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WORK PLAN FOR IN SITU CHEMICAL OXIDATION AT STUDY AREA 17 WITH TRANSMITTAL LETTER NTC ORLANDO FL
9/26/2000
CH2M HILL

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September 26, 2000

Ms. Barbara Nwokike
Remedial Project Manager
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
Charleston, SC 29406

Subject: Work Plan for In-Situ Chemical Oxidation IRA at Study Area 17
Naval Training Center, Orlando, Florida
CTO 0017, Contract No. N62467-98-D-0995

Dear Ms. Nwokike:

Enclosed please find the Work Plan for the In-Situ Chemical Oxidation IRA at Study Area 17, Naval Training Center, Orlando. Copies are also being distributed to members of the Orlando Partnering Team.

If you have any questions regarding this document, please call.

Sincerely,

CH2M HILL CONSTRUCTORS, Inc.

Steven N. Tsangaris, P.E.
Project Manager

xc: Wayne Hansel, Southern Division
Nancy Rodriguez, USEPA Region IV (2 copies)
David Grabka, FDEP (2 copies)
Rick Allen, HLA
Steve McCoy, Tetra Tech NUS
Craig Haas, CH2M HILL

WORK PLAN MEMORANDUM

Work Plan for In-Situ Chemical Oxidation IRA at Study Area 17, Naval Training Center, Orlando

PREPARED FOR: Barbara Nwokike – SoDiv

PREPARED BY: Steve Tsangaris - CH2M HILL

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Dan Bryant – Geo Cleanse
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CONTRACT: Navy Contract # N62467-98-D-0995

CTO: CTO 0017, Naval Training Center (NTC) Orlando

DATE: September 26, 2000

1. Introduction

This memorandum presents the Work Plan for activities related to the in-situ chemical oxidation injection Interim Remedial Action (IRA) at Study Area (SA) 17 at Orlando Naval Training Center (NTC). This work is being performed under the Remedial Action Contract No. N62467-98-D-0995, Contract Task Order (CTO) No. 0017 at Naval Training Center (NTC) Orlando in Orlando, Florida.

This document includes a description of the following:

- Project Background
- Project Objectives
- Project Organization
- Schedule
- Summary of Injector and Monitoring Well Installation Activities
- Summary of Reagent Injection Activities
- Groundwater Sampling Activities
- Waste Management Plan
- IRA Construction Documentation Report

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2. Project Background

SA 17 is located at the NTC Orlando, a former Navy facility located in the city of Orlando, Florida (Figure 1).

SA 17 occupies approximately 25 acres in the central part of the McCoy Annex. The site includes Buildings 7178, 7191, 7193, and the adjacent area that formerly served as the Defense Property Disposal Office (DPDO) complex for the McCoy Annex. The southwestern corner of the site is undeveloped. A shallow canal that drains to the east extends along the entire southern boundary of the site (Figure 2)

In order to identify and evaluate areas where environmental media may have been adversely affected by past site activities, an initial site screening investigation was performed in 1995 by ABB Environmental Services, Inc. Findings from that investigation indicated exceedances of screening criteria for polynuclear aromatic hydrocarbons (PAHs) in soil and chlorinated volatile organic compounds (VOCs) in groundwater. Subsequently, the Orlando Partnering Team (OPT) requested that Harding Lawson Associates (HLA) perform supplemental screening investigations to evaluate and characterize the VOC contamination at the site.

The results of the supplemental screening investigation indicated that the source of VOC-contaminated groundwater at the site is suspected to be related to operations at the former motor pool area. The highest total chlorinated VOC concentration detected during the investigation was 65,000 ug/L.

The OPT requested that CCI perform an Interim Remedial Action (IRA), consisting of confirming site conditions, development of an IRA approach, and implementation of an appropriate IRA. A two-phased approach was chosen by CCI to confirm site conditions. The objectives of the Phase I site characterization were to evaluate site hydrogeologic and geochemical conditions using existing monitoring wells and available data and to identify data gaps. The objectives of the Phase II site characterization were to complete the delineation (nature and extent) of the contamination and obtain additional information on site-specific geologic conditions, especially as they relate to the potential implementation of specific interim remedial actions. In addition, CCI collected and provided media and groundwater samples from contaminated areas at the site for use by bidders in bench scale treatability testing. The results of the Phase I/II confirmatory sampling activities completed by CCI are documented in the *Technical Memorandum: Phase I and II Data Report for Study Area 17, NTC Orlando (May 15, 2000).*

Chlorinated VOCs have adversely affected the groundwater throughout the surficial aquifer and the upper part of the intermediate aquifer of the Hawthorn Group sediments in isolated areas. Given the contaminant distribution pattern, the plume appears to have originated from two release points at the surface located in the western and central parts of the former motor pool area . In the western source area, the compounds detected at the highest concentrations were cis-1,2-DCE and vinyl chloride at concentrations of up to 400 ug/l. In the eastern source area, TCE was the predominant compound detected, with concentrations of up to 65,000 ug/l. The highest contaminant concentrations were detected along the water table in the source areas and along the upper surface of a silty sand layer that is located between 15 and 25 ft bls. This

layer and another somewhat deeper layer of silty sand act as aquitards that divide the surficial aquifer into three units – shallow, intermediate, and deep.

