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WORK PLAN FOR TREATABILITY STUDY AT STUDY AREA 2 WITH TRANSMITTAL LETTER
NTC ORLANDO FL
12/13/2000
TETRA TECH

0003

TETRA TECH NUS, INC.
800 Oak Ridge Turnpike, A-600 ▪ Oak Ridge, Tennessee 37830
(865) 483-9900 ▪ FAX: (865) 483-2014 ▪ www.tetratech.com

1200-A232

December 13, 2000

Commanding Officer
SOUTHNAVFACENGCOM
ATTN: Ms. Barbara Nwokike, Code 1873
P.O. Box 190010
2155 Eagle Drive
North Charleston, SC 29419-9010

Subject: Work Plan for the Treatability Study at Study Area 2
Naval Training Center, Orlando

Reference: CLEAN Contract No. N62467-94-D-0888
Contract Task Order No. 0151

Dear Ms. Nwokike:

Enclosed is the final Work Plan for the ORC® injection treatability study at Study Area 2. The primary change to the plan is the addition of the microbiological test results, which were received this last weekend. The test results showed that the existing nutrients in the groundwater are sufficient to support microbial growth.

If you have any questions, please contact me at (865) 220-4730.

Sincerely,

Steven B. McCoy

Steven B. McCoy, P.E.
Task Order Manager

SBM:ckf

Enclosure

c: Mr. Rick Allen, Harding Lawson Associates
Mr. David Grabka, FDEP
Mr. Wayne Hansel, SOUTHNAVFACENGCOM
Ms. Nancy Rodriguez, USEPA Region IV
Mr. Steve Tsangaris, CH2M Hill
Dr. Rick Arnseth, Tetra Tech NUS
Mr. Michael Campbell, Tetra Tech NUS
Ms. Teresa Grayson, Tetra Tech NUS
Mr. Mark Perry, Tetra Tech NUS (unbound)
Mr. Steve Ruffing, Tetra Tech NUS
Ms. Debbie Wroblewski, Tetra Tech NUS (cover letter only)
File/db

WORK PLAN FOR THE TREATABILITY STUDY AT STUDY AREA 2

Naval Training Center
Orlando, Florida

Southern Division
Naval Facilities Engineering Command
Contract Number N62467-94-D-0888
Contract Task Order 0151

DECEMBER 2000

Rev. 1
12/13/00

WORK PLAN
FOR
TREATABILITY STUDY AT STUDY AREA 2

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:

Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29406

Submitted by:

Tetra Tech NUS, Inc.
661 Andersen Drive
Foster Plaza 7
Pittsburgh, Pennsylvania 15220

CONTRACT NO. N62467-94-D-0888
CONTRACT TASK ORDER 0151

DECEMBER 2000

PREPARED UNDER THE SUPERVISION OF:

Steven B. McCoy

STEVEN B. McCOY
TASK ORDER MANAGER
TETRA TECH NUS, INC.
OAK RIDGE, TENNESSEE

APPROVED FOR SUBMITTAL BY:

Debra M Wroblewski

DEBBIE WROBLEWSKI
PROGRAM MANAGER
TETRA TECH NUS, INC.
PITTSBURGH, PENNSYLVANIA

4711003

PROFESSIONAL ENGINEER CERTIFICATION

I hereby certify that this document, *Work Plan for the Treatability Study at Study Area 2, Naval Training Center, Orlando, Florida,* was prepared under my direct supervision in accordance with acceptable standards of engineering practice.

Steven B. McCoy, P.E. / Date
License No. PE-0041511

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APPENDICES

TABLES

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FIGURES

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ACRONYMS

bls	below land surface
DO	dissolved oxygen
DPT	direct push technology
FDEP	Florida Department of Environmental Protection
FL SOPs	Florida Standard Operating Procedures
FOL	Field Operations Leader
HASP	Health and Safety Plan
HDPE	high-density polyethylene
HLA	Harding Lawson Associates
HSM	Health and Safety Manager
IDW	investigation-derived waste
MCL	maximum contaminant level
MS	matrix spike
MSD	matrix spike duplicate
MSDS	Material Safety Data Sheet
NTC	Naval Training Center
NTU	Nephelometric Turbidity Unit
OAFB	Orlando Air Force Base
OPT	Orlando Partnering Team
ORC®	Oxygen Release Compound®
ORP	oxidation reduction potential
PPE	personal protective equipment
QA	quality assurance
QC	quality control
SA	Study Area
SOP	Standard Operating Procedure
SOUTHDIV	Southern Division
TCL	Target Compound List
TO	Task Order
TOC	total organic carbon
TtNUS	Tetra Tech NUS
USAF	U.S. Air Force
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

1.0 INTRODUCTION

A site screening investigation and a year of quarterly sampling have been completed at the Navy's Herndon Annex property, designated as Study Area (SA) 2. Herndon Annex is one of the four facilities that comprised the former Naval Training Center (NTC), Orlando, Florida. During the investigation, benzene was detected in groundwater at concentrations exceeding the State of Florida maximum contaminant level (MCL) of 1 μg/L. Due to the depth of the groundwater, it is believed that the rate of natural biodegradation processes has been retarded by a lack of oxygen. The Orlando Partnering Team (OPT) has decided to perform a Treatability Study to determine whether injecting Oxygen Release Compound (ORC®) into the aquifer will enhance the natural processes that consume the benzene and reestablish compliance with the State groundwater criteria. This Work Plan presents the objectives for the Treatability Study and the technical approach by which the study will be performed.

The Work Plan incorporates data presented in the Base Realignment and Closure, Environmental Site Screening Report, Study Area 2, Herndon Annex (Harding Lawson Associates, 1999) and the Decision Document, Study Area 2 (Tetra Tech NUS, Inc., 2000).

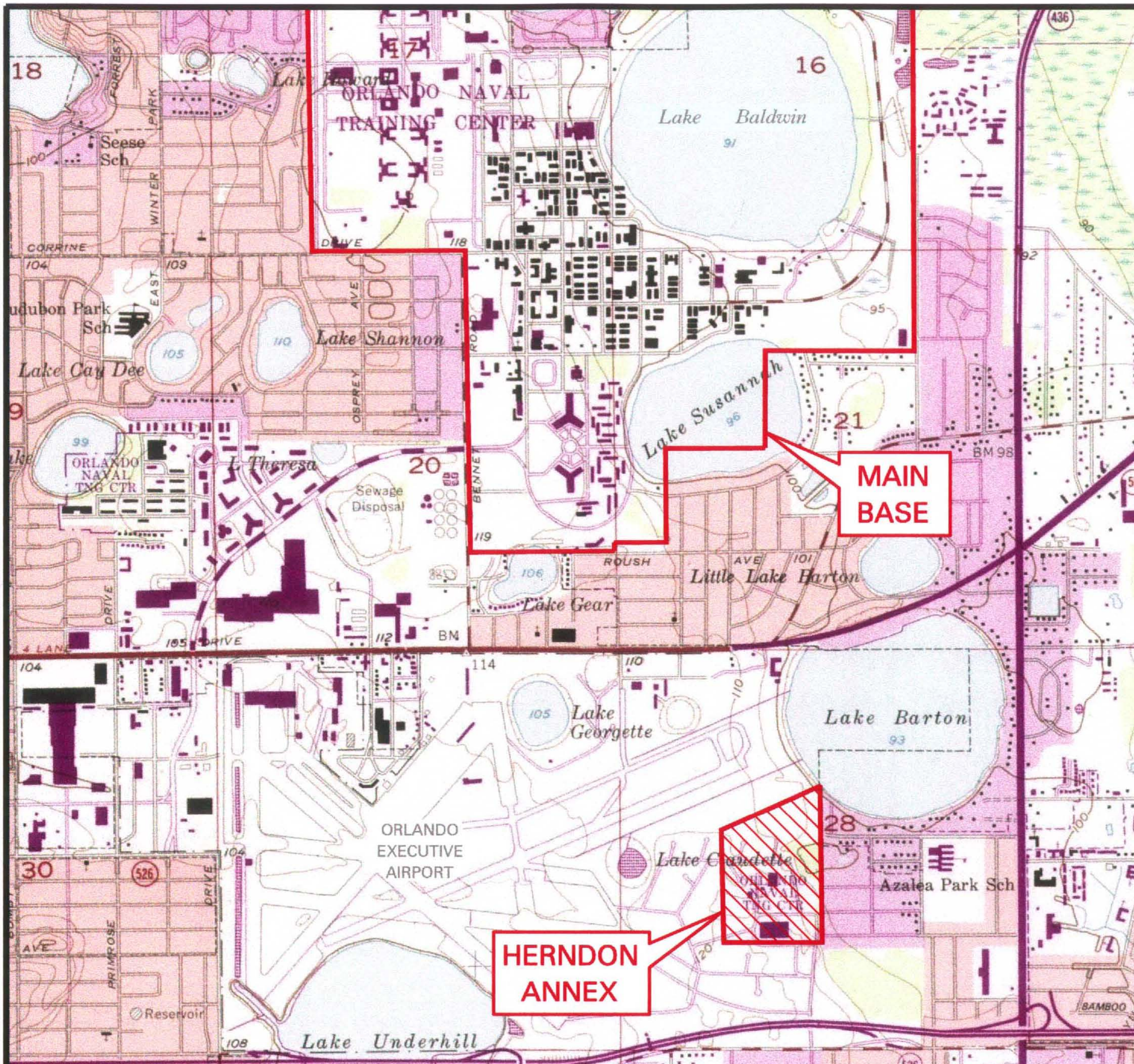
1.1 SITE DESCRIPTION

Herndon Annex (Figure 1-1) is located approximately 1.5 miles south of the Main Base and adjacent to the city-owned Orlando Executive Airport. Private homes (the Azalea Park neighborhood) are located east of the site with Lake Barton to the northeast (Figure 1-2).

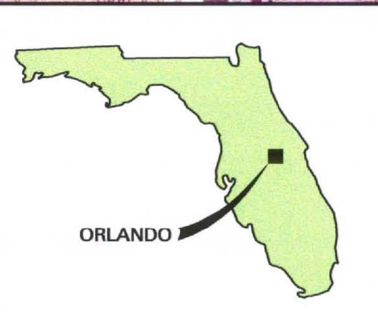
1.1.1 Site Operations and History

The Study Area includes an abandoned septic system (Facility 6001) and several former aircraft parking aprons. A review of the NTC Public Works Department drawings indicates that Building 602 was the only facility connected to the septic system. Building 606, which once contained a machine shop and baths for metal treatment, appears to have discharged wastewater to an off-site treatment system.

Beginning in 1940, the facilities were known as the Orlando Army Air Base and were operated under command of the U.S. Army Air Corps. Between 1947 and 1968, the U.S. Air Force (USAF) commanded the facilities at Orlando and the facilities were renamed the Orlando Air Force Base (OAFB). The USAF used the Herndon Annex property as a sanitary landfill on an occasional basis in the 1950s and early 1960s. In 1968, the USAF ceased operations at the OAFB and the Navy acquired the properties now known as the Main Base, Area C, and Herndon Annex. NTC, Orlando was closed in April 1999 as part of the Defense Base Realignment and Closure Act of 1990.



SOURCE:
TAKEN FROM U.S.G.S. TOPOGRAPHIC QUADRANGLE
ORLANDO EAST, FLORIDA (1980 EDITION).



