00		28-Jun-00	
Volatile organics, ug/L						
Dichlorodifluoromethane	**1400**	MC/ST	1.0	U	1.0	U
Chloromethane	**2.7**	MC/C	1.0	U	1.0	U
Vinyl chloride	**1**	P/C	1.0	U	1.0	U
Bromomethane	**9.8**	MC/ST	1.0	U	1.0	U
Chloroethane	**12**	MC/C	1.0	U	1.0	U
Trichlorofluoromethane	**2100**	MC/ST	1.0	U	1.0	U
1,1-Dichloroethene	**7**	P/C	1.0	U	1.0	U
Methylene chloride	**5**	P/C	3.0	U	3.0	U
trans-1,2-Dichloroethene	**100**	P/ST	1.0	U	1.0	U
1,1-Dichloroethane	**70**	MC/ST	1.0	U	1.0	U
Chloroform	**5.7**	MC/C	1.0	U	1.0	U
cis-1,2-Dichloroethene	**70**	P/ST	1.0	U	1.0	U
1,1,1-Trichloroethane	**200**	P/ST	1.0	U	1.0	U
Carbon tetrachloride	**3**	P/C	1.0	U	1.0	U
1,2-Dichloroethane	**3**	P/C	1.0	U	1.0	U
Trichloroethene	**3**	P/C	1.0	U	1.0	U
1,2-Dichloropropane	**5**	P/C	1.0	U	1.0	U
Bromodichloromethane	**1**	PQL/C	1.0	U	1.0	U
cis-1,3-Dichloropropene	**0.2**	PQL/C	1.0	U	1.0	U
trans-1,3-Dichloropropene			1.0	U	1.0	U
1,1,2-Trichloroethane	**5**	P/C	1.0	U	1.0	U
Tetrachloroethene	**3**	P/C	1.0	U	1.0	U
Dibromochloromethane	**0.4**	MC/C	1.0	U	1.0	U
Chlorobenzene	**100**	P/ST	1.0	U	1.0	U
Bromoform	**4.4**	MC/C	1.0	U	1.0	U
1,1,2,2-Tetrachloroethane	**0.5**	PQL/C	2.0	U	2.0	U
1,3-Dichlorobenzene	**10**	MC/O	1.0	U	1.0	U
1,4-Dichlorobenzene	**75**	P/C	1.0	U	1.0	U
1,2-Dichlorobenzene	**600**	P/ST	1.0	U	1.0	U

Table A-8. Summary of Groundwater Analytical Results
Influent and Effluent VOC Concentrations
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Sample ID	FDEPGCTL		U4GEFF12		U4GEFF13	
Sampling Date			21-Jun-00		28-Jun-00	
Dilution						

Appendix A-9

Summary of Groundwater Analytical Results, Influent and Effluent TAL Metals

Table A-9. Summary of Groundwater Analytical Results
Influent and Effluent TAL Metals
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval training Center Orlando
Orlando, FL