The plume extends along the water table from both source areas for a distance of approximately 50 to 100 ft in the direction of groundwater flow (east-southeast). In the intermediate unit of the surficial aquifer, the plume extends to a distance of approximately 250 ft downgradient, and in the deep unit of the aquifer, the plume extends approximately 300 ft from the source areas. Data from direct push samples collected during CCI's confirmatory sampling activities are shown on Figure 3.

Plume migration has been affected by the natural groundwater flow pattern. Groundwater flows horizontally in the source areas in a radial pattern, with the steeper gradient southward toward the drainage canal. There is a strong downward component to groundwater flow in the surficial aquifer. Groundwater contour drawings for the shallow, intermediate, and deep zones of the surficial aquifer at the site are shown on Figures 4 – 6, respectively.

Subsequent to completion of the confirmatory site characterization activities, CCI issued a Request for Bid for to implement an IRA consisting of in-situ oxidation using Fenton's Chemistry for source control/reduction of chlorinated solvent plume at the site. GeoCleanse International was selected as CCI's subcontractor to implement the IRA. The remedial goal for the IRA will be to mitigate the source areas at the site so that total VOC concentrations within the treatment area are below 500 ppb. After the source area treatment activities, it is believed that biodegradation of VOCs (natural and/or enhanced) will occur so that groundwater at the site will meet maximum contaminant levels.

3. Project Objectives

The objectives of the activities outlined in this Work Plan for SA 17 are to:

1) Install injectors for the remediation technology (in-situ chemical oxidation);

2) Install monitoring wells needed for this technology;

3) Determine baseline groundwater chemical concentrations in the newly installed wells and select injectors;

4) Implement the chemical oxidation injection activities, and monitor groundwater chemical concentrations during and immediately after in-situ chemical oxidation injection.

5) Upon completion of the injection activities and injection-related monitoring, begin a one year quarterly monitoring period to assess the effectiveness of the treatment and collect data to determine the feasibility of natural and/or enhanced biodegradation for residual VOC concentrations in groundwater at the site.

4. Project Organization

The U.S. Naval Facilities Engineering Command, Southern Division is the lead agency for this project.

The Southern Division Project Manager (PM), Mrs. Barbara Nwokike, is responsible for providing contract oversight for the Navy. Wayne Hansel, also with the Navy Southern Division, is the BRAC Environmental Coordinator responsible for the overall environmental activities at NTC. Bill Jacobs is the site caretaker for the Navy, and is responsible for contractor site access.

A summary of key project personnel is presented in Table 1.

4.1 Subcontractor Information

The in-situ chemical oxidation treatment program will be implemented by Geo-Cleanse International, Inc. (GCI) in collaboration with Harding/ESE, Inc. Groundwater samples collected during injection related sampling activities will be sent to a Navy- approved laboratory analysis for all required parameters.

4.2 CH2M HILL Project Team

Members of the CH2M HILL project team are presented below:

Project Manager – Steve Tsangaris, PE

Site Supervisor – Craig Haas

QC Manager – Jennifer Ottoson

Site Safety Coordinator – Fernando Ferreira

Field Team Members - Fernando Ferreira
Emiliano Cabale
Jennifer Ottoson
Kim-Lee Murphy
Isaac Lynch
Joshua Hayes

Contact information for key CH2M HILL project team members is included in Table 1.

5. Schedule

The following is a tentative schedule for in-situ treatment activities:

- Injector and monitoring well installation and development is scheduled to begin Wednesday, September 13, 2000, and last approximately four weeks.
- The pre-injection groundwater sampling event will commence immediately after the installations and last for approximately 3 days. The pre-injection groundwater sampling is tentatively set to begin on September 25, 2000.
- Approximately a week after analytical data is received from the pre-injection sampling event, GCI will mobilize at SA-17 and conduct Geo-Cleanse® Treatment injection. GCI has tentatively set an October 16, 2000 start date to begin reagent injection. During this injection, GCI will break approximately three days to allow for sampling of injectors and

monitoring wells by CH2M HILL. Sampling during injection is tentatively set to begin on October 30, 2000.

- A post-injection sampling will commence immediately after the injection at SA-17 is completed and will last approximately three days. The post-injection sampling event is scheduled for November 17, 2000.

A milestone project schedule is presented in the *Injection Work Plan*, prepared by GCI, and included as Attachment A in this Work Plan.

6. Summary of Injector and Monitoring Well Installation Activities

In general, the treatment area is roughly an L-shaped area encompassing the primary source area near DPT-1 (see Figure 3), extending southwest past DPT-16 to the fence line, and northwest to incorporate the portion of the plume extending to DPT-10. The vertical extent of the treatment area extends from the water table to a depth of approximately 26 feet below grade. This depth is based upon contaminant distribution and lithologic data that indicates the presence of an aquitard layer at approximately 26 feet below grade that significantly inhibits downward migration of VOCs below that depth.

A total of 69 injectors will be installed in three vertical levels. One level consisting of 9 injectors will be installed and screened from 10 to 13 feet below grade (shallow injectors). The second level consisting of 30 injectors will be installed and screened from 16-19 feet below grade (intermediate injectors). The third level consisting of 30 injectors will be installed and screened from 22 to 25 feet below grade (deep injectors). The deep injectors are screened at 25 feet below grade, rather than 26 feet below grade, to ensure that the aquitard layer is not penetrated. Details on the construction and location of these injectors are provided in the *Injection Work Plan*, prepared by GCI (Attachment A).