-N-

2000 0 2000
SCALE IN FEET

FIGURE 1-1

SITE LOCATION MAP
ORC TREATABILITY STUDY
STUDY AREA 2 - HERNDON ANNEX

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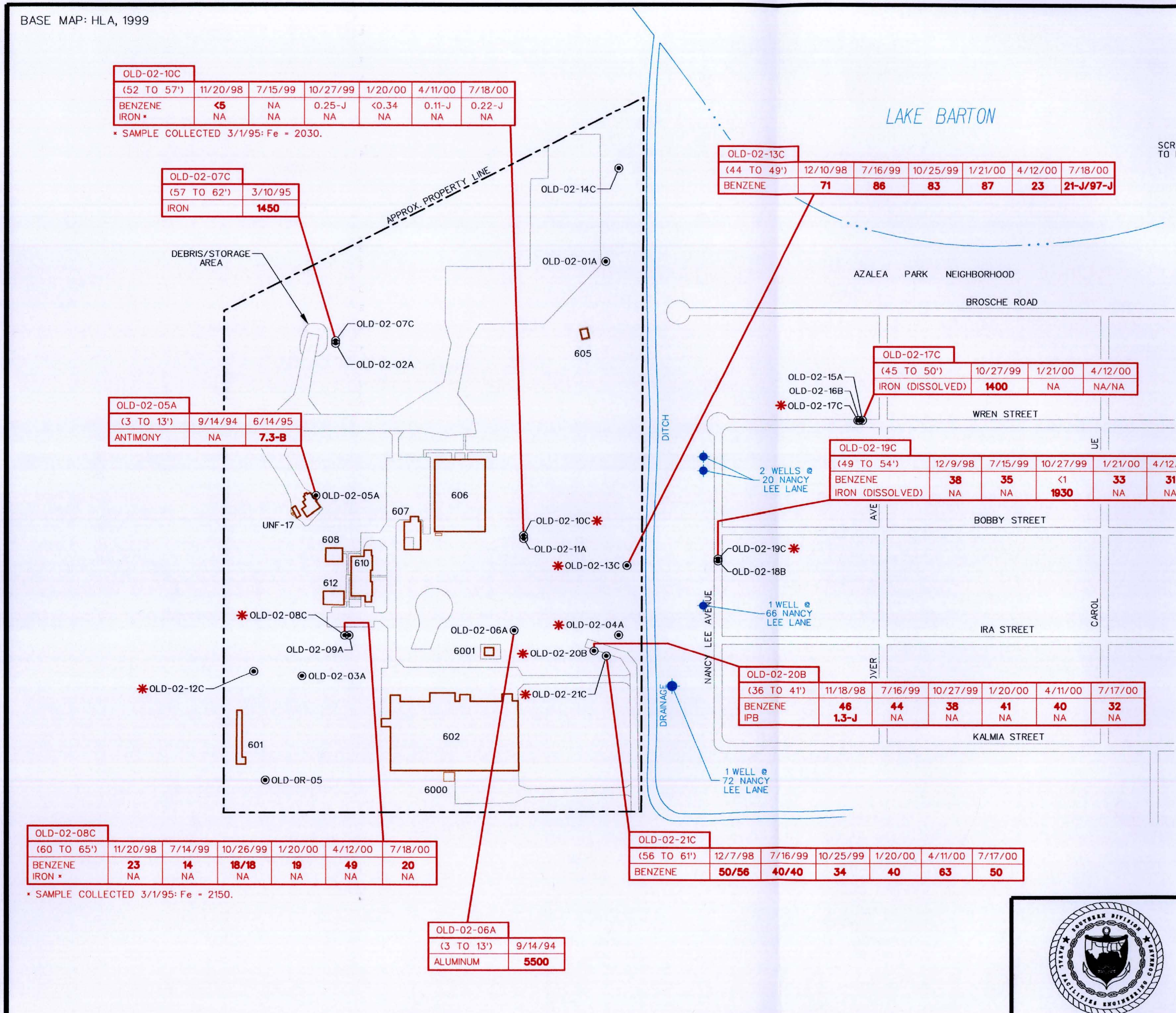

OLD-02-10C (52 TO 57')	11/20/98	7/15/99	10/27/99	1/20/00	4/11/00	7/18/00
BENZENE	**<5**	NA	0.25-J	<0.34	0.11-J	0.22-J
IRON *	NA	NA	NA	NA	NA	NA

* SAMPLE COLLECTED 3/1/95: Fe = 2030.

OLD-02-07C (57 TO 62')	3/10/95
IRON	**1450**

OLD-02-05A (3 TO 13')	9/14/94	6/14/95
ANTIMONY	NA	**7.3-B**

OLD-02-13C (44 TO 49')	12/10/98	7/16/99	10/25/99	1/21/00	4/12/00	7/18/00
BENZENE	**71**	**86**	**83**	**87**	**23**	**21-J/97-J**

OLD-02-17C (45 TO 50')	10/27/99	1/21/00	4/12/00
IRON (DISSOLVED)	**1400**	NA	NA/NA

OLD-02-19C (49 TO 54')	12/9/98	7/15/99	10/27/99	1/21/00	4/12/00	7/17/00
BENZENE	**38**	**35**	<1	**33**	**31**	**29**
IRON (DISSOLVED)	NA	NA	**1930**	NA	NA	NA

OLD-02-20B (36 TO 41')	11/18/98	7/16/99	10/27/99	1/20/00	4/11/00	7/17/00
BENZENE	**46**	**44**	**38**	**41**	**40**	**32**
IPB	**1.3-J**	NA	NA	NA	NA	NA

OLD-02-21C (56 TO 61')	12/7/98	7/16/99	10/25/99	1/20/00	4/11/00	7/17/00
BENZENE	**50/56**	**40/40**	**34**	**40**	**63**	**50**

OLD-02-08C (60 TO 65')	11/20/98	7/14/99	10/26/99	1/20/00	4/12/00	7/18/00
BENZENE	**23**	**14**	**18/18**	**19**	**49**	**20**
IRON *	NA	NA	NA	NA	NA	NA

* SAMPLE COLLECTED 3/1/95: Fe = 2150.

OLD-02-06A (3 TO 13')	9/14/94
ALUMINUM	**5500**

LEGEND

ASTERISK INDICATES WELL SAMPLED — * OLD-02-10C

MONITORING WELL

PRIVATE WATER WELL

WELL ID — OLD-02-21C; SCREEN INTERVAL TO NEAREST FOOT — (56 TO 61'); SAMPLE COLLECTION DATE — 12/7/98, 7/16/99, 10/25/99; ANALYTE — BENZENE; DUPLICATE SAMPLE — 50/56, 40/40; ANALYTE CONCENTRATION[1,2] — 34

INDICATES CONCENTRATION IS BETWEEN INSTRUMENT DETECTION LIMIT AND THE CONTRACT-REQUIRED DETECTION LIMIT — B

DILUTION — D

ESTIMATED VALUE — J

NOT ANALYZED — NA

1-GROUNDWATER CONCENTRATIONS IN MICROGRAMS PER LITER (µg/L)

2-BOLD CONCENTRATION INDICATES EXCEEDANCE

NOTE:

DATA ARE SHOWN FOR LOCATIONS WITH PAST OR CURRENT EXCEEDANCES.

SCREENING CRITERIA

ANALYTE	GCTL[1]	BGSV[1]
BENZENE	1	-
ALUMINUM	200	4067
ANTIMONY	6	4.1
IRON	300	1227
IPB	0.8	-

GCTL-GROUNDWATER CLEANUP TARGET LEVEL

BGSV-BACKGROUND SCREENING VALUE

IPB-ISOPROPYL BENZENE

N

300 0 300

SCALE IN FEET

FIGURE 1-2

GROUNDWATER EXCEEDANCES JULY 2000 ORC TREATABILITY STUDY STUDY AREA 2 - HERNDON ANNEX

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

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1.1.2 Site Investigation Summary

The site screening investigation of SA 2 was completed in five phases starting in July 1994 and ending in December 1998. The results of the investigation are described in a report entitled *Base Realignment and Closure, Environmental Site Screening Report, Study Area 2, Herndon Annex* (Harding Lawson Associates, 1999). The investigation is summarized below.

Groundwater Investigation. During the groundwater investigation, benzene was detected at concentrations exceeding the State MCL of 1 μg/L. The data indicate that the benzene plume is defined and is migrating northeasterly beneath the Azalea Park neighborhood. The most comprehensive groundwater data set was collected in 1997 through DPT investigations and monitoring well sampling. This groundwater data set was used to define the extent of the benzene plume at a depth of greater than 40 feet below land surface (bls) and the area of highest benzene concentration. The highest benzene concentrations occur around well OLD-02-13C.

Since the benzene concentrations have remained relatively constant for a number of years, it is believed that the benzene has effectively created a reservoir within the soil in this area that acts as a continual source as groundwater travels through the area. Organic material within the soil at the contaminated depth has absorbed benzene that has been slowly released back into the dissolved phase as fresh groundwater flows through. Figure 1-3 illustrates the groundwater contamination documented at a depth greater than 40 feet bls during the DPT screening in 1997.

From August 1997 to November/December 1998, there was a 14 to 100 percent decrease in groundwater benzene concentrations. Subsequent sampling has been performed on a quarterly basis beginning in July 1999, and no significant changes in the benzene concentrations have occurred.

Private Wells. The Navy and the City of Orlando conducted a well survey and found no permitted potable water wells screened in the surficial aquifer in the Azalea Park neighborhood. However, three private irrigation wells and one well used to cool an air conditioning system exist in this neighborhood.

The private Azalea Park wells were sampled in August 1999, and benzene concentrations above State and Federal criteria were measured in the samples collected from the irrigation and air conditioning wells at 20 Nancy Lee. The source of the benzene has not been determined, but based upon the hydrogeology of the area, it is unlikely that Herndon Annex is the source of the contamination. The wells at 20 Nancy Lee are believed to be less than 20 feet deep, while the benzene contamination associated with the Herndon Annex has been detected in wells more than 35 feet deep.