Well ID			INF													
Sample ID	FDEPGCTL		U4HINF02		U4HINF04		U4HINF06		U4HINF08		U4HINF10		U4HINF12		U4HINF13	
Sampling Date			8-Mar-00		30-Mar-00		12-Apr-00		24-May-00		8-Jun-00		21-Jun-00		28-Jun-00	
Inorganics, mg/L																
Aluminum	**0.2**	S/	0.054		0.084		0.05	U	0.13		**0.23**		**0.24**			
Antimony	**0.006**	P/ST	0.005	U	0.005	U	0.005	U	0.006	U	0.006	U	0.007	I		
Arsenic	**0.05**	P/C	0.01	U	0.01	U	0.01	U	0.01	U	0.01	U	0.01	U		
Barium	**2**	P/ST	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U		
Beryllium	**0.004**	P/C	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U		
Cadmium	**0.005**	P/C	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U		
Calcium			24		26		31		32		32		34			
Chromium	**0.1**	P/	0.01	U	0.01	U	0.01	U	0.01	U	0.01	U	0.01	U		
Cobalt	**0.42**	MC/ST	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U		
Copper	**1**	S/ST	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U	0.05	U		
Iron	**0.3**	S/	**0.55**		0.05	U	0.05	U	0.05	U	0.05		0.05	U		
Lead	**0.015**	P/ST	0.005	U	0.005	U	0.005	U	0.005	U	0.005	U	0.005	U		
Magnesium			2.4		2.8		3.0		3.1		2.6		3			
Manganese	**0.05**	S/ST	**0.056**		**2.9**		NA		**3.3**		**3.1**		**3**			
Mercury	**0.002**	P/ST	0.0005	U	0.00024	I	0.0002	U	0.0002	U	0.0002	U	0.0003	I		
Nickel	**0.1**	P/ST	0.01	U	0.01	U	0.01	U	0.1	U	0.1	U	0.1	U		
Potassium			1.7		2.4		21		160		260		280			
Selenium	**0.05**	P/ST	0.01	U	0.01	U	0.01	U	0.01	U	0.01	U	0.01	U		
Silver	**0.1**	S/ST	0.01	U	0.01	U	0.01	U	0.01	U	0.01	U	0.01	U		
Sodium	**160**	P	7.8		6.9		NA		8.6		9.5		9.2			
Thallium	**0.002**	P/	0.002	U	0.002	U	0.002	U	**0.002**	I	0.002	U	0.002	U		
Vanadium	**0.049**	MC/ST	0.01	U	0.01	U	0.01	U	0.01	U	0.01	U	0.01	U		
Zinc	**5**	S/ST	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U		

Table A-9. Summary of Groundwater Analytical Results
Influent and Effluent TAL Metals
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval training Center Orlando
Orlando, FL

Well ID			EFF											
Sample ID	FDEPGCTL		U4HEFF02		U4HEFF04		U4HEFF06		U4HEFF08		U4HEFF10		U4HEFF12	
Sampling Date			8-Mar-00		30-Mar-00		12-Apr-00		24-May-00		8-Jun-00		21-Jun-00	
Inorganics, mg/L														
Aluminum	0.2	S/	1.5		1.4		0.85		1.3		0.99		0.49	
Antimony	0.006	P/ST	0.005	U	0.005	U	0.005	U	0.03	U	0.006	U	0.006	U
Arsenic	0.05	P/C	0.05	U	0.01	U	0.01	I	0.05	U	0.01	U	0.01	U
Barium	2	P/ST	0.5	U	0.1	U	0.1	U	0.5	U	0.1	U	0.1	U
Beryllium	0.004	P/C	0.005	U	0.001	U	0.001	U	0.005	U	0.001	U	0.001	U
Cadmium	0.005	P/C	0.005	U	0.001	U	0.001	U	0.005	U	0.001	U	0.001	U
Calcium			21		25		29		29		18		24	
Chromium	0.1	P/	1.1		0.92		0.037		0.044		0.043		0.021	
Cobalt	0.42	MC/ST	0.25	U	0.05	U	0.05	U	0.25	U	0.05	U	0.05	U
Copper	1	S/ST	0.25	U	0.05	U	0.05	U	0.25	U	0.05	U	0.05	U
Iron	0.3	S/	0.25	U	0.16		0.09		0.25	U	0.05	U	0.05	U
Lead	0.015	P/ST	0.19		0.18		0.005		0.005	U	0.005	U	0.005	U
Magnesium			3.5		4.0		3.8		25	U	2.2		2.9	
Manganese	0.05	S/ST	600		1400		NA		1100		830		450	
Mercury	0.002	P/ST	0.0005	U	0.00024	I	0.0002	U	0.0002	U	0.0003	I	0.0004	
Nickel	0.1	P/ST	0.12		0.12		0.029		0.1	U	0.1	U	0.1	U
Potassium			480		1000		680		1100		1000		650	
Selenium	0.05	P/ST	0.48		0.37		NA		0.01	U	0.01	U	0.01	U
Silver	0.1	S/ST	0.2		0.01	U	0.01	U	0.05	U	0.11		0.05	U
Sodium	160	P	4.8		9.8		NA		11		9.2		9	
Thallium	0.002	P/	0.0089		0.006		0.002	U	0.012		0.0051		0.0038	
Vanadium	0.049	MC/ST	0.05	U	0.01	U	0.01	U	0.05	U	0.01	U	0.01	U
Zinc	5	S/ST	0.5	U	0.1	U	0.1	U	0.5	U	0.1	U	0.1	U