Two monitoring wells will be replaced, OLD–17-23A and OLD-17-24B. They are located in the most contaminated portion of the plume and treatment area. The new wells will be designated OLD-17-23A-R and OLD-17-24B-R. Details on the construction of these wells are also provided in Attachment A.

7. Summary of Fenton Reagent Injection Activities

The Geo-Cleanse® Process is a patented technology to simultaneously inject hydrogen peroxide and trace quantities of metallic salts under pressure to the subsurface in order to destroy organic contaminants in soil and groundwater. U.S. patents 5,525,008 and 5,611,642 protect the technology. The Geo-Cleanse® Process delivers a calculated charge of hydrogen peroxide and catalyst to the contaminated region via specially designed injection equipment consisting of mixing heads and subsurface injectors. The injection methodology and equipment are the keys to the Geo-Cleanse® Process. The chemistry involved is based upon Fenton's reagent. Fenton's reagent oxidizes organic contaminants to carbon dioxide and water, plus chloride (in the case of chlorinated compounds). The basics of Fenton's reagent chemistry and application to site-specific contaminants are described in detail in GCI's Work Plan provided in Attachment A. GeoCleanse was issued an order from FDEP granting a variance from underground injection control requirements for implementation of the Geo-Cleanse® Process.

During the primary phase of the Geo-Cleanse® Treatment Program at SA 17, an estimated 215,000 lbs (21,586 gal) of 50% hydrogen peroxide are anticipated for injection (50% concentration hydrogen peroxide is staged at the site for economic reasons; maximum injected concentration is 25%). A similar volume of catalyst solution is also anticipated for injection. A polish treatment will be conducted if necessary based on data collected during the injection data and discussions with the OPT.

The reagents used in the Geo-Cleanse® Process, and their purpose, injected concentrations and fate, are summarized as follows.

- *Hydrogen peroxide:* 50% technical grade, used as oxidizing agent. Injected into groundwater and soils with a maximum 25% concentration, with resultant concentrations to groundwater of less than 1%. This concentration quickly falls to less than 25 ppm within several hours following injection and typically is completely consumed within 2 to 3 days.

- *Ferrous sulfate:* 100-ppm aqueous solution of food grade reagent, used as catalyst. This concentration is typically diluted in groundwater to less than 10 ppm. The ferrous iron is oxidized in the subsurface to ferric iron and precipitates as an iron oxide or iron hydroxide. Ferrous sulfate may not be used if sufficient natural iron (greater than 25 mg/L) is present in groundwater.

- *Sulfuric acid:* 66° (98%) technical grade, diluted prior to injection in water to a pH of approximately 4. This is used in the catalyst solution to inhibit oxidation of ferrous iron to ferric iron in the catalyst solution prior to injection, and to adjust pH of the groundwater to the optimal range for Fenton's reagent (<6). Groundwater pH will return to ambient background conditions within a few days of injection. This reagent may not be utilized depending upon site-specific conditions. Sulfuric acid may not be used if either the groundwater pH is already acidic (<6) or if a more stabilizing catalyst solution is desired (in which case phosphoric acid may be used).

- *Phosphoric acid:* 85% technical grade, diluted prior to injection in water to a pH of approximately 4. This is used in the catalyst solution to inhibit oxidation of ferrous iron to ferric iron in the catalyst solution prior to injection, and to adjust pH of the groundwater to the optimal range for Fenton's reagent (<6). Groundwater pH will return to ambient background conditions within a few days of injection. This reagent may not be utilized depending upon site-specific conditions. Phosphoric acid may not be used if either the groundwater pH is already acidic (<6) or if a more reactive catalyst solution is desired (in which case sulfuric acid may be used).

- *Calcium phosphate:* 10-ppm aqueous solution of food grade reagent, used to stabilize the Fenton's reagent. This concentration is diluted in groundwater to less than 1 ppm. The calcium remains dissolved in solution and the phosphate is either precipitated or is utilized as a nutrient in biological reactions. This reagent may not be utilized depending upon site-specific conditions. Calcium phosphate may be used if additional phosphate is desired for stabilization, without additional acidity

As part of the process monitoring, GCI will collect field measurements during the injection to ensure that appropriate subsurface conditions exist for Fenton's reagent, that an efficient reaction is occurring, and to monitor the reaction progress. Parameters that are monitored

include both groundwater quality and liberated gas measurements. At least two rounds of groundwater samples are collected each day, including one in the morning prior to beginning the injection and one in the afternoon prior to concluding injection for the day. Gas measurements are conducted at approximately 2-hour intervals throughout the day. Monitoring is performed only in the active treatment area (i.e., the entire site is not monitored during every round). Additional analyses may be performed as dictated by site conditions, but not at prescribed time intervals. Parameters that are monitored, and their purpose, method, resolution and range are as follows:

- *pH:* Groundwater pH is monitored to ensure that appropriate pH conditions (pH <6) are established. A Hach test kit model 17-F is used. The test is a colorimetric method using bromothymol blue as an indicator. The range is 5.5 to 8.5 with resolution of ±0.1 units. The pH measurements may be supplemented with test strips (0 to 6 with resolution of ±0.5 units) if necessary. A pH meter is not used because the electrodes are damaged by hydrogen peroxide.