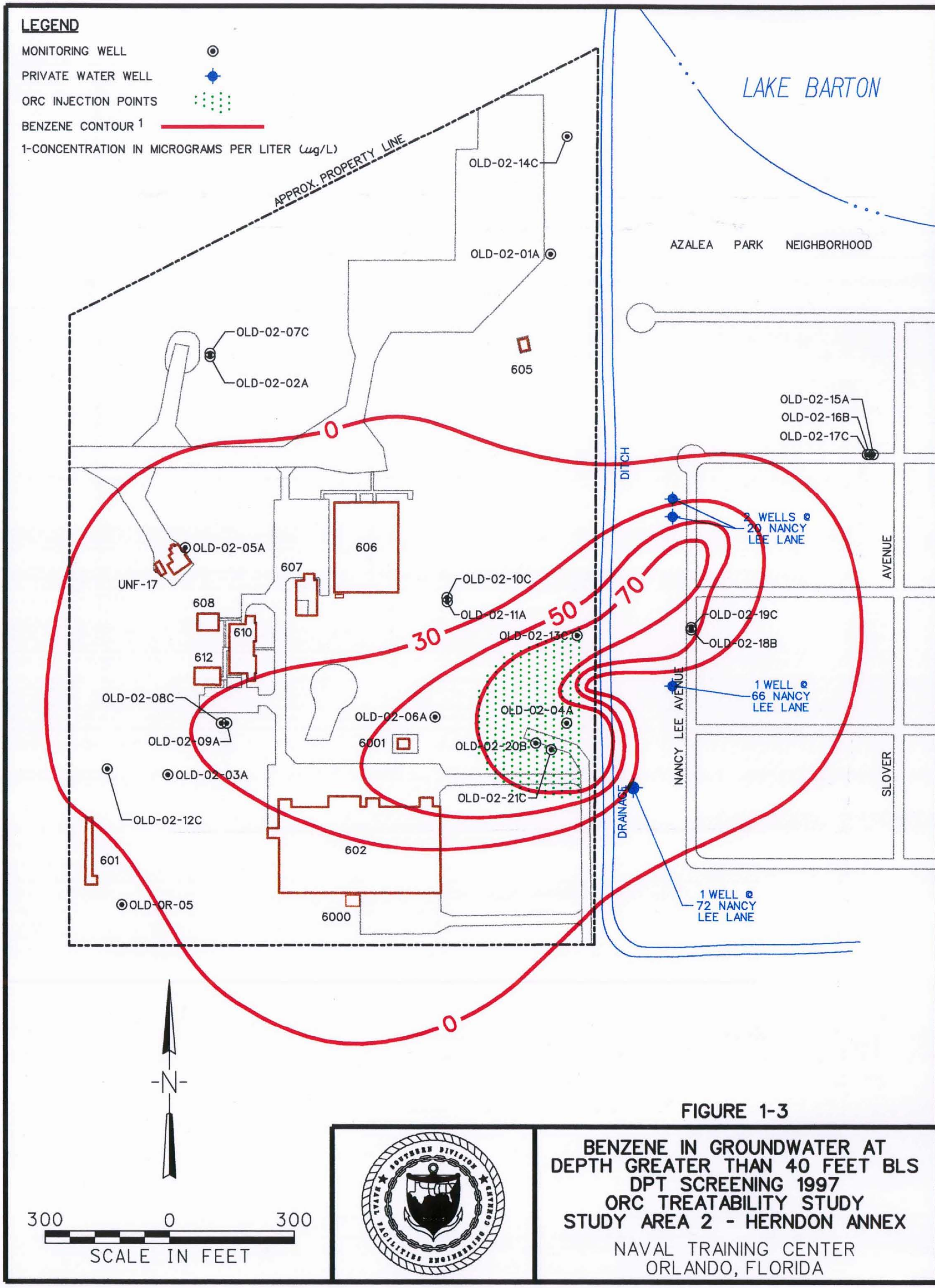

FIGURE 1-3

BENZENE IN GROUNDWATER AT DEPTH GREATER THAN 40 FEET BLS
DPT SCREENING 1997
ORC TREATABILITY STUDY
STUDY AREA 2 - HERNDON ANNEX

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

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CAD FILE NO./DATE: 74570117.dgn/12-14-00

1.2 SCOPE AND GOALS

ORC® is a proprietary product produced by Regenesis Bioremediation Products, of San Clemente, California. ORC® is a patented formulation of magnesium peroxide (MgO_2) that slowly releases molecular oxygen into the aquifer when hydrated. The hydrated product becomes magnesium hydroxide ($Mg(OH)_2$). The oxygen release rate is dependent upon the level of the contaminant flux. This allows ORC® to release oxygen at a relatively constant rate over an extended period of time. The increase in dissolved oxygen in the aquifer creates aerobic conditions that will stimulate in situ bioremediation of the petroleum hydrocarbon plume.

During this treatability study, an ORC® and water mixture (slurry) will be injected into the area of impacted groundwater with the highest benzene concentrations (i.e., the "source area"). By reducing the benzene concentrations in the source area, natural attenuation of the remaining portion of the plume should be accelerated since the electron acceptor pool (e.g., ferric iron, sulfate, etc.) will be significantly increased.

The objective of the treatability study is to determine the effectiveness of ORC® at reducing the contaminant concentrations within the source area. This strategy is relying on the release of dissolved oxygen to increase the microbial activity, thereby increasing contaminant reduction through aerobic respiration. Then as the electron acceptor pool is increased throughout the remaining groundwater plume, anaerobic utilization rates will be increased, further reducing contaminant concentration away from the source area.

The results of the treatability study will be used to answer the questions:

- How does aquifer dissolved oxygen increase and decrease over time and space within the source area?
- Does the introduction of oxygen stimulate growth of in situ microbiota capable of degrading benzene?
- Is the source area dissolved benzene concentration permanently reduced after the ORC® treatment?

Data collected to answer these questions include field and fixed-base laboratory analyses collected over the treatment period from new and existing wells within and near the source area.

Four quarters of groundwater samples will be collected from 6 selected existing monitoring wells and 15 microwells to be installed. Quarterly performance monitoring letter reports will be prepared, and a final treatability study report will be submitted after the first year of sampling.

2.0 PROJECT MANAGEMENT

2.1 PROJECT ORGANIZATION

TtNUS has responsibility to perform the Treatability Study at SA 2. The responsibilities of key TtNUS project personnel are defined in the following paragraphs.

Task Order (TO) Manager - The TO Manager reports to the TtNUS Program Manager, Ms. Debbie Wroblewski, and is responsible for project performance, budget, and schedule, and for ensuring the availability of necessary personnel, equipment, subcontractors, and services. He will direct the development of the field program, evaluation of findings, determination of conclusions and recommendations, and preparation of technical reports. The TO Manager will coordinate the schedule of field sampling activities with the schedule and capacity requirements of the selected analytical laboratory. The TtNUS Project Manager for CTO No. 0151 is Mr. Steven McCoy, P.E.

Field Operations Leader - The Field Operations Leader (FOL), responsible for providing onsite supervision of day-to-day activities on the project. The FOL serves as the primary onsite contact with the client and subcontractors. In addition, the FOL is responsible for all field quality assurance (QA)/quality control (QC) and safety-related issues as defined in the Health and Safety Plan and will ensure that environmental sampling complies with all QA/QC requirements and with holding time and analytical procedure requirements.

Health and Safety Manager - The Program Health and Safety Manager (HSM) will review and internally approve the Health and Safety Plan tailored to the specific needs of the investigation. In consultation with the Project Manager/FOL, the HSM will ensure that an adequate level of personal protection exists for anticipated potential hazards for all field personnel. As the HSM does not report to either the Program or Project Manager, his/her actions are not dictated by Program or project constraints (such as budget and schedule) other than the assurance of appropriate safeguards while conducting investigation activities. The TtNUS HSM is Mr. Matthew Soltis, CIH.

2.2 PROJECT SCHEDULE

MILESTONE SCHEDULE

TASK	START DATE	FINISH DATE	DURATION
Notice to Proceed		16 Oct 00	1
Submit HASP Addendum		10 Nov 00	1
Submit Draft Work Plan		07 Nov 00	1
Submit Final Work Plan		17 Nov 00	1
Mobilization		06 Dec 00	1
DPT/ORC® Injection/Microwell Installation	06 Dec 00	27 Dec 00	20
1st Quarter Sampling	28 Mar 01	03 Apr 01	5
Submit - 1st Quarter Report		10 Jul 01	1
2nd Quarter Sampling	26 Jun 01	02 Jul 01	5
Submit - 2nd Quarter Report		03 Oct 01	1
3rd Quarter Sampling		TBD	
Submit - 3rd Quarter Report		TBD	
4th Quarter Sampling		TBD	
Submit - 4th Quarter Report		TBD	
End Project		TBD	

TBD – To be determined.

3.0 TREATABILITY LABORATORY TESTING

The primary goal of the ORC® injection is to add dissolved oxygen (DO) to the groundwater and thereby stimulate the activity of aerobic microorganisms to facilitate the destruction of organic compounds such as benzene. The assumption in most ORC® injections is that the activity of microorganisms present in the aquifer is limited by the lack of available oxygen. However, the microorganisms have other nutrient requirements that may limit their activity even in the presence of abundant oxygen. A small-scale treatability study was performed on a groundwater sample from the core of the proposed treatment (well OLD-02-13C) area to identify any other limiting factors for the ambient microorganisms before implementing the ORC® injection.

Tests on the initial water sample included:

- Total heterotrophs plates count – a measure of total aerobic population present in the aquifer.
- Total degraders plate count – a measure of aerobic microorganisms present and capable of degrading petroleum hydrocarbon contaminants.
- Select degraders plate count – a more specific measure of aerobic microorganisms present and capable of degrading volatile organic compounds (VOCs).
- Nutrient supplement respirometer tests – tests in which samples were spiked with individual nutrients (i.e., nitrogen and phosphorous) and one combination to evaluate the need for additional nutrients during the full scale ORC® injection.

3.1 TREATABILITY LABORATORY TEST RESULTS

The plate counts indicated that the ambient microbial population is very low, but should be adequate to support the ORC injection project. The results of the plate counts are provided in Table 3-1. The higher numbers of degraders relative to total heterotrophs indicates that the ambient microbial population has been selected for microorganisms that can degrade the contaminants present in the groundwater.

TABLE 3-1

RESULTS OF MICROBIAL PLATE COUNTS
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ORLANDO, FLORIDA

TEST	RESULT*
Total Heterotrophs Plate Count	110 CFU/mL
Total Degraders Plate Count	207 CFU/mL
Select Degraders Plate Count	303 CFU/mL

*Colony Forming Units per Milliliter

The results of the nutrient supplement respirometer tests show that the rate of oxygen use by the microbes is approximately equal for all tests. The addition of nutrients did not result in a significant increase in the rate of oxygen consumption. These results indicate that the availability of nutrients is not a limiting factor to the destruction of organic compounds. The oxygen uptake rate is proportional to the rate of contaminant degradation and is approximately the same for all tests. These results show that the addition of nutrients is not required to encourage microbial growth and the accompanying degradation of benzene.

Following installation of the ORC®, groundwater samples will be collected quarterly from several microwells to monitor the impact of the injection. One measure of effectiveness will include additional microbiological tests (heterotroph and degrader plate counts and respirometer tests) run on water samples from the wells. The results of these tests will be used to evaluate the impact of the ORC® injection on the ambient microbial population.

4.0 ORC® INJECTION - FIELD OPERATIONS

4.1 FIELD OPERATIONS SUMMARY

The pilot-scale study consists of the following field activities:

- Sampling and analysis of six selected monitoring wells (OLD–02-08C, OLD-02-10C, OLD-02-13C, OLD-02-19C, OLD-02-20B, and OLD-02-21C) to evaluate baseline contaminant concentrations and geochemistry.
- Sampling and analysis of one selected monitoring well (OLD-02-13C) to evaluate microbiological needs.
- Installation and survey of 300 ORC® injection borings in the source area.
- Injection of an ORC® enriched slurry into each of the above-referenced points.
- Installation and survey of 15 microwells.
- Quarterly sampling and analysis of 6 selected monitoring wells (OLD–02-08C, OLD-02-10C, OLD-02-13C, OLD-02-19C, OLD-02-20B, and OLD-02-21C) and 15 microwells to evaluate natural attenuation parameters and contaminant concentrations.

The pilot study will target the area of the groundwater contaminant plume located in the immediate vicinity of the historically highest groundwater benzene concentrations. The plume is defined as the contour of the 70-µg/L concentration isopleth remaining on the SA 2 property (Figure 1-3). For this treatability study, the Navy is focusing on the zone of highest concentrations.

The pilot-scale study involves the installation of 300 injection points using direct push technology (DPT) (e.g., Geoprobe), and will be divided among a series of 13 barriers and installed as illustrated on Figure 4-1. Each barrier will contain a variable number of injection points ranging from 10 to 30 as depicted in Figure 4-1 and subject to site constraints. Groundwater contamination is assumed to extend to approximately 55 feet bls based on the depth of the monitoring wells previously installed at the site. Therefore, each of the injection points will be installed to a depth of 55 feet bls and the ORC® slurry injected from 55 feet bls to 35 feet bls. Details of the sampling and analysis program are presented in Section 5.0.