Table A-9. Summary of Groundwater Analytical Results
Influent and Effluent TAL Metals
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval training Center Orlando
Orlando, FL

Well ID			EFF	
Sample ID	FDEPGCTL		U4HEFF13	
Sampling Date			28-Jun-00	
Inorganics, mg/L				
Aluminum	**0.2**	S/		
Antimony	**0.006**	P/ST		
Arsenic	**0.05**	P/C		
Barium	**2**	P/ST		
Beryllium	**0.004**	P/C		
Cadmium	**0.005**	P/C		
Calcium				
Chromium	**0.1**	P/		
Cobalt	**0.42**	MC/ST		
Copper	**1**	S/ST		
Iron	**0.3**	S/		
Lead	**0.015**	P/ST		
Magnesium				
Manganese	**0.05**	S/ST		
Mercury	**0.002**	P/ST		
Nickel	**0.1**	P/ST		
Potassium				
Selenium	**0.05**	P/ST		
Silver	**0.1**	S/ST		
Sodium	**160**	P		
Thallium	**0.002**	P/		
Vanadium	**0.049**	MC/ST		
Zinc	**5**	S/ST		

APPENDIX B

APPENDIX B

SELECTED PHOTOGRAPHS OF OPERABLE UNIT 4 AND THE CHEMICAL OXIDATION SYSTEM

Figure 1. Aerial Photo of Area C and Pilot Study Location

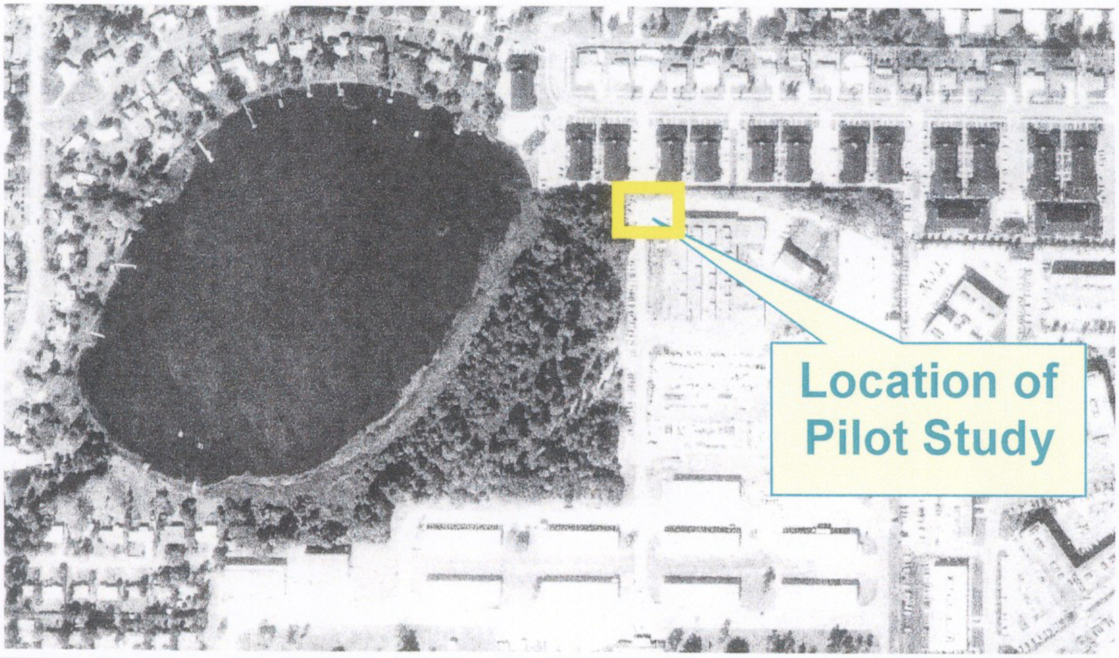


Figure 2. Interior of Building 1100

Figure 3. Potassium Permanganate Feed System

Figure 4. Potassium Permanganate Feed System

Figure 5. Feed Skid

Figure 6. Drum Feeders

Figure 7. Drum Feeders

Figure 8. Pilot Study Layout

Figure 9. Manganese Dioxide (MnO2) Filter Cake

Figure 10. Manganese Dioxide (MnO2) Filter Cake

APPENDIX C

APPENDIX C

GRAPHS OF SHALLOW AND DEEP ZONE WATER LEVELS IN THE TREATMENT CELL

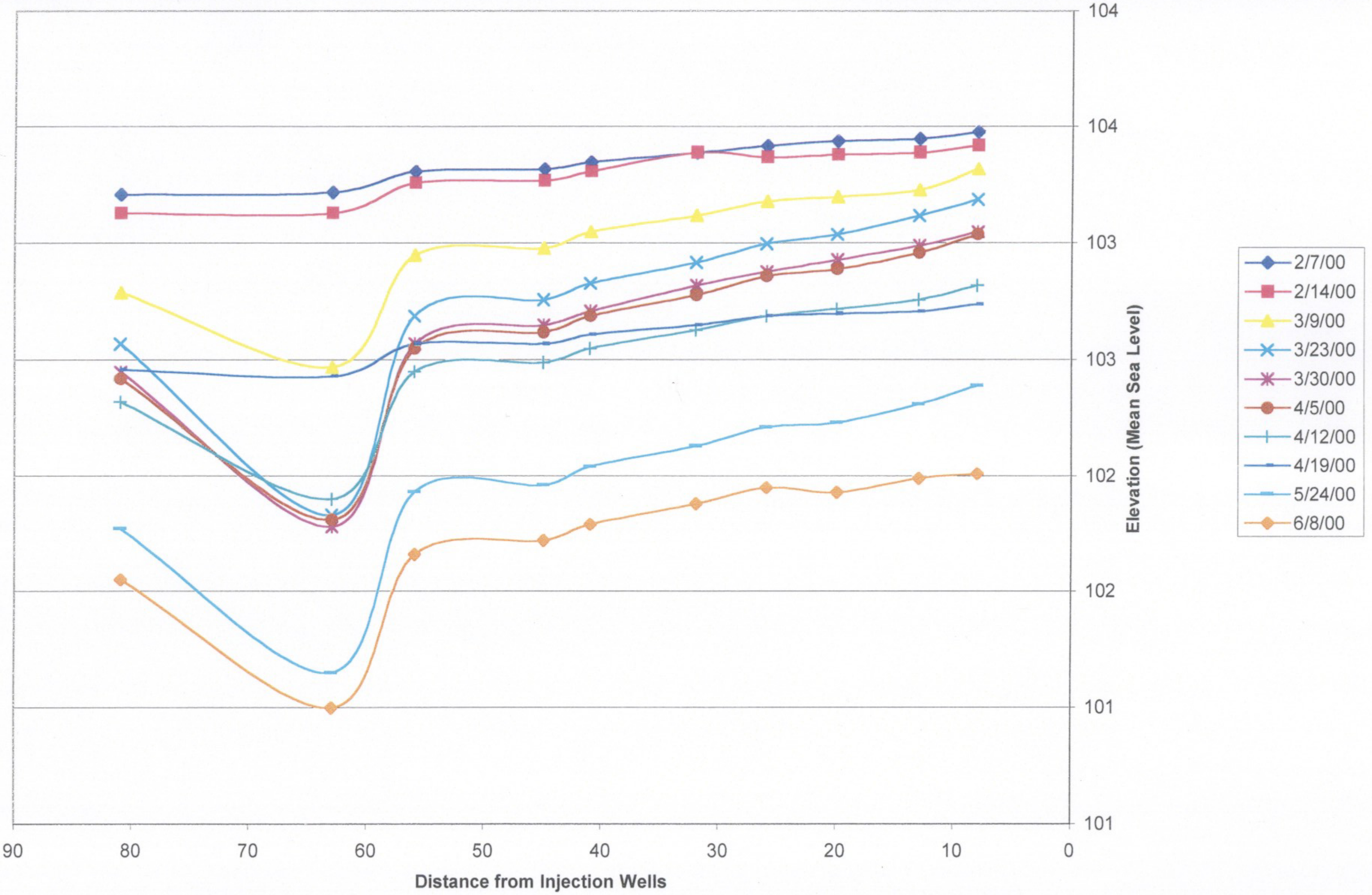


FIGURE C-1
WATER TABLE ELEVATIONS - SHALLOW ZONE

GROUNDWATER TREATABILITY STUDIES
IN-SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