- *Alkalinity:* Alkalinity affects Fenton's reagent treatment because dissolved bicarbonate (the predominant component of groundwater alkalinity) is an efficient hydroxyl free radical scavenger. A target value of <100 mg/L is desired. Alkalinity is also related to pH, because groundwater pH controls bicarbonate equilibrium and the capacity of the groundwater to contain bicarbonate. A Hach test kit model AL-AP/MG-L is used. The test is a titration method using a sulfuric acid reagent. The range is 0 to 100 mg/L (as $CaCO_3$) with resolution of ±5 mg/L, or 20 to 400 mg/L with resolution of ±20 mg/L.

- *Dissolved Chloride:* Chloride is produced as an oxidation product of chlorinated hydrocarbons (see Section 2.2). A Hach test kit model 8-P is used. The test is a titration method using a silver nitrate indicator. The range is 5 to 100 mg/L (as Cl^-) with ±5 mg/L resolution, or 20 to 400 mg/L (as Cl^-) with ±20 mg/L resolution.

- *Dissolved Iron:* Dissolved iron (either as ferrous or ferric forms) is a catalyst for Fenton's reagent. A minimum of 10 mg/L is desired in groundwater, and dissolved iron monitoring determines if ferrous sulfate is used in the catalyst blend. A Hach test kit model IR-18B is used. The test is a colorimetric method using phenanthroline reagent. The range is 0 to 10 mg/L with resolution of ±0.2 mg/L.

- *Hydrogen Peroxide:* Hydrogen peroxide is monitored to ensure that reagents are distributed throughout the treatment area. Hydrogen peroxide is measured with Merckoquant colorimetric test strips (E.M. Science, Gibbstown, NJ) with a measurable range of 0 to 100 mg/L. The test strips have indicators labeled at 0, 1, 3, 10, 30, and 100 mg/L peroxide, and intermediate concentrations can be interpolated.

- *Carbon dioxide:* Oxidation of organic compounds yields carbon dioxide (see Section 2.2), which is liberated from the subsurface through adjacent injectors and monitoring wells. Carbon dioxide production is a sensitive measure of the efficiency and progress of the treatment. At sites impacted by chlorinated aliphatics such as TCE, carbon dioxide production typically reach maximum levels of approximately 7 to 10% in the early stages (first 2 to 4 days) of injection then decrease asymptotically to zero over the course of the treatment as the subsurface organic contaminants are destroyed. Carbon dioxide concentration is measured in headspaces of injectors and monitoring wells within and

adjacent to the treatment area. The measurement is performed with a GasTech GT series carbon dioxide/oxygen meter. The meter uses a non-dispersive infrared absorbance detection method. Resolution is ±0.1% and range is 0 to 20%.

- *Oxygen:* Reaction of hydroxyl free radicals with hydrogen peroxide, other radicals, or other non-organic compounds produces oxygen. Oxygen is liberated from the subsurface through adjacent injectors and monitoring wells. At sites impacted by chlorinated aliphatics such as TCE, oxygen production is typically low in the first few days of injection (approximately 10 to 15%) then increases to >30% over the course of the treatment as the subsurface organic contaminants are destroyed. Oxygen concentration is measured in headspaces of injectors and monitoring wells within and adjacent to the treatment area. The measurement is performed with a GasTech GT series carbon dioxide/oxygen meter. The meter uses an electrochemical detection method. Resolution is ±0.1% and range is 0 to 30%.

- *Volatile Organic Compounds:* Fenton's reagent produces offgases, which pass through potentially contaminated water prior to liberation via adjacent wells. Gases passing through a contaminated groundwater may entrain relatively low concentrations of volatile organic compounds. Henry's Law predicts the maximum concentration of a volatile organic compound in a gas that has passed through a contaminated water sample. As a rule of thumb (supported by GCI field experience), the maximum concentration of a VOC in the offgas is approximately the same order of magnitude as the concentration of the VOC in groundwater. Thus the concentration of VOCs in offgases is typically a maximum in the initial stages (one to two days) of injection and then decreases over the course of the treatment. Volatile organic compounds are monitored with a PID meter. The PID meter reads a concentration in parts per million (ppm) by volume, however that reading does not correspond exactly to a concentration of VOCs in the air sample. The PID response varies among organic compounds, and the PID also responds to water vapor (resulting in a PID reading that is much higher than the actual VOC concentration in the offgas). PID readings are measured in headspaces of injectors and monitoring wells within and adjacent to the treatment area. The measurement is performed with a ThermoEnvironmental 580B PID meter with a 10.6 eV lamp. Resolution is ±0.1 ppm and range is 0 to 2,500 ppm.

Complete details on the Geo-Cleanse® Process and injection activities are provided in GCI's Work Plan in Attachment A.

8. Groundwater Sampling Activities

Three different groundwater sampling events for laboratory analysis will be conducted during the injection activities. The first event occurs before the GCI injection (pre-injection); the second event occurs during the injection (concurrent-injection); and the third event occurs after the injection (post-injection).

Four quarterly sampling events will be performed after injection-related activities are complete.

A description of each of the sampling events is presented below, along with sampling procedures.

All sampling will be in accordance with the Orlando POP and CH2M HILL's approved FDEP CompQAP. Field testing equipment will be calibrated according to the manufacturer instructions and recorded in the site logbook.