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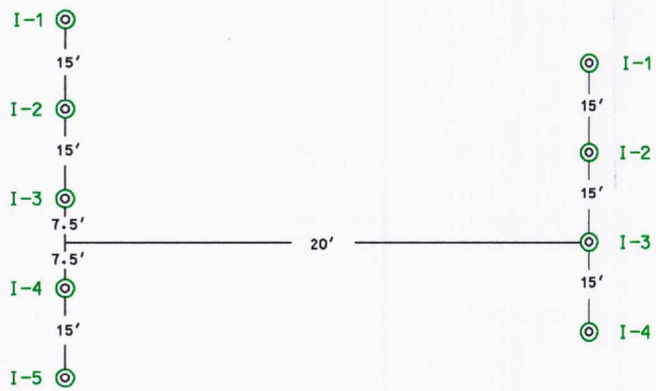
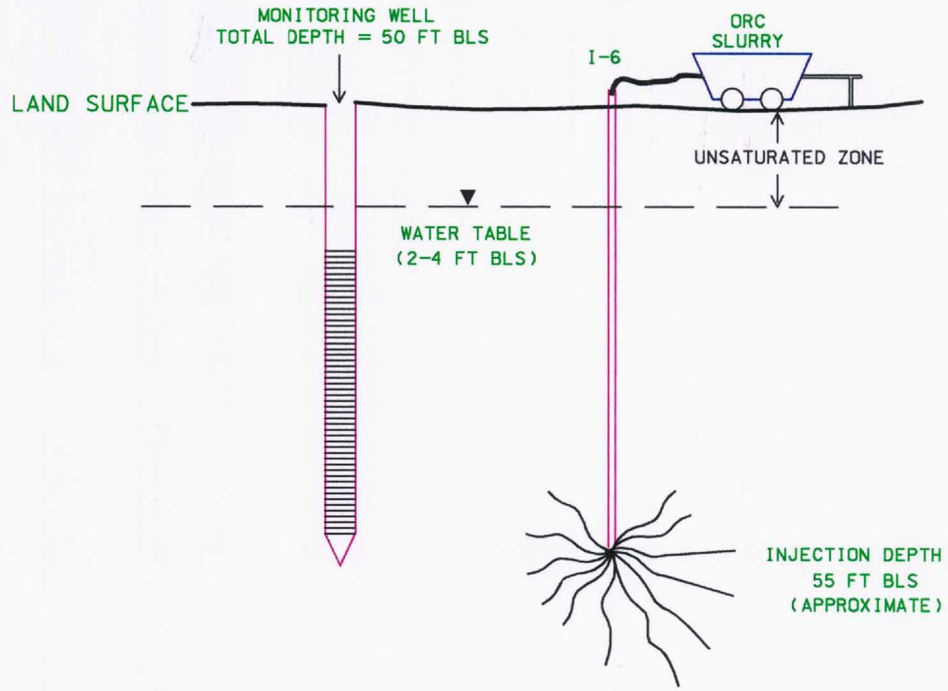


PLAN VIEW SHOWING TYPICAL ADJACENT PAIR OF PROPOSED ORC INJECTION POINT BANKS



CROSS-SECTIONAL VIEW SHOWING TYPICAL INJECTION POINT AND MONITORING WELL WITHIN TREATMENT ZONE

I-4 ◎ ORC INJECTION POINT AND DESIGNATION (Typ.)

NOTES:

1) 300 total injection points: 13 rows spaced approximately 20 ft apart
2) See previous figure (Figure 1-3) for proposed locations of injection points relative to monitoring wells and hydrocarbon plume
3) 20 lbs. ORC slurry to be injected at each point one time only

FIGURE 4-1

INJECTION BORING
ORC TREATABILITY STUDY
STUDY AREA 2 - HERNDON ANNEX

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

CAD FILE NO./DATE: 74570118.dgn/12-15-00

4.2 HEALTH AND SAFETY

Health and Safety aspects of TtNUS' work at NTC, Orlando are controlled in accordance with the *Health and Safety Plan for Completion of Investigative Work and Data Sampling* (Brown & Root Environmental, 1997) and addenda. An addendum to address the hazards specific to the ORC® injection has been prepared for this study.

4.3 MOBILIZATION/DEMOBILIZATION

Following approval of this Work Plan, TtNUS will procure the required subcontractors and begin mobilization activities. Mobilization/demobilization includes:

- Mobilizing all required subcontractors, equipment and materials to the site.
- Obtaining all necessary drilling and/or well permits.
- Conducting an approximately 1-hour-long, site-specific health and safety review meeting.
- Delineation of work zones (exclusion zone, contamination reduction zone, and support zone) as required by the Health and Safety Plan (HASP).
- Arranging an area to perform decontamination procedures.
- Demobilizing all equipment and materials from the site.
- Performing general site clean-up and removal of trash.
- Submission of all boring logs in accordance with applicable regulations (by DPT subcontractor).

All field team members will review the Work Plan, the Site Emergency Procedures Plan, and the HASP. Mobilization includes attendance at a site-specific health and safety meeting during the initiation of onsite activities. This meeting will also include field team orientation to familiarize all personnel with the scope of the field activities.

The FOL will coordinate the mobilization activities. These activities include responsibilities such as initiating and conducting equipment inventories to ensure equipment is available, purchasing equipment as required, staging equipment for efficient loading and transport to the site, and, after field activities are completed, demobilizing the equipment.

The DPT subcontractor will furnish a truck-mounted DPT rig, support crew, all necessary tools required, personal protective equipment (PPE) for their crew, and any miscellaneous equipment and materials required to complete the described activities. All downhole DPT equipment, sampling tools, and the rear of the DPT rig will be steam cleaned prior to arrival onsite. All safety shut-off equipment will be in full working condition and will be tested by the FOL prior to initiating DPT activities.

4.4 INJECTION POINT ARRAY

Design of the injection point array (Figures 1-3 and 4-1) is based on site-specific data (e.g., depth of the treatment zone, groundwater velocity) and recommendations from the ORC® vendor. The ORC® treatment area will concentrate within the 70 ppb benzene isoconcentration contour. This area has been termed the "source" area.

Within the source area, the depth interval with the highest dissolved benzene concentration is centered around 40 feet bls. The design requires ORC® injection at an interval of 55 feet to 35 feet bls to span the zone of maximum benzene concentration.

For each mg of degradable hydrocarbon present, 3 mg of oxygen are required for aerobic biological degradation. Additional oxygen will be depleted by other processes. ORC® has 10 percent available O_2; therefore, 33 mg of MgO_2 are required for each mg of hydrocarbon destroyed (in addition to any oxygen demand for other processes), assuming 100 percent conversion efficiency. A minimum of 1 pound of ORC® per linear vertical foot of contamination per injection point is recommended by the manufacturer of ORC® to ensure adequate dispersion of oxygen within the aquifer. ORC® injected as a slurry mixed with water at a rate of 1 pound per linear vertical foot of contaminant translates to 20 pounds per hole assuming a vertical thickness of contamination of 20 feet.

The ORC® injection must provide sufficient oxygen to consume all readily oxidized materials within a representative aquifer volume. A representative volume of the aquifer with the highest recently measured benzene (80 μg/L) and methane 1274 μg/L concentrations will consume <200 grams of the 900 grams of oxygen produced by each injection point. The unknown sink for DO is the natural organic carbon in the aquifer matrix. Based on literature values and the assumption that all of the total organic carbon (TOC) can be readily oxidized, the dissolved oxygen will be consumed within each representative volume.

Data from the ORC® vendor suggest that ORC® will release approximately 10 percent of its available oxygen within the first two weeks of injection and the remaining 90 percent of available oxygen will be released relatively uniformly for a total of approximately 180 days. Using the most conservative groundwater velocity data, groundwater will travel approximately 21 feet in 180 days. Placing the series of oxygen barriers 20 feet apart should allow oxygenated groundwater to reach the next barrier prior to depletion under optimum conditions. Injection points will be placed on 15-foot centers in a series of barriers across the area identified as the potential source area. The points will also be staggered on each barrier to increase oxygen dispersion within the aquifer.

4.5 ORC® MIXING AND INJECTION

The ORC® bulk powder will be drop-shipped from the Regenesis manufacturing facility in Inwood, New York. For the ORC® injection boring, approximately 2.38 gallons of potable water will be mixed with 20 pounds of ORC® powder. This will create 50 percent solids slurry. If the 50 percent solids slurry enters the formation, the remaining injections will be at a 50 percent solids slurry. If however, difficulty is encountered in injection of the 50 percent mixture, the percent solids will be increased accordingly. Mixing will be performed in a 5-gallon bucket or other appropriate container and injected through the DPT rig's pump or any slurry/grout pump. The mixed ORC® powder is a thin liquid, similar in chemical composition to diluted Milk of Magnesia. A hand-held drill with a paint or stucco mixer will be used to mix the slurry. Standard environmental slurry mixers/grout pumps may also be used. The ORC® slurry must be mixed immediately before using; it cannot be allowed to stand for more than 30 minutes since it will settle and eventually harden. Details on the mixing and injection instruction for the ORC® slurry are provided in Appendix B. Material Safety Data Sheets (MSDSs) for the ORC® powder are provided in Appendix A and in the HASP.

4.6 MICROWELL INSTALLATION

Additional monitoring wells (microwells) will be installed downgradient of selected ORC® injection points to monitor the movement of oxygenated water, the impact on the microbial environment, and the rate of oxygen consumption. The microwells will be installed approximately 7 feet, 14 feet, and 20 feet directly downgradient of an injection point, corresponding to conservative groundwater flow times of 60, 90, and 180 days. In addition, several microwells will be installed downgradient but off center of the injection point to evaluate the horizontal dispersion of oxygenated water.

Microwells will be constructed of Schedule 40 PVC risers and screens. The TtNUS on-site representative will provide specific microwell locations. All well screens will be 5-feet long and will be placed from 45 to 50 feet bls. All well screens will be factory slotted to 0.010-in size. The filter pack will be clean silica sand of U.S. Standard Sieve Size No. 20 to 30. The sand pack will extend approximately 0.5 feet below the bottom of the screen and approximately 0.5 feet above the top of the well screen. A minimum 1-foot thick layer of fine sand (uniformly graded clean silica sand of U.S. Standard Sieve Size No. 30 to 65) will be placed on top of the filter pack. The remaining annulus above the fine sand layer will be backfilled to the surface with a 10:1 cement/bentonite grout. A maximum of 6 to 7 gallons of water per 94-pound bag of Type I cement will be used.

The surface completions for the microwells will be flush mount, sealing, well covers. The flush mount cover will be an 8 or 10-inch round security vault with bolt-down manhole cover provided with sealing gasket and a water-tight well cap to reduce the amount of water infiltration. Approximately 4 to 6 in. of clearance will be left between the lid of the well cover and the top of the well riser. A 2-ft by 2-ft by 4-in. thick concrete apron will be constructed around each flush mount well. The flush mounted casings will be completed a minimum of 1-inch above existing grade and the apron tapered to be flush with existing grade at the edges such that water will run off of the apron.

The microwells will be numbered in accordance with the existing wells at the site. Well designations will be of the following form:

OLD-02*NN*C

Where: *NN* is the well number beginning with 23. For example the first microwell will be numbered OLD-02-23C.

5.0 FIELD OPERATIONS - SAMPLING

Both field and laboratory analyses will be conducted to quantify any increase in the rate of microbial activity within the aerobic reaction zones and to determine the contaminant reduction rates. Groundwater samples will be obtained from six selected groundwater monitoring wells (OLD–02-08C, OLD-02-10C, OLD 02-13C, OLD-02-19C, OLD-02-20B, and OLD-02-21C) during four quarters of sampling. Samples will be collected quarterly for the above laboratory groundwater analyses and reference field analytical tests.