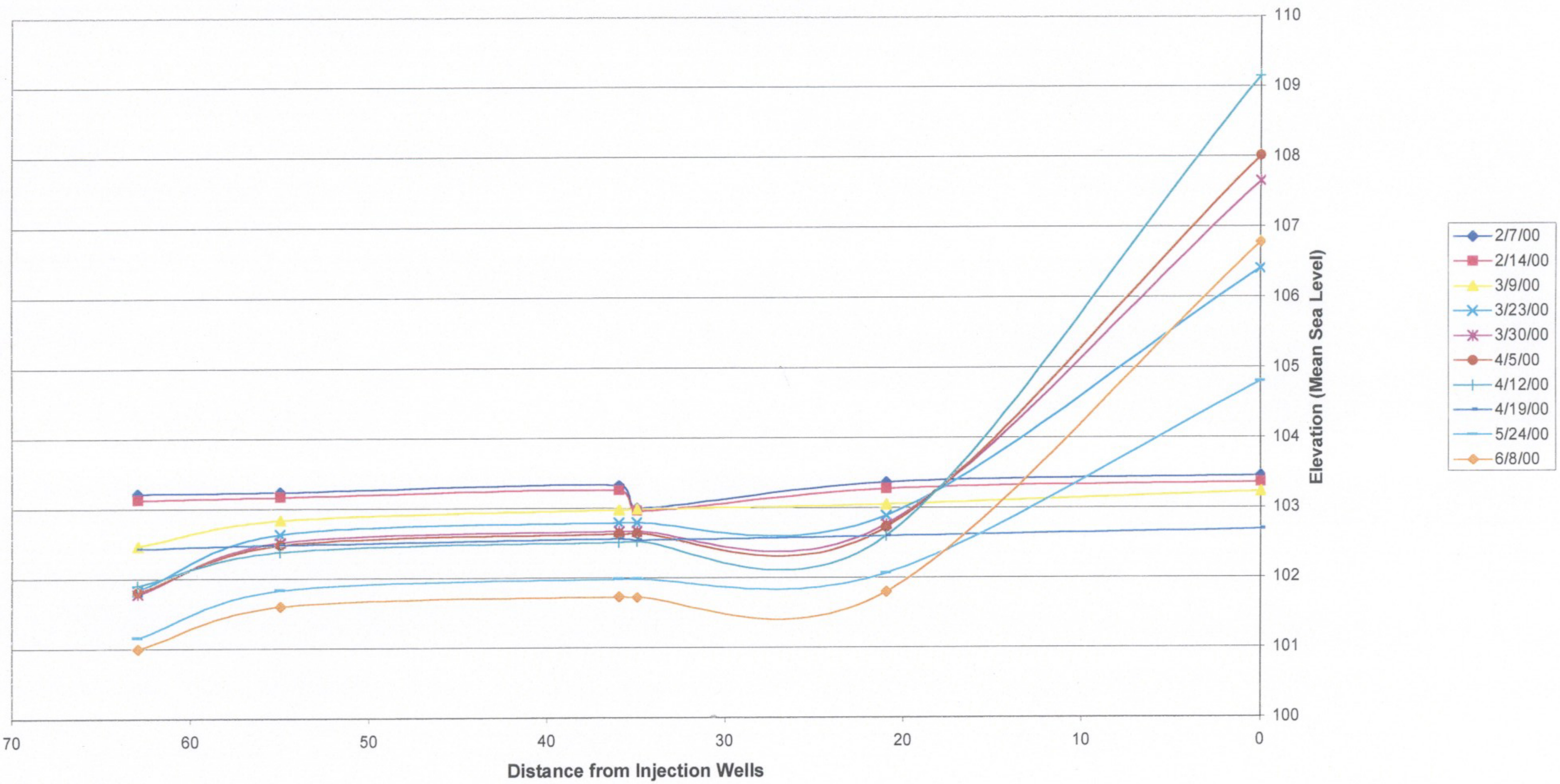


FIGURE C-2
WATER TABLE ELEVATIONS
DEEP ZONE

GROUNDWATER TREATABILITY STUDIES
IN-SITU CHEMICAL OXIDATION PILOT STUDY
OPERABLE UNIT 4

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

APPENDIX D

APPENDIX D

WELL CONSTRUCTION DETAILS

Table D-1. Well Construction Details
Groundwater Treatability Studies
In-Situ Chemical Oxidation Pilot Study, Operable Unit 4

Naval Training Center Orlando
Orlando, FL

Well ID	Easting	Northing	Elevation Top of Casing	Elevation of Ground	Casing Inner Diameter (inches) and Well Construction Material		Total Depth (ft bls)	Screen Length (ft)	Screened Interval (ft bls)
Shallow Zone Wells									
OLD-13-07A	544842.6	1536854.6	108.71	109.02	2	PVC	18.5	15	3.5 to 18.5
GMP 07	544838.1	1536845.3	108.95	108.90	0.5	PVC	18	3	15 to 18
GMP 08	544853.1	1536846.1	109.18	109.06	0.5	PVC	18	3	15 to 18
GMP 09	544868.0	1536846.6	109.37	109.28	0.5	PVC	18	3	15 to 18
GMP 10	544885.7	1536847.1	109.72	109.64	0.5	PVC	18	3	15 to 18
GMP-11	544878.8	1536844.3	109.56	109.45	0.5	PVC	18	9	9 to 18
GMP 12	544877.0	1536870.0	109.70	109.59	0.5	PVC	18	9	9 to 18
GMP 13	544879.6	1536876.8	109.76	109.61	0.5	PVC	18	9	9 to 18
GMP 14	544871.3	1536857.1	109.50	109.37	0.5	PVC	18	9	9 to 18