8.1 Summary of Sampling Events

Pre-Injection Sampling Event

Groundwater samples will be collected from 3 shallow injectors, 9 intermediate injectors, 8 deep injectors, and the 2 newly replaced monitoring wells. The locations of these monitoring wells are shown on figures in Attachment A. They are listed below:

- S-1, S-5, and S-9 (shallow injectors)
- I-1, I-4, I-12, I-15, I-17, I-21, I-24, I-29, and I-30 (intermediate injectors)
- D-3, D-6, D-7, D-19, D-20, D-26, D-28, and D-30 (deep injectors)
- OLD-17-23A-R and OLD-17-24B-R (monitoring wells within contaminant plume)

Groundwater samples will be analyzed for volatile organic compounds (VOCs) by Method 8260B, chloride by Method 315.5, and target analyte list (TAL) metals by Method 6010B/7000 series. Sampling parameters are summarized in Table 2.

The Field Team will also collect field measurements for temperature, pH, conductivity, dissolved oxygen, turbidity, and redox potential.

Samples will be collected using low flow techniques, with a flow through cell for the collection of field measurements. Additional information on sampling and analysis is included below.

Concurrent-Injection Sampling Event

Groundwater samples will be collected from the 22 injectors and monitoring wells listed above in the pre-injection sampling event.

Groundwater samples will be analyzed for VOCs by Method 8260B and chloride by Method 315.5.

The Field Team will also collect field measurements for temperature, pH, conductivity, dissolved oxygen, turbidity, and redox potential.

Samples will be collected with a flow through cell for the collection of field measurements. Since no metals will be sampled, low flow techniques will not be necessary. Additional information on sampling and analysis is included below.

Post-Injection Sampling Event

Groundwater samples will be collected from 5 monitoring wells once the injection is completed.

- OLD-17-04A (upgradient)
- OLD-17-26A and OLD-17-27B (within contaminant plume)
- OLD-17-23A-R and OLD-17-24B-R (within contaminant plume)

Groundwater samples will be analyzed for VOCs by Method 8260B, chloride by Method 315.5, and target analyte list (TAL) metals by Method 6010B/7000 series.

The Field Team will also collect field measurements for temperature, pH, conductivity, dissolved oxygen, turbidity, and redox potential.

Samples will be collected using low flow techniques, with a flow through cell for the collection of field measurements. Additional information on sampling and analysis is included below.

Quarterly Sampling Events

Groundwater samples will be collected from up to 15 monitoring wells at the site as part of the treatment efficiency quarterly monitoring after completion of the injection-related activities. The list of monitoring wells to be sampled and sampling parameters will be determined upon completion of the injection activities, and will be provided to the OPT for approval prior to the initiation of sampling.

8.2 Monitoring Well Purging and Sampling Procedures

Collection of groundwater samples from monitoring wells is required to characterize the nature and extent of contamination. Because of concerns about turbidity in the wells and the effects on metals sampling results, the low-flow purge and sample method will be used during the pre- and post-injection sampling events. No metals will be sampled during the injection; thus, this is not a concern.

Pre-purging Activities

The following activities will be performed immediately prior to purging each well:

1. Check the well or injector for proper identification and location.
2. Measure and record the height of protective casing.
3. Measure and record the distance between the top of the well casing and the top of the protective casing.
4. Using the electronic water-level meter, measure and record the static water level from the reference point to an accuracy of 0.01 foot. Upon removing the water-level wire, rinse it with analyte-free water from an approved water source.

Well heads will be inspected for any signs of forced entry, which could invalidate the sampling data.

Purging

The pre- and post-injection groundwater sampling should be conducted using low-flow purge techniques. The low-flow purge and sample method consists using a submersible or peristaltic pump to purge the well at a very low flow rate (less than 1 liter per minute [l/min]). The pump intake is set approximately in the middle of the well screen, with a stagnant water column over the top of the pump. The well is purged at the low-flow rate until the field parameters (temperature, pH, specific conductance, turbidity, DO, and redox potential) have stabilized. The sample is then collected using the peristaltic pump.

A submersible pump capable of achieving higher purge rates (>1 l/min) should be used during the concurrent-injection sampling. As with low-flow purging, the pump intake is set approximately in the middle of the well screen, with a stagnant water column over the top of

the pump. The well is purged until the field parameters (temperature, pH, specific conductance, turbidity, DO, and redox potential) have stabilized. The sample is then collected.

The following steps outline the purging and sampling activities.

1. The intake for the pump should be set at approximately the middle of the screen. Be careful not to place the pump intake less than 2 feet above the bottom of the well because this may cause mobilization of any sediment present in the bottom of the well. Start pumping the well at less than 1 l/min.

2. The water level in the well should be monitored during pumping and, ideally, the pump rate should equal the well recharge rate with little or no water-level drawdown in the well (the water level should stabilize for the pumping rate). There should be at least 1 foot of water over the pump intake so there is no risk of the pump suction being broken or entrainment of air in the sample. Record the pumping rate adjustments and depth(s) to water in the logbook. If the recharge rate of the well is very low and the well is purged dry, then wait until the well has recharged to a sufficient level and collect the appropriate volume of sample with the pump, or use standard purge-and-sample techniques.

3. During purging, monitor the field parameters (temperature, pH, turbidity, specific conductance, DO, and redox potential) using the flow through cell approximately every 3 to 5 minutes (or as often as practical) until the parameters have stabilized to within 10 percent (plus or minus 5 percent) over a minimum of three readings. Wells should be purged a minimum of three well volumes, but no more than five well volumes. If field parameters do not stabilize after five well volumes, the monitor well should be sampled.