5.1 WATER LEVEL MEASUREMENTS

Groundwater level measurements will be obtained during the baseline sampling event from the following site monitoring wells: OLD-02-01A, OLD-02-02A, OLD-02-03A, OLD-02-04A, OLD-02-05A, OLD-02-06A, OLD-02-07C, OLD-02-08C, OLD-02-09A, OLD-02-10C, OLD-02-11A, OLD-02-12C, OLD-02-13C, OLD-02-14C, OLD-02-15A, OLD-02-16B, OLD-02-17C, OLD-02-18B, OLD-02-19C, OLD-02-20B, OLD-02-21C. The synoptic measurements will be taken within a 2-hour period of consistent weather conditions to minimize atmospheric/precipitation effects on groundwater levels. Measurements will be taken with an electronic water level indicator or interface probe using the marked location on the top of the well casing as the reference point. Groundwater level measurements will be recorded to the nearest 0.01 foot on the appropriate field log. This information will be used to confirm groundwater flow direction. Only the monitoring wells to be sampled will be measured during the quarterly sampling events.

5.2 PURGING PROCEDURES FOR MONITORING WELLS

Unless otherwise specified herein, all work will be performed following guidance detailed in the *Project Operations Plan for Site Investigations and Remedial Investigations* (ABB-ES, 1997). In addition, wells will be purged and sampled meeting or exceeding the guidance detailed in *Environmental Investigations, Standard Operating Procedures and Quality Assurance Manual* (USEPA, 1996).

Peristaltic pumps using dedicated Teflon®-lined discharge tubing will be used for both purging and sampling of the wells. Flow-through cells will be used to collect purged groundwater in-line for real-time parameter monitoring.

The newly installed monitoring wells are to be purged using microflow purging techniques prior to sampling. The steps listed below are to be followed for the purging procedure.

1. The water level will be measured and recorded prior to placing the tubing into the well.

2. The discharge tubing will be lowered into the well as slowly as possible to minimize disturbance to the water in the well.

3. The end of the tubing will be positioned at the midpoint of the saturated screen length. The end of the tubing will be kept at least 2 feet above the bottom of the well to minimize mobilization of any particulates present (where practical).

4. The water level will be measured and recorded before starting the pump.

5. Purging will begin with the pump at the lowest setting and will slowly increase until discharge occurs.

6. The water level will be checked again.

The following guidance applies to the purging of monitoring wells.

- The pumping rate will be adjusted until there is little or no water level drawdown. Drawdown should be less than 0.3 foot unless site conditions warrant a change. If the least drawdown that can be achieved exceeds 0.3 foot but remains stable, the purging procedure will continue.

- The water level and pumping rate will be monitored and recorded every 3 to 5 minutes (or as appropriate) during purging. Pumping rate adjustments will be recorded (both time and flow rate). Adjustments are best made during the first 15 minutes of pumping to minimize purging time. During pump start-up, drawdown may exceed the 0.3 foot target and then recover as pump flow adjustments are made. Unless site conditions warrant a change, purging will proceed at approximately 100 mL/min.

- Field parameters will be monitored and recorded every 3 to 5 minutes (or as appropriate) for stabilization. Note: During the early phase of purging, emphasis will be placed on minimizing and stabilizing pumping stress and recording those adjustments.

- Purging will be considered complete when temperature, specific conductance, pH, oxidation reduction potential (ORP), and DO have stabilized and turbidity has stabilized below 10 Nephelometric Turbidity Units (NTUs) (USEPA, 1996).

- Stabilization is considered to be achieved when three consecutive readings, taken at 3- to 5-minute intervals, are within the limits listed in Table 5-1.

- If turbidity is greater than 10 NTUs and has not decreased significantly after 60 minutes, purging will be discontinued and sample collection will be performed at the discretion of the Project Manager.

TABLE 5-1

**FIELD PARAMETERS STABILIZATION CRITERIA
NAVAL TRAINING CENTER
ORLANDO, FLORIDA**

Parameter	Unit	Limit
Temperature	Degrees Fahrenheit (°F)	± 5%
Specific Conductance	Microsiemens/centimeter (μs/cm)	± 5%
pH	Standard Unit (SU)	± 0.1
Oxidation Reduction Potential (ORP)	Millivolts (mV)	± 5%
Dissolved Oxygen (DO)	Milligrams per liter (mg/L)	± 5%
Turbidity	Nephelometric Turbidity Unit (NTU)	± 5% for values > 7 ± 10% for values < 7

5.3 MONITORING WELL SAMPLING PROCEDURES

When purging is complete, the flow-through cell will be disconnected and sample bottles will be filled directly from the Teflon® or Teflon®-lined tubing prior to its interface with the silastic tubing used in the peristaltic pump head.

Samples for Target Compound List (TCL) volatile organic compounds (VOCs) will be collected using the tube evacuation method.

Samples will be shipped on a daily basis with accompanying trip blanks to:

Katahdin Analytical Services
340 County Road No. 5
Westbrook, ME 04092
Attn: Andrea Colby
Phone: (407) 425-6700

5.3.1 Sample Numbering

The groundwater samples will be numbered as follows:

NTC02*TWWWRR*

where: NTC = Naval Training Center

02 = two-digit SA designation (02)

T = sample type ("G" for groundwater, "D" for duplicate)

WWW = well location and screen depth designation (e.g., 15A)

RR = sampling round number (e.g., 10)

For example, the sample collected from well OLD-02-15A will be designated as NTC02G15A10. Dashes will not be used in the sample numbers. Samples for field duplicates will be identified with a "blind" number (e.g., the first duplicate would be NTC02D00110, the second would be NTC02D00210). The corresponding environmental sample will be noted in the field logbook.

Rinsate and field blanks are not required because all sampling will be done with dedicated Teflon® tubing. Trip blanks are to be numbered consecutively (e.g., NTC02TB0110 for the first trip blank).

5.3.2 Quality Control Samples

QC samples will be collected at the frequencies listed below.

- One set of trip blanks will accompany each cooler shipment containing VOCs.
- One field duplicate per 10 environmental samples.
- One matrix spike (MS)/matrix spike duplicate (MSD) per 20 environmental samples.
- No rinsate blanks (unless downhole pumps or non-dedicated tubing are used for sampling).
- No field blanks (unless decontamination of sampling equipment is required).

"MS/MSD" will be added to the sample label and the chain of custody. New sample numbers will not be created for these samples. MS/MSD samples will be selected in the field by the FOL and will require 3X sample volume for each set (1X for environmental sample, 1X for MS sample, and 1X for MSD sample).

If a rinsate blank is required (should downhole submersible pumps be used), analyte-free water from a decontaminated bucket or other decontaminated container will be pumped through the entire reel of discharge tubing directly into the sample bottles.

5.4 LABORATORY SAMPLE ANALYSIS SUMMARY

Severn Trent Laboratory, Inc. has been subcontracted by TtNUS to perform the routine chemical analyses for the environmental samples collected for the SA 2 site during the ORC® pilot-scale study.

The laboratory analytical methods, bottle requirements, preservation requirements, and holding times are shown in Table 5-2.

TABLE 5-2

**ANALYTICAL LABORATORY ANALYSES
NAVAL TRAINING CENTER
ORLANDO, FLORIDA**

Parameter	Analytical Method	Bottle/Preservation Requirements	Holding Time
Target Compound List Volatile Organic Compounds	SW-846 5030B 8260B	40-mL septum vial/hydrochloric acid 3 vials per sample	14 days
Iron (Dissolved/Filtered)	SW-846 6010B	1-L plastic/nitric acid	6 months
Manganese (Dissolved/Filtered)	SW-846 6010B	1-L plastic/nitric acid	6 months
Dissolved Organic Carbon	USEPA 415.1	Two 40 mL septum vial/sulfuric acid	28 days
Nitrite	USEPA 300	One 250-mL HDPE Cool to 4°C	48 hours to analysis
Nitrate	USEPA 300	One 250-mL HDPE Cool to 4°C	48 hours to analysis
Sulfate	USEPA 300	One 250-mL HDPE Cool to 4°C	28 days to analysis

Vapor Tech Services, Inc. has been subcontracted by TtNUS to perform the routine dissolved gases analyses for the environmental samples collected for the SA 2 site during the ORC® pilot-scale study.

The laboratory analytical methods, bottle requirements, preservation requirements, and holding times are shown in Table 5-3.

TABLE 5-3

**DISSOLVED GASES ANALYSES
NAVAL TRAINING CENTER
ORLANDO, FLORIDA**

Parameter	Analytical Method	Bottle/Preservation Requirements	Holding Time
Carbon Dioxide	Modified Kerr Lab SOP# RSK-175	40-mL septum vial Cool 4°C	1 week
Hydrogen	Modified Kerr Lab SOP# RSK-175	12-mL septum vial Cool 4°C	28 days
Methane	Modified Kerr Lab SOP# RSK-175	40-mL septum vial Cool 4°C	1 week
Oxygen	Modified Kerr Lab SOP# RSK-175	40-mL septum vial Cool 4°C	1 week

5.4.1 Field Analysis Summary

Field geochemical analyses will be performed during field sampling activities on the six selected monitoring wells for the parameters specified in Table 5-4.

TABLE 5-4

FIELD ANALYSES
NAVAL TRAINING CENTER
ORLANDO, FLORIDA

Parameter	Analytical Method	Holding Time	Analyze
Dissolved oxygen	CHEMetrics K-7501/7512	Analyze immediately	Field
Carbon dioxide	CHEMetrics K-1910/1920/1925	Analyze immediately	Field
Alkalinity	CHEMetrics K-9810/9815/9820	Analyze immediately	Field
Ferrous iron	HACH IR-18C	Analyze immediately	Field
Hydrogen sulfide	HACH HS-C	Analyze immediately	Field
Oxidation Reduction Potential (ORP)	Horiba U-22	Analyze immediately	Field

5.4.2 Sample Packaging and Shipping

The FOL will be responsible for completion of the following forms:

- Sample Labels
- Chain-of-Custody Forms
- Appropriate labels applied to shipping coolers
- Chain-of-Custody Seals
- Federal Express Air Bills

All samples will be packaged and shipped in accordance with Florida Standard Operating Procedures (FL SOPs).

5.4.3 Sample Custody

Custody of samples must be maintained and documented at all times. Chain-of-custody begins with the collection of the samples in the field. TtNUS Standard Operating Procedure (SOP) SA-6.3 describes the chain-of-custody procedures to be followed.

5.5 EQUIPMENT CALIBRATION

Several monitoring instruments may be used during field activities; these include:

- Photoionization or flame ionization detector
- Horiba U-22 water quality meter/probe
- Electronic water-level meter

Calibration will be documented on an equipment calibration log (Appendix C). During calibration, an appropriate maintenance check will be performed on each piece of equipment. If damaged or defective parts are identified during the maintenance check and it is determined that the damage could have an impact on the instrument's performance, the instrument will be removed from service until the defective parts are repaired or replaced.

5.6 RECORD KEEPING

In addition to chain-of-custody records, certain standard forms will be completed for sample description and documentation. These forms will include sample log sheets, boring logs, well completion diagrams, daily record of subsurface investigation reports, and logbooks. Field documentation and example field log forms are provided in Appendix D.

A bound/weatherproof site logbook will be maintained by the FOL. All information related to sampling or field activities will be recorded in the site logbook. This information will include, but is not limited to, sampling time, weather conditions, unusual events, field measurements, descriptions of photographs, etc.

6.0 DECONTAMINATION

6.1 DOWNHOLE EQUIPMENT

All downhole drilling equipment, including the rear of the drill/DPT rig, will be steam cleaned on these occasions:

- Prior to arrival onsite.
- Prior to beginning work.
- Any time the drill rig leaves the site.
- Any time the drill rig returns to the site.
- At the conclusion of the drilling/DPT program.