GMP 15	544859.3	1536856.8	109.39	109.23	0.5	PVC	18	9	9 to 18
GMP 16	544846.3	1536856.3	109.23	109.08	0.5	PVC	18	9	9 to 18
GMP 17	544810.7	1536853.5	108.92	108.78	0.5	PVC	18	9	9 to 18
Deep Zone Wells									
OLD-13-41B	544837.0	1536846.4	108.61	108.90	2	PVC	28	5	23 to 28
OLD-13-42B	544857.1	1536847.3	108.82	109.12	2	PVC	28	5	23 to 28
OLD-13-44B	544871.0	1536847.2	108.98	109.31	2	PVC	30	10	20 to 30
OLD-13-45B	544855.2	1536865.8	109.13	109.27	2	PVC	30	10	20 to 30
OLD-13-46B	544810.1	1536857.9	108.64	108.78	2	PVC	30	10	20 to 30
System Wells									
OLD-13-IW2	544891.8	1536867.3	109.60	109.77	4	PVC	35	25	5 to 30
OLD-13-IW3	544891.5	1536857.4	109.28	109.72	4	PVC	35	25	5 to 30
OLD-13-IW4	544891.7	1536847.3	109.48	109.72	4	PVC	35	25	5 to 30
OLD-13-RW2	544828.4	1536865.6	108.73	108.98	4	PVC	35	20	10 to 30
OLD-13-RW3	544828.8	1536855.5	108.78	108.94	4	PVC	35	20	10 to 30
OLD-13-RW4	544829.0	1536845.4	108.64	108.91	4	PVC	35	20	10 to 30

Notes:
bls - below land surface
ft - feet
PVC - polyvinyl chloride
Eastings and Northings are in U.S. Survey feet and are referenced to the State Plane Coordinate System, Florida East Zone, North American Datum 1983, Adjustment of 1990 (NAD 1983/90).