4. Record the *in situ* parameters (pH, temperature, specific conductance, turbidity, DO, and redox potential), along with the corresponding volume purged, on a Groundwater Sample Field Data Record or in a bound field logbook.

Sampling Procedures

Once the field parameters have stabilized, collect the samples. Volatiles and analytes that degrade by aeration must be collected first. Volatile samples will be collected by shutting off the pump, disconnecting the tubing, holding a thumb over the end of the tubing, and withdrawing the tubing from the well. The sample containers will be filled by removing the thumb and allowing groundwater to flow, by gravity, into the containers containing preservatives. All other sample bottles should be filled, using the submersible pump, by allowing the water to flow gently down the inside of the bottle with minimal turbulence. Cap each bottle as it is filled. Document all field procedures used and any pertinent field observations.

Clean unused tubing should be used for each monitoring well. Used tubing will be disposed of as solid waste.

Shipping

Samples will be preserved, labeled, and placed immediately into a cooler and maintained at 4 degrees Celsius (°C) throughout the sampling and transportation period. Samples should be labeled, recorded on the COC, and shipped/delivered to the appropriate laboratory.

Analytical Turn Around Times (TATs)

Due to the schedule of the chemical oxidation injection and the data required to perform the injection, quick TATs are required for all three sampling events.

Pre-Injection Sampling Event

A 3-day TAT will be required of Form 1 data for VOC analyses. A 7-day TAT will be required of Form 1 data for chloride and metals analyses. The data packages for the Level III analyses will be due within 21 days of receipt of samples at lab.

Concurrent-Injection Sampling Event

A 24-hour TAT will be required of Form 1 data for VOC analyses. A 7-day TAT will be required of Form 1 data for chloride analyses. The data packages for the Level III analyses will be due within 21 days of receipt of samples at lab.

Post-Injection Sampling Event

A 3-day TAT will be required of Form 1 data for VOC analyses. A 7-day TAT will be required of Form 1 data for chloride and metals analyses. The data packages for the Level III analyses will be due within 21 days of receipt of samples at lab.

Field Documentation

A single responsible party will be designated for field documentation whenever feasible. For multi-person sampling teams, the party responsible for documentation will be focused on the field documentation effort such as the daily log and other related forms and will not be directly involved in the sample collection activities. The field documentation will include sufficient detailed information so that the history of each sample can be retained when necessary without the assistance of the sample collection personnel. Data will typically include a detailed description of equipment decontamination procedures, equipment calibration procedures, preparatory purging at each sample location, inventory of all generated wastes, and disposition of all generated wastes. Information can be recorded in the field log book, or on the attached Waste Inventory Tracking Form, Water Level Form, Monitoring Well Purging Form, Field Sampling Report.

Sample Identification

All samples and field quality control will be designated a unique sample identification. The sample identification procedure to be implemented for the monitoring well samples is described as follows:

CTO Number-Monitoring Well/Injector Location-Q #-Year-Number of Months of Treatment System Operation (if applicable)

- Q #: Represents the quarter number in the calendar year (e.g., fourth quarter is Q4)
- Number of Months of Treatment System Operation (if applicable): Represents the number of months the groundwater treatment system, soil treatment system, and/or product recovery system has been in operation since start-up.
- An example of the monitoring well sample identification protocol is a quarterly sampling event conducted at a site with an air sparge system that has been in operation since November 1997. The sample event, conducted under CTO No. 0002, included a

sample collected from groundwater monitoring well MW-1 in May 1998. This example has the following identification number: 002-MW1-Q2-98-06.

Sample Custody

Because of the evidentiary nature of samples collected throughout the project, the possession of samples must be traceable from the time the samples are collected until they are introduced as evidence in legal proceedings. To maintain and document sample possession, chain-of-custody procedures are followed as described below:

A sample is under your custody if:

- It is in your actual possession, or
- It is in your view, after being in your physical possession, or
- It was in your physical possession and then you locked it up to prevent tampering, or
- It is in a designated secure area.

The custody of samples is recorded in the following field documents:

- Sample logs
- Sample labels
- Custody seals
- Chain-of-custody (COC) form

Sample Log Book

It is necessary for the sampling crew to maintain daily field notes. Items that must be included are sampling protocol, any changes to the procedures, meetings, instructions, safety precautions, personnel protection, and activities pertaining to the samples. The person taking notes must be knowledgeable enough about these activities to know which details are important.

Repetition of information recorded in other permanent logs should be avoided, but enough should be recorded to present a clear and accurate picture of technical activities. At a later date, should a question arise concerning a specific event or a procedure used, it will be answered from these notes. The following information should be logged into the log books and/or database:

- Date and time of sampling
- Sample number, locations, type, matrices, volumes, sample ID and descriptions, type and number of sample containers, names and signatures of individuals performing sampling tasks, COC and airbill numbers, preservatives, and date samples were sent
- Name of laboratories and contacts to which the samples were sent, and data results, when possible
- Termination of a sample point or parameter and reasons
- Unusual appearance or odor of a sample
- Measurements, volume of flow, temperature, and weather conditions

- Additional samples and reasons for obtaining them
- Levels of protection used (with justification)
- Meetings and telephone conversations held with the Southern Division, NTR, regulatory agencies, project manager, or supervisor
- Details concerning any samples split with another party
- Details of QC samples obtained
- Field testing equipment calibration results

These notes must be dated and signed (each page) for validity in a court of law. All log books will be bound and pre-numbered. All log book entries will be made with indelible ink and legibly written. The language will be factual and objective. No erasures will be permitted. If an incorrect entry is made, the error will be crossed out with a single strike mark, initialed, and dated.