Due to the nature of this pilot study and previous delineation of impacted groundwater, the DPT equipment will not be decontaminated between injection points or microwell installation. All large equipment decontamination activities will take place at a location designated by base personnel. However, all loose soil material and debris will be removed at the individual site prior to decontamination. Decontamination operations will consist of washing large equipment (drill rig, augers, push probes, downhole tools, etc.) using a high-pressure potable steam wash.

6.2 SAMPLING EQUIPMENT

All sampling tools and miscellaneous sampling equipment coming in contact with contaminated media will be decontaminated using the steps identified below.

1. Wash with potable water and Alconox.
2. Rinse thoroughly with potable water.
3. Rinse with deionized water or analyte-free water.
4. Rinse with isopropanol.
5. Rinse with analyte-free water and air dry.

Clean sampling equipment will be wrapped in aluminum foil to prevent contamination during storage or transport.

6.3 DISPOSABLES

The field team PPE will be disposed as required. These items, such as disposable latex gloves and paper towels, will be temporarily stored in plastic bags with daily transfer to 55-gallon drums (with lids) at the end of each workday. Personnel will also perform decontamination procedures as required by the HASP before any departure from the site.

7.0 INVESTIGATION-DERIVED WASTE (IDW) MANAGEMENT

All IDW created during DPT installation, well purging and sampling, and decontamination activities will be stored in Department of Transportation-approved 55-gallon steel drums or disposed of in a manner approved by the base contact. Each drum will be clearly marked with the following information or as otherwise directed by the base contact:

- Identification No. (TtNUS-SA2-xxx)
- Company name (Tetra Tech NUS)
- Base contact (Wayne Hansel) and phone number (407-895-6714)
- Site (NTC SA2)
- Material contained in the drum (e.g., decon fluids)
- Date the IDW was produced

All drums will be removed from SA 2 prior to leaving the site. The IDW will be picked up by a licensed waste hauler or sampled for analysis (if necessary) and moved to the storage area at Area C. Navy personnel will sign all manifests and bills of lading prior to transporting the drums from NTC.

Miscellaneous sampling material (e.g., gloves, tubing, and plastic) will be disposed of in dumpsters located in Area C near Building 1056 on Seabee Street.

8.0 REPORTING

During performance of the Treatability Study, TtNUS will prepare the following reports:

ORC® Application and First Quarterly Monitoring Report

Upon completion of the initial quarter of performance monitoring, TtNUS will prepare the first Treatability Study Report, which will include the following:

- The results of the pre-installation sampling and ORC® injection activities.
- The ORC® installation procedures, drilling logs, and any other data developed as part of the pilot-scale field activities.
- The groundwater sampling procedures and sample results.
- The groundwater flow conditions.
- Any other data collected during the most recent sampling event.

This Treatability Study Report will be prepared in draft form for Southern Division (SOUTHDIV) review and final form to be submitted to the Florida Department of Environmental Protection (FDEP).

Second and Third Treatability Study Results Transmittal Letters

Upon completion of the second and third quarters of performance monitoring, TtNUS will prepare a brief letter report presenting the sample results.

Final Treatability Study Report

Upon completion of the fourth quarter of performance monitoring, TtNUS will prepare a Final Treatability Study Report discussing the groundwater sampling procedures and presenting a summary and comparison of the previous three quarters of sample results. The Final Treatability Study Report will present information on the groundwater flow conditions and any other data collected during the past year of sampling. In addition, the report will present conclusions and recommendations for future remedial action at the site, if any. The Final Treatability Study Report will be prepared in draft form for SOUTHDIV review and in final form for SOUTHDIV, NTC, and the FDEP.

9.0 CONTACTS

The following personnel are approved contacts for their respective project areas.

Project Area	Responsible Personnel	Phone Number
Base Contact	Wayne Hansel	407-895-6714
	Bill Jacobs/John Sweeney	407-895-9442/9578
Task Order Management	Steven McCoy	865-220-4730
Technical Issues	Teresa Grayson (ORC® Injection)	865-220-4701
	Michael Campbell (Well installation/sampling)	865-220-4714
Health & Safety	Matthew Soltis	412-921-8912
Procurement	Sandy D'Alessandris	412-921-8435
Analytical Laboratory Analysis	Dave Heakins, Severn Trent Laboratory	330-966-7269
Dissolved Gases Lab	David Masdea, Vapor Tech	724-898-2622
Task Order Chemist	Joe Samchuck	412-921-8510
DPT Contractor	Randy Robinson, Precision Sampling	407-656-0615

Sampling Shipping Addresses:

Chemical Analysis

Katahdin Analytical Services
340 County Road No. 5
Westbrook, ME 04092
Attn: Andrea Colby
Phone: (407) 425-6700

Dissolved Gases Laboratory

Vapor Tech Services, Inc.
1158 Pittsburgh Road, Suite 201
Valencia, PA 16059
Phone: (724) 898-2622

REFERENCES

ABB-ES (ABB Environmental Services, Inc.), 1997. *Project Operations Plan for Site Investigations and Remedial Investigations, Volume I of II, Naval Training Center,* Orlando, Florida. Unit Identification Code N65928, Contract No. N62467-89-D0317/107, August.

Brown & Root Environmental, 1997. *Health and Safety Plan for Completion of Investigative Work and Data Sampling,* Naval Training Center, Orlando, Florida, Contract No. N62467-94-D-0888, May.

HLA (Harding Lawson Associates), 1999. *Base Realignment and Closure, Environmental Site Screening Report, Study Area 2,* Naval Training Center, Orlando, Florida, Unit Identification Code N65928, Contract No. N62467-89-D-0317/107, July.

TtNUS (Tetra Tech NUS, Inc.), 2000. *Decision Document, Naval Training Center, Orlando, Florida,* Contract No. N62467-94-D-0888, April.

USEPA, 1996. *Environmental Investigations, Standard Operating Procedures and Quality Assurance Manual,* California, May.

APPENDIX A

ORC® MSDS

(As retrieved from Regenesis' Website on October 27, 2000.)

ORC® MATERIAL SAFETY DATA SHEET

Last Revised: April 17, 1998

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SECTION #1 - MATERIAL IDENTIFICATION

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SUPPLIER:

REGENESIS Bioremediation Products

1011 Calle Sombra
San Clemente, CA 92673

Tel: 949-366-8000
Fax: 949-366-8090
Email: orc@regenesis.com

CHEMICAL DESCRIPTION:
A mixture of Magnesium Peroxide [MgO2], Magnesium Oxide [MgO], and Magnesium Hydroxide [Mg(OH)2]

CHEMICAL FAMILY:
Inorganic Chemicals

PRODUCT NAME:
Oxygen Release Compound (ORC®)

PRODUCT USE:
Used for environmental remediation of contaminated soil and groundwater

****

SECTION #2 - CHEMICAL IDENTIFICATION

****

CHEMICAL CHARACTERIZATION

Magnesium Peroxide [MgO2]: CAS Reg. No. 14452-57-4

Magnesium Oxide [MgO]: CAS Reg. No. 1309-48-4

Magnesium Hydroxide ((Mg(OH)2): CAS Reg. No. 1309-42-8

FORM : powder

COLOR: white

ODOR: odorless

ASSAY: 25 - 35% Magnesium Peroxide (MgO2)

****

SECTION #3 - PHYSICAL AND TECHNICAL SAFETY DATA

****

MELTING POINT: Not Determined

BOILING POINT: Not Determined

DENSITY: .6 - .8 g/cc

BULK DENSITY: ---

VAPOR PRESSURE: Data not available

VISCOSITY: ---

SOLUBILITY: Reacts with water. Soluble in acid

pH VALUE: Approx. 10 in saturated solution

FLASH POINT: Not applicable

SELF-IGNITION TEMPERATURE: Not applicable

EXPLOSION LIMITS % BY VOLUME: ---

THERMAL DECOMPOSITION: Spontaneous decomposition possible about 150° C

HAZARDOUS DECOMPOSITION PRODUCTS: Not known

HAZARDOUS REACTIONS: Hazardous polymerization will not occur

FURTHER INFORMATION: Non-combustible, but will support combustion

****

SECTION #4 - REACTIVITY DATA

****

STABILITY: Product is stable unless heated above 150°C. Magnesium Peroxide reacts with water to slowly release oxygen. React by product is magnesium hydroxide

CONDITIONS TO AVOID: Heat above 150°C. Open flames

INCOMPATIBILITY: Strong Acids. Strong chemical agents

HAZARDOUS POLYMERIZATION: None known

****

SECTION #5 – REGULATIONS

****

PERMISSIBLE EXPOSURE LIMITS IN AIR: Not established. Should be treated as a nuisance dust.

****

SECTION #6 - PROTECTIVE MEASURES, STORAGE, AND HANDLING

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TECHNICAL PROTECTIVE MEASURES
STORAGE: Keep container tightly closed. Keep away from combustible material

HANDLING: Use only in well-ventilated areas

PERSONAL PROTECTIVE EQUIPMENT

RESPIRATORY PROTECTION: Recommended (HEPA Filters)

HAND PROTECTION: Wear suitable gloves

EYE PROTECTION: Use chemical safety goggles

OTHER: ---

INDUSTRIAL HYGIENE: Avoid contact with skin and eyes

PROTECTION AGAINST FIRE AND EXPLOSION: ---

DISPOSAL: Dispose via sanitary landfill per state/local authority

FURTHER INFORMATION: Not flammable, but may intensify fire

****

SECTION #7 - MEASURES IN CASE OF ACCIDENTS AND FIRE

****

AFTER SPILLAGE/LEAKAGE/GAS LEAKAGE: Collect in suitable containers. Wash remainder with copious quantities of water.

EXTINGUISHING MEDIA
SUITABLE: Carbon dioxide, dry chemicals, foam
NOT TO BE USED: ---

FURTHER INFORMATION: Self contained breathing apparatus or approved gas mask should be worn due to small particle size. Use extinguishing media appropriate for surrounding fire.

FIRST AID: After contact with skin, wash immediately with plenty of water and soap. In case of contact with eyes, rinse immediately with plenty of water and seek medical attention.

FURTHER INFORMATION: ---

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SECTION #8 - INFORMATION ON TOXICOLOGY

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TOXICITY DATA: Data not available

****

SECTION #9 - INFORMATION ON ECOLOGY

****

WATER POLLUTION HAZARD RATING (WGK): 0

****

SECTION #10 - FURTHER INFORMATION

****

After the reaction of magnesium peroxide to form oxygen the resulting material, magnesium hydroxide is mildly basic. The amounts of magnesium oxide (magnesia) and magnesium hydroxide in the initial product have an effect similar to lime, but with lower alkalinity.

The information contained in this document is the best available to the supplier at the time of writing, but is provided without warranty of any kind. Some possible hazards have been determined by analogy to similar classes of material. The items in this document are subject to change and clarification, as more information becomes available.

APPENDIX B

ORC® MIXING AND INJECTING INSTRUCTIONS

(As retrieved from Regenesis' Website on October 27, 2000.)

DIRECTIONS FOR ORC® SLURRY MIXING

1. OPEN 5 GALLON BUCKET, AND REMOVE PRE-MEASURED BAG OF ORC.

2. MEASURE AND POUR WATER INTO THE 5-GALLON BUCKET ACCORDING TO THE FOLLOWING DESIRED CONSISTENCY:

65% Solids Slurry	Mix .63 gallons of water per 10 pounds of ORC powder.	
	Example:	Mix 20 pounds of ORC with 1.26 gallons of water.
		Mix 30 pounds of ORC with 1.89 gallons of water.

60% Solids Slurry	Mix .79 gallons of water per 10 pounds of ORC powder.	
	Example:	Mix 20 pounds of ORC with 1.58 gallons of water.
		Mix 30 pounds of ORC with 2.37 gallons of water.