APPENDIX E

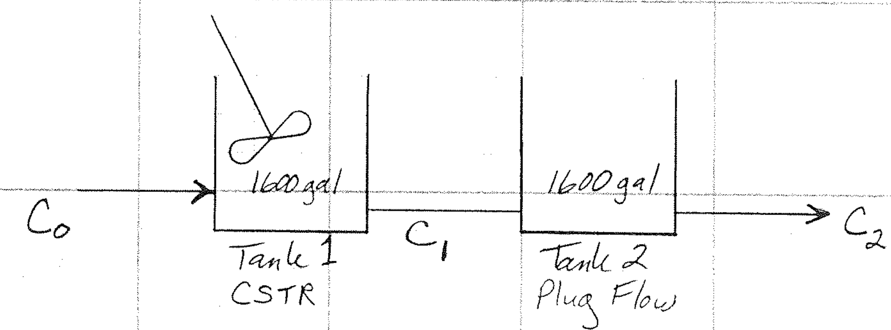
APPENDIX E

KINETICS CALCULATIONS

PROJECT NTC Orlando OU4 $KMnO_4$ Pilot

SUBJECT Kinetics Calc

Purpose: Compare PCE oxidation rates measured in the field during startup with those predicted from bench-scale kinetics.



From the pilot study workplan, at a $KMnO_4$ concentration of 4 g/L the PCE rate constant is:

$$k_{PCE} = 3.66\ hr^{-1}$$

At 4 gpm, the residence time τ in each 1600 gallon tank is:

$$\tau = 6.7\ hrs$$ ✓

Refer to Appendix A, Table A-7 for startup data.

For Tank 1, use data collected between 18:20 + 20:29, as at this point Tank 1 was full and overflowing to Tank 2. Therefore Tank 1 is about at steady state.

$$C_o^{PCE} = \frac{(2800 + 3500)}{2} = 3150\ ppb$$

$$C_1 = \frac{(80 + 75 + 84)}{3} = 80\ ppb$$

These concentrations are actual data. Now compare to calculated results.

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For Tank 1 (CSTR):

$$\frac{C_o}{C_1} = 1 + k\tau$$

$$C_1 = \frac{C_o}{1 + k\tau}$$

$$C_1 = \frac{3150}{1 + (3.66)(6.7)}$$

$$\boxed{C_1 = 123 \text{ ppb}}$$ ✓

Based on the above calculation, the predicted concentration of PCE flowing from Tank 1 to Tank 2 is 123 ppb, but we measured 80 ppb.

The field result could reflect volatilization of PCE due to the operation of the mixer in Tank 1. The above kinetics calculation does not account for volatilization.

Now evaluate performance of Tank 2 as a plug flow reactor.

Refering to Appendix A, Table A-7, treated water began to flow from Tank 1 to Tank 2 at 17:05, and reached a PCE concentration of 1.5 µg/L 2 hrs and 14 minutes (2.23 hr) later.

$$C = C_o e^{-k\tau}$$

$$= (80 \text{ ppb}) e^{-(3.66)(2.23)}$$

$$C = 0.02 \text{ ppb}$$ ✓

The predicted concentration is much less than actual, indicating that Tank 2 oxidation of PCE is less efficient than predicted. However, during startup when there is very little water in Tank 2, the incoming flow from Tank 1 serves to keep Tank 2 slightly stirred, so performance may be closer to a CSTR than plug flow.

So now try applying CSTR equation to Tank 2:

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$$\frac{C_o}{C} = 1 + k\tau$$

$$C = \frac{C_o}{1+k\tau}$$

$$= \frac{80}{1+(3.66)(2.23)}$$

$$C = 8.7 \text{ ppb}$$

This predicted PCE concentration is greater than observed, suggesting that Tank 2 is operating somewhere between a plug flow reactor and a CSTR.

Now try using the observed PCE data to solve for τ in the plug flow equation. This will give an estimate of how much time Tank 2 needed to operate as an ideal plug flow reactor to achieve the observed results.

$$C = C_o e^{-k\tau}$$

$$\frac{C}{C_o} = e^{-k\tau}$$

$$\ln\frac{C}{C_o} = -k\tau$$

$$\ln\left(\frac{1.5}{80}\right) = -(3.66)\tau$$

$$\boxed{\tau = 1.1 \text{ hr}}$$

This value is about half of the actual measured τ, which is consistent with Tank 2 operating less as a plug flow reactor and more like a CSTR.