When audits are performed, the auditor's remarks and decisions must also appear in these notes. These audits should be followed up by written report submitted by the auditor, including opinions and conclusions. A copy of this report should be placed in the project file and one copy kept in the sampling file for easy reference.

Sample Labels

Any samples placed into a sample container will be identified by a sample label. The following information is included on the label:

- Project Number and Project Name
- Date – month, day, year
- Time – Military time
- Sample Identification
- Sample Description
- Sampler – Sampler's name(s)
- Preservatives
- Analyses Requested

This information should be printed neatly using an indelible marker. After the sample is taken and the label is securely attached, the sample is logged into the sample log book.

Custody Seals

Custody seals are narrow strips of adhesive tape of glass fiber used to demonstrate that no tampering has occurred. They may be used on sampling equipment, sample transport containers, and individual sample jars. They should be signed and dated by the sampler and placed from one side, across the top, and to the other side of the sample bottle or across the openings of the sample transport containers.

Chain-of-Custody Form

A COC form will be completed for each sampling event and will accompany the samples during shipment. The COC record documents the sample information and the transfer of

custody from the sampler to the laboratory. The record will, at a minimum, contain the following:

- Project Name
- Project Location – City and State in which the project is located
- Project Number
- Project Contact – CCI employee responsible for overseeing the sampling operation. This person should be the individual to whom questions are to be directed or verbal results given (Project Manager, Site Supervisor, Project QC Officer, or Project Chemist)
- Site Telephone Number – Telephone number of on-site office trailer or number where person responsible for samples can be contacted.
- Sample Date – month, day, year
- Sample Time – military time
- Sample Identification – unique sample number/identifier
- Sample Type – designation of sample as grab or composite
- Sample Description – sample matrix and a brief description of the sampling location
- Sample Preservation – preservatives used
- Analytical Parameters Requested – analytical parameter, method numbers, and specific compounds of interest, if applicable.
- Airbill or courier tracking number
- Laboratory – laboratory where samples are to be sent
- Laboratory Phone – telephone number of laboratory
- Laboratory Contact – contact for laboratory
- Relinquished by – signature of sender (CCI)
- Date Relinquished – date samples were relinquished
- Accepted by – signature of acceptor
- Date Received – date samples were accepted
- Turnaround Time – turnaround times requested or date the results are required from the lab
- Sampler's Signature – signature of sampler
- Signature of person(s) involved in chain of possession
- Transfer date(s) and time(s) in chain of possession

Personnel preparing the COC form (i.e., sampler) will retain a copy of the form and attach it to the project's daily field logs.

If the samples are shipped by common carrier, the COC form will be placed in a sealed plastic bag inside the shipping container. Prior to shipment, the shipping container will be secured with strapping tape and a custody seal. Thus, in the case of using a common carrier for shipment, two signatures will be required on the final chain-of-custody: one signature by the sample technician who prepared the form and one signature of the sample custodian assigned by the laboratory. The sample technician will relinquish the samples to the carrier. The carrier's company name and tracking number will be placed in the box of "receiver" and in the box of "relinquisher" upon being received at the laboratory by the sample custodian. The sample custodian must ensure that the tracking number on the sample container matches that on the COC. The sample custodian assigned by the laboratory will open the shipping container and will document on the chain-of-custody form any shipping container custody seal breaks and/or shipping container or sample container(s) damage.

Equipment Decontamination

Field equipment decontamination should follow the procedures described below. For equipment not listed below, refer to the ***Performance Operations Plan*** for proper decontamination procedures

Well Sounders and Groundwater Measurement Tapes: Decontamination procedures for Teflon™, PVC, stainless-steel, and glass tubing used for groundwater sampling are listed below.

- Wash with laboratory detergent and tap water.
- Rinse with tap water.
- Rinse with analyte-free (deionized) water.
- Wrap equipment in aluminum foil.

Field Parameter Measurement Probes: Field parameter measurement probes, (e.g., pH or specific ion electrodes, geophysical probes, or thermometers) that come in direct contact with the sample will be decontaminated using the procedures listed below, unless manufacturer's instructions indicate otherwise. Probes that make no direct contact (e.g., OVA equipment) will be wiped with clean paper towels.

- Rinse with tap water.
- Rinse with analyte-free (deionized) water.
- Solvent rinse if obvious contamination remains after rinsing and if solvent will not damage probe.
- Rinse with analyte-free (deionized) water.

Sampling Equipment for Organic and Metal Analysis: Teflon™, stainless-steel, glass, or metal sampling equipment used to collect samples for organic and metal analysis will be cleaned between sample locations as listed below.

- Wash and scrub equipment thoroughly with laboratory detergent and tap water.
- Rinse thoroughly with tap water.
- Rinse thoroughly with deionized, analyte-free water.
- Rinse with solvent (pesticide-grade isopropanol). Note: Do not rinse PVC or plastic materials with solvent.
- Rinse with organic-free water and allow to air dry as long as possible.
- Wrap with aluminum foil to prevent contamination.

Field Quality Control

The following Field Quality Control Samples will be collected during the sampling activities (see Table 2 for numbers of samples and analytes)

Duplicate Sample -- two or more samples collected from a common source. The purpose of a duplicate sample is to estimate the variability of a given characteristic or contaminant associated with a population.