50% Solids Slurry	Mix 1.19 gallons of water per 10 pounds of ORC powder.	
	Example:	Mix 20 pounds of ORC with 2.38 gallons of water.
		Mix 30 pounds of ORC with 3.57 gallons of water.

25% Solids Slurry	Mix 3.57 gallons of water per 10 pounds of ORC powder.	
	Example:	Mix 10 pounds of ORC with 3.57gallons of water.

3. ADD THE APPROPRIATE ORC QUANTITY TO THE WATER . Check weight of each bucket (see label). The 5-gallon shipping bucket weighs 2 pounds. An additional 4 pounds of ORC® would require one additional quart of water, at the 65% solids level.

4. USE AN APPROPRIATE MIXING DEVICE TO THOROUGHLY MIX ORC® AND WATER. A hand held drill with a "jiffy mixer" or a stucco mixer on it may be used in conjunction with a small paddle to scrape the bottom and sides of the container. Standard environmental slurry mixers may also be used, following the equipment instructions for operation. For small quantities a usable slurry can be mixed by hand, if care is taken to blend all lumps into the mixture thoroughly.

CAUTION: ORC® MAY SETTLE OUT OF SLURRY IF LEFT STANDING. ALSO, ORC® EVENTUALLY HARDENS INTO A CEMENT-LIKE COMPOUND, AND CANNOT BE RE-MIXED AFTER THAT HAS HAPPENED. THEREFORE:
Mix immediately before using. Do not let stand more than 30 minutes, and re-mix immediately before use, to be sure the mixture has not settled out. If a mechanical slurry mixer attached to a pump is being used, the material may be cycled back through the mixer to maintain slurry suspension and consistency.

5. CHECK SLURRY CONSISTENCY FOR POURABILITY. ADD WATER IF NECESSARY (IN 1 CUP INCREMENTS) TO ACHIEVE THE CORRECT CONSISTENCY.

ORC® Slurry Installation Instructions

Geoprobe® Hole Back-Fill Method

SAFETY:
Pure ORC® is shipped to you as a fine powder rated at -325 mesh (passes through a 44 micron screen). It is considered to be a mild oxidizer and as such should be handled with care while in the field. Field personnel should take precautions while applying the pure ORC®. Typically, the operator should work upwind of the product as well as use appropriate safety equipment. These would include eye and respiratory protection, and gloves as deemed appropriate by exposure duration and field conditions.

Personnel operating the field equipment utilized during the installation process should have appropriate training, supervision and experience.

GENERAL GUIDELINES:
ORC® may be installed in the contaminated saturated zone in the ground utilizing hand augered holes, Geoprobe® type hydraulic punch equipment, or hollow stem augers. This set of instructions is specific for Geoprobe equipment. Alternate instructions may be obtained from the Regenesis Technical Support Department.

For optimum results the ORC® slurry installation should span the entire vertical contaminated saturated thickness, including the capillary fringe and "smear zone".

Two general installation approaches are available. The first is to backfill only the probe hole with slurry. This is a simple approach, in that it is easy, straightforward, and the location of the ORC® slurry is precisely known after installation. However, this method requires significantly more probe holes than the alternative, and may take more time for the completion of the remediation process. A separate set of instructions for this method utilizing Geoprobe equipment is available from Regenesis.

The second method is to inject the slurry through the probe holes into the contaminated saturated zone. This method requires fewer probe holes, is less disruptive to the site, and aids the spread of oxygen by spreading the ORC® source material. However, it may be difficult to know the exact, final disposition of the ORC® installed with this method. This is the method described in these instructions.

Note: It is important that the installation method and specific ORC® slurry point location be established prior to field installation. It is also important that the ORC® slurry volume and solids content for each drive point be predetermined. The Regenesis Technical Service Department is available to discuss these issues, and Helpful Hints at the end of these instructions offers relevant information. Regenesis also has available Technical Bulletins covering source treatments with ORC®.

SPECIFIC INSTALLATION PROCEDURES
1. Identify the location of all underground structures, including utilities, tanks, distribution piping, sewers, drains, and landscape irrigation systems.
2. Identify surface and aerial impediments.
3. Adjust planned installation locations for all impediments and obstacles.
4. Pre-mark the installation grid point locations, noting any that have special depth requirements.
5. Set up the Geoprobe unit over each specific point, following manufacturer recommended procedures. Care should be taken to assure approximate vertical probe holes.
6. Penetrate surface pavement, if necessary, following standard Geoprobe procedures.
7. Drive the 1 1/2" (one-and-one-half inch) pre-probe (part #AT-148B) with the expendable tip (part #AT142B) to the desired maximum depth. Standard 1" (one inch) drive rods (part AT104B) should be used, after the pre-probe. (Hint: Pre-counted drive rods should be positioned prior to the installation driving procedure to assure the desired depth is reached.)
8. Disconnect the drive rods from the expendable tip, following standard Geoprobe procedures.
9. Mix the appropriate quantity of ORC® slurry for the current drive point. (See separate "Directions for ORC® Slurry Mixing" and Helpful Hints). **Note: Do not mix more slurry than will be used within a 30 minute period.**

10. Set up and operate an appropriate slurry pump according to manufacturer's directions. Based on our experience, a Geoprobe model GS-1000 pump is recommended. Connect the pump to the probe grout pull cap (GS-1054) via a 1 inch diameter delivery hose. The hose is then attached to the 1" drive rod with its quick connector fitting. Upon confirmation of all connections add the ORC® slurry to the pump hopper/tank.
11. Withdraw the pre-probe and drive stem 4'(four feet). (Also note Helpful Hints - Operations at end of instructions.)
12. Optional pretreatment step. (See Helpful Hints - Operations at end of instructions). Pump one to two gallons of tap water into the aquifer to enhance dispersion pathways from the probe hole.
13. Pump the predetermined quantity of ORC® slurry for the depth interval being injected. Observe pump pressure levels for indications of slurry dispersion or refusal into the aquifer. (Increasing pressure indicates reduced acceptance of material by the aquifer).
14. Remove one 4' section of the 1" drive rod. The drive rod will contain slurry. This slurry should be returned to the ORC® bucket for reuse.
15. Repeat steps 11, 13, and 14 until treatment of the entire affected thickness has been achieved. It is generally recommended that the procedure extend to the top of the capillary fringe/smear zone.
16. Install an appropriate seal, such as bentonite, above the ORC® slurry through the entire vadose zone. This helps assure that the slurry stays in place and prevents contaminant migration from the surface. Depending on soil conditions and local regulations, a bentonite seal can be pumped through the slurry pump or added via chips or pellets after probe removal.
17. Remove and decontaminate the drive rods and pre-probe.
18. Finish the probe hole at surface as appropriate (concrete or asphalt cap, if necessary).
19. Move to the next probe point, repeating steps 5 through 18.

HELPFUL HINTS:

A. Physical characteristics
B. A1. Slurry

The ORC® slurry is made using the dry ORC® powder (rated at -325 mesh). It makes a smooth slurry, with a consistency that depends on the amount of water used.

A thick, but pumpable, slurry that approaches a paste can be made by using 65-67% solids. This material would normally be used for back-filling a bore or probe hole. It is especially useful where maximum density is desired such as where ground water is present in the hole or there are heaving sands.

Thinner slurries can be made by using more water. Typical solids for the thinner slurries content will range from 35% to 62%. Such slurries are useful for injecting through a probe or bore hole into the saturated aquifer.

As a rule, it is best to mix the first batch of slurry at the maximum solids content one would expect to use. It can then be thinned by adding additional water in small increments. By monitoring this process, the appropriate quantities of water for subsequent batches can be determined.

The slurry should be mixed at about the time it is expected to be used. It is best to not hold it for more than 30 minutes. Thinner slurries, especially, can experience a separation upon standing. All ORC® slurries have a tendency to form cements when left standing. If a slurry begins to thicken too much, it should be mixed again and additional water added if necessary.

Care should be taken with slurry that may be left standing in a grout pump or hose. Problems can generally be avoided by periodically re-circulating the slurry through the pump and hose back into the pump's mixing or holding tank.

A2. Equipment

Most geotechnical grout pumping equipment has a holding tank with a capacity sufficient for injection.

When applying measured volumes of ORC® slurry to probe holes, it is sometimes useful to know the volumes and content of the delivery system lines. The following information may be useful in this regard.

Geoprobe pump: At the end of a pump stroke virtually no deliverable slurry remains in the pump.

5/8" O.D. connecting hose (10 feet long):	0.2 gallons (26 fluid ounces).
Four foot (4') length of 1" drive rod:	.04 gallons (5 fluid ounces).
Three foot (3') length of 1 1/2" pre-probe:	.03 gallons (4 fluid ounces).

Cleaning and maintenance:

Pumping equipment and drive rods can be lightly cleaned by circulating clear water through them. Further cleaning and decontamination (if necessary due to subsurface conditions) should be performed according to the equipment supplier's standard procedures and local regulatory requirements.

B. Operating characteristics

B1. Operations - General

Judgment will be needed in the field when injecting ORC® slurries. In general, it is relatively easy to inject ORC® slurries into sandy soils, and this can usually be accomplished at very moderate pressures. Silts and clays require more pressure, and may accept less slurry.

Careful observation of pressure during slurry pumping is the best indication of the effectiveness of the slurry injection. To test the soil's ability to accept the slurry and to "precondition" the injection point for the slurry, it is sometimes useful to inject a small volume of plain water prior to the slurry. Normally, one-half (0.5) gallons to two (2) gallons would be appropriate.

During injection, increasing pressure and decreasing flow rate are signs of refusal by the soil matrix to accept the slurry. The site geologist should determine whether to increase pressure, and possibly fracture ("frac") the soil matrix to achieve ORC® slurry installation in a tight site that has refused the slurry at lower pressures.

B2. Fill Volumes

Probe hole back-filling

Probe hole capacities:

Per 10' (Ten Foot) Length			
Theoretical		**Operating Volume**	
(Gallons/Fluid Ounces/Cubic Inches)		**(Gallons/Fluid Ounces)**	
Sand, Silts & Clay		**Sand**	**Silts & Clay**
1" Diameter	.41 gal/52 fl. oz./94.2 cu. in.	.61 gal/78 fl. oz.	.51 gal/65 fl. oz.
1 1/2" Diameter	.92 gal/117 fl. oz./212.0 cu. in.	1.38 gal/176 fl. Oz.	1.15 gal/146 fl. oz.
2" Diameter	1.63 gal/209 fl. oz./376.8 cu. in.	2.44 gal/313 fl. Oz.	2.04 gal/261 fl. oz.
2 1/4" Diameter	2.06 gal/264 fl. oz./476.9 cu. in	3.09 gal/396 fl. Oz.	2.57 gal/330 fl. oz.

Note that the operating volumes include a 50% excess above the theoretical volume in sands and 25% in clays and silts. This is important to successful treatment. The additional material allows for a small degree of infiltration of the slurry into the surrounding soil and fractures, as well as hole diameter variability. It is important to assure that the entire contaminated saturated zone is treated (including the capillary fringe), since this is often the area of highest pollution concentration. Failure to treat this area due to improper installation can undermine an otherwise successful remediation effort.

APPENDIX C

FIELD FORMS

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Project Site Name: **SA2 TREATABILITY STUDY**
Sample ID No.:
Project No.:
Sample Location:
Sampled By:
Duplicate: ☐
Field Analyst:
Blank: ☐
Field Form Checked as per QA/QC Checklist (initials):

SAMPLING DATA:

Date: / Time: / Method:	Color (Visual)	ORP (Eh) (+/- mv)	S.C. (mS/cm)	Temp. (^0C)	Turbidity (NTU)	DO (Meter, mg/l)	Sal. (%)	pH (SU)

SAMPLE COLLECTION/ANALYSIS INFORMATION:

Dissolved Oxygen:

Equipment: HACH Digital Titrator OX-DT CHEMetrics (Range: _______mg/L) Analysis Time: ________

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	1-5 mg/L	200 ml	0.200 N	0.01
☐	2-10 mg/L	100 ml	0.200 N	0.02

Titration Count	Multiplier	Concentration
________	x 0.01	= mg/L
________	x 0.02	= mg/L

CHEMetrics: ________mg/L

Notes:

Alkalinity:

Analysis Time: ________

Equipment: HACH Digital Titrator AL-DT CHEMetrics (Range: _______mg/L) Filtered: ☐

Range Used:	Range	Sample Vol.	Cartridge	Multiplier	Titration Count	Multiplier	Concentration
☐	10-40 mg/L	100 ml	0.1600 N	0.1	______ & ______	x 0.1	= mg/L
☐	40-160 mg/L	25 ml	0.1600 N	0.4	______ & ______	x 0.4	= mg/L
☐	100-400 mg/L	100 ml	1.600 N	1.0	______ & ______	x 1.0	= mg/L
☐	200-800 mg/L	50 ml	1.600 N	2.0	______ & ______	x 2.0	= mg/L
☐	500-2000 mg/L	20 ml	1.600 N	5.0	______ & ______	x 5.0	= mg/L
☐	1000-4000 mg/L	10 ml	1.600 N	10.0	______ & ______	x 10.0	= mg/L

Parameter:	Hydroxide	Carbonate	Bicarbonate
Relationship:			

CHEMetrics: ________mg/L

Notes:

Standard Additions: ☐ Titrant Molarity:________ Digits Required: 1st.:________ 2nd.:________ 3rd.:________

Carbon Dioxide:

Equipment: HACH Digital Titrator CA-DT CHEMetrics (Range: _______mg/L) Analysis Time: ________

Range Used:	Range	Sample Vol.	Cartridge	Multiplier
☐	10-50 mg/L	200 ml	0.3636 N	0.1
☐	20-100 mg/L	100 ml	0.3636 N	0.2
☐	100-400 mg/L	200 ml	3.636 N	1.0
☐	200-1000 mg/L	100 ml	3.636 N	2.0

Titration Count		Concentration
________	x 0.1	= mg/L
________	x 0.2	= mg/L
________	x 1.0	= mg/L
________	x 2.0	= mg/L

CHEMetrics: ________mg/L

Notes:

Standard Additions: ☐ Titrant Molarity:________ Digits Required: 1st.:________ 2nd.:________ 3rd.:________

Tetra Tech NUS, Inc.

FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS

Project Site Name: **SA2 TREATABILITY STUDY**
Sample ID No.:
Project No.:
Sample Location:
Sampled By:
Duplicate: ☐
Field Analyst:
Blank: ☐
Field Form Checked as per QA/QC Checklist (initials):

SAMPLE COLLECTION/ANALYSIS INFORMATION:

Manganese (Mn^{2+}):

Equipment: DR-700 DR-8 _ _ HACH MN-5 Other: ________ Analysis Time: ________
Program/Module: 525nm 41
Concentration: ________ mg/L Filtered: ☐
Digestion: ☐
Standard Solution: ☐ Results: ______ Reagent Blank Correction: ☐
Standard Additions: ☐ Digits Required: 0.1ml:______ 0.2ml:______ 0.3ml:______
Notes:

Ferrous Iron (Fe^{2+}):

Equipment: DR-700 DR-8 _ _ IR-18C Color Wheel Other: ________ Analysis Time: ________
Program/Module: 500nm 33
Concentration: ________ mg/L Filtered: ☐
Notes:

Hydrogen Sulfide (H_2S):

Equipment: HS-C Other: ________ Analysis Time: ________
Concentration: ________ mg/L Exceeded 5.0 mg/L range on color chart: ☐
Notes:

QA/QC Checklist:

All data fields have been completed as necessary: ☐
Correct measurement units are cited in the SAMPLING DATA block: ☐
Mulitplication is correct for each *Multiplier* table: ☐
Final calulated concentration is within the appropriate *Range Used* block: ☐
Alkalinity *Relationship* is determined appropriatly as per manufacturer instructions: ☐
QA/QC sample (e.g., Std. Additions, etc.) frequency is appropriate as per the project planning documents: ☐
Nitrite Interference treatment used for Nitrate test if Nitrite was detected: ☐
Title block is initialized by person who performed the QA/QC Ckecklist: ☐

Tetra Tech NUS
Groundwater Purging and Sampling Log

Date ______________

Project Site Name:
Project No.: ____________

[ ] Domestic Well Data
[X] Monitoring Well Data
[ ] Other Well Type:____________

Flow-Thru Cell
Make\Model: __________
Serial Nos.:____________________

Sample Location:____________________
Sample ID No.:____________________
Sampled By:______________
C-O-C No.:______________

PURGING DATA

Casing	Gals. / Liters	Time	pH	S.C.	Temp.	Turbidity	DO	ORP	DTW	Flow Rate
Size (in.)	per ft. of Water	Hr:Min	pH units	mS/cm	°C	NTU	mg/L	mV	ft BTOC	ml/min
0.5	0.01 / 0.038									
1	0.041 / 0.155									
2	**0.163 / 0.617**									
4	0.653 / 2.47									
6	1.469 / 5.56									
8	2.611 / 9.88									
10	4.08 / 15.44									
	[1 gal. = 3.785 L]									
PID Reading (ppm):										
Well Casing Diameter:										
Total Well Depth:										
Static Water Level:										
Tube Intake Depth:										
Start Purge (hr):										
End Purge (hr):										
Total Purge Time (min):										
Total Vol. Purged:										

WATER QUALITY SAMPLE PARAMETERS

	Color	pH	S.C.	Temp.	Turbidity	DO	ORP	DTW	Flow Rate
Date:	Description	pH units	mS/cm	°C	NTU	mg/L	mV	ft BTOC	ml/min
Time:									

ANALYSES INFORMATION

Analysis		Preservative	Container Requirements			Collected
TCL VOCs	8260B	HCl	3	40 ml	glass vials	
SVOCs/PAHs	8270C/8310	None	2	1-liter	amber glass	
Pesticides	8081A	None	1	1-liter	amber glass	
Herbicides	8151	None	1	1-liter	amber glass	
X-tra Organic	8XXX	None	1 or 2	1-liter	amber glass	
TAL Metals	6000/7000	HNO_3	1	1-liter	HDPE	
TRPH	FL PRO	H_2SO_4	1	1-liter	amber glass	

ADDITIONAL INFORMATION

Comments:

Method:
[ ] Peristaltic Pump
[ ] Centrifugal Pump
[ ] Bladder Pump
[ ] Tube Evacuation
[ ] Vacuum Jug Assembly
[ ] Bailer

Tubing Type:
[ ] Polyethylene
[ ] Teflon
[ ] Teflon-lined Polyethylene

QA\QC SAMPLES

MS/MSD:

Duplicate ID No.:

Signature(s):

Tetra Tech NUS, Inc.

WELL COMPLETION FORM

JOB NAME:

JOB NUMBER:	PROJECT MANAGER:
LOGGED BY:	EDITED BY:
WELL NAME:	DATE:
DRILLING COMPANY:	
EQUIPMENT:	DRILLER:

☐ ____ INCH HOLLOW STEM AUGER

☐ ____ INCH ROTARY WASH

HOURS DRILLED:

GALLONS OF WATER USED DURING DRILLING:

METHOD OF DECONTAMINATION PRIOR TO DRILLING:

DEVELOPMENT

METHOD OF DEVELOPMENT:

DEVELOPMENT BEGAN DATE: TIME:

YEILD: GPM	TIME: FROM	TO	DATE:
YEILD: GPM	TIME: FROM	TO	DATE:
YEILD: GPM	TIME: FROM	TO	DATE:

TOTAL WATER REMOVED DURING DEVELOPMENT: GALLONS

DESCRIPTION OF TURBIDITY AT END OF DEVELOPMENT: ☐ CLEAR ☐ SLIGHTLY CLOUDY ☐ MOD. TURBID ☐ VERY MUDDY

ODOR OF WATER:

WATER DISCHARGED TO: ☐ GROUND SURFACE ☐ TANK TRUCK ☐ STORM SEWERS ☐ STORAGE TANK ☐ DRUMS ☐ OTHER ____

MATERIALS USED

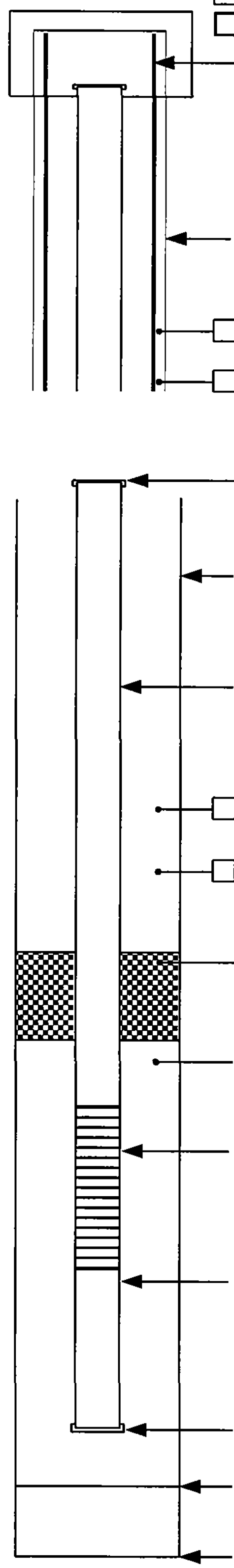
____ SACKS OF ____ SAND
____ SACKS OF ____ CEMENT
____ GALLONS OF GROUT USED
____ SACKS POWDERED BENTONITE
____ POUNDS OF BENTONITE PELLETS
____ FEET OF ____ INCH PVC BLANK CASING
____ FEET OF ____ INCH PVC SLOTTED SCREEN

____ YARD3 CEMENT-SAND (REDI-MIX) ORDERED
____ YARDS3 CEMENT-SAND (REDI-MIX) USED

CONCRETE PUMPER USED? ☐ NO ☐ YES

NAME ____

WELL COVER USED: ☐ LOCKING STEEL COVER ☐ CHRISTY BOX ☐ OTHER ____



☐ SEE "OTHER" BELOW
☐ LOCKING STEEL COVER
____ INCH DIAMETER
STEEL CONDUCTOR CASING
____ to ____ feet
____ INCH DIAMETER BOREHOLE
____ to ____ feet
☐ BENTONITE-CEMENT SEAL OR
☐ 8-SACK CEMENT-SAND SEAL
____ to ____ feet
TOP OF CASING AT
____ FEET ABOVE AT BELOW GROUND LEVEL
____ INCH DIAMETER BOREHOLE
____ to ____ feet
____ INCH DIAMETER SCHEDULE 40 PVC BLANK CASING
____ to ____ feet
☐ BENTONITE-CEMENT SEAL OR
☐ 8-SACK CEMENT-SAND SEAL
____ to ____ feet
BENTONITE PELLET SEAL
____ to ____ feet
SAND PACK
____ to ____ feet
____ INCH DIAMETER SLOTTED ____ INCH SCREEN
____ to ____ feet
____ INCH DIAMETER SCHEDULE 40 PVC BLANK SILT TRAP
____ to ____ feet
BOTTOM WELL CAP
____ feet
HOLE CLEANED OUT TO
____ feet
BOTTOM OF BOREHOLE
____ feet

NOT TO SCALE

ADDITIONAL INFORMATION: ____