Trip Blanks -- a sample which is prepared at the laboratory using analyte-free water and shipped with the empty sampling containers and is stored with the samples throughout the sampling event. They are then packaged for shipment with the other samples and submitted for analysis. At no time after their preparation are trip blanks to be opened before they reach the laboratory. Trip blanks are used to determine if samples were contaminated during storage and/or transportation back to the laboratory (a measure of sample handling variability resulting in positive bias in contaminant concentration). If volatile organic samples are to be shipped, trip blanks are to be provided with each cooler.

Pre-Cleaned Equipment Blanks - a sample collected using analyte-free water which has been run over/through sample collection equipment. These samples are used to determine if contaminants have been introduced by contact of the sample medium with sampling equipment. Pre-cleaned equipment blanks will be collected on equipment that is brought to the site pre-cleaned and ready for use. Pre-cleaned equipment will include disposable sampling equipment (i.e., disposable Teflon bailers, etc.). These blanks will be collected from the sampling equipment immediately prior to sampling by rinsing the sampling equipment with analyte-free water and collecting rinseate in the appropriate sample containers.

Field-Cleaned Equipment Blanks - a sample collected using organic-free water which has been run over/through sample collection equipment. These samples are used to determine if contaminants have been introduced by contact of the sample medium with sampling equipment. Field-cleaned equipment blanks are often associated with collecting rinse blanks of equipment that has been field-cleaned. These blanks will be collected after the equipment is decontaminated by rinsing the sampling equipment with analyte-free water and collecting rinseate in the appropriate sample containers.

Field Water Blanks Field water blanks include a complete set of samples collected from each water source used in the investigation. One set of samples will be collected from each water source used at the beginning of the project and one set at the completion of the project. These

blanks should account for potential artifacts that could be introduced through decontamination procedures.

MS and MSD Samples An important element of the NTC, Orlando effort will be the collection and analysis of samples to evaluate matrix effects on target compound response. Extra sample volume will be provided to the laboratory for the preparation of MS/MSD samples. MS/MSD samples will be prepared in the laboratory by adding a known amount of pure compounds to an environmental sample to simulate background and interference found in actual samples. MS/MSDs will be performed for every 20 samples of similar matrix.

9. Waste Management Plan

As part of the field activities, a certain amount of waste material will be generated in association with personal protection, sample handling, injector and monitoring well installation, well purging and sampling, and decontamination. Every effort will be made to minimize the waste generated and to dispose of the material in the most appropriate, cost-effective manner. The majority of material generated by investigation activities will be uncontaminated or below applicable disposal limits; however, some material will come in contact with, or be composed of contaminated media, which may require pretreatment or off-site disposal.

The IDW will be segregated by medium (i.e., solids or liquids) and by location (i.e., boring, well, study area) into storage containers (generally, Department of Transportation [DOT]-approved 55-gallon drums). Analysis Pending labels will be attached to the storage containers that describe the content of the specific container, the POI or Study Area of origin, the specific exploration location, and the date of generation. The storage containers will be segregated on pallets by POI or Study Area of origin.

After receipt of analytical results, the IDW storage containers will be labeled as "Non-Hazardous" or "Hazardous Waste", using the criteria below.

- Analytical results are less than TCLP threshold values (40 CFR §261.24) - the corresponding IDW will be labeled as "Non-Hazardous"

- Analytical results exceed TCLP threshold values - the corresponding IDW will be labeled as "Hazardous Waste"

Labels will also include the initial date of accumulation (i.e., the date the waste is first placed in a tank or drum). Wastes will be disposed of from the site within 45 days of generation.

The storage container pallets will be arranged so as to allow access between them for inspection. A logbook will be maintained with the preceding information recorded in it, as well as a sketch map of the storage areas. The IDW storage area will be designated within the fenced area of the site. Daily inspections of the IDW storage areas will be conducted to confirm that all requirements are being met and that the integrity of all storage containers remains uncompromised.

Approximately 4 weeks of drilling is anticipated at the site. A representative IDW soil sample will be collected each week to characterize the soil IDW generated that week. Laboratory

analysis of composite soil samples from IDW drums will be compared to background soil screening criteria developed for NTC Orlando. If analytical results are below background screening criteria, the material can be spread on the ground surface within the contaminated area at the site. Analytical results above background screening criteria will be used to characterize the material for offsite disposal.

Laboratory analysis of groundwater samples from the representative monitoring wells will be used to determine if the liquid IDW is acceptable to the City of Orlando for disposal to the onsite sewer systems. If representative groundwater samples have been collected and submitted for laboratory analysis of site-specific compounds, those results will be submitted to determine disposal options.

Analytical results, either from the contract laboratory (Level III or IV data) will be submitted to the City of Orlando for approval, on a drum-by-drum basis, to dispose of the IDW in the onsite sewer system. Once approval for disposal via the sewers is received, the City and Public Works Center (PWC) Orlando are notified of the date, location, and approximate amount of liquid to be disposed of. A designated drain at each separate facility at NTC, Orlando has been designated for IDW disposal to minimize the handling and transportation of the containers. If the City of Orlando rejects a specific container or group of containers, a determination will be made whether some pretreatment (e.g., carbon stripping) will render the material suitable for on-site disposal or whether off-site disposal will be necessary.

10. IRA Construction Documentation Report

Upon completion of the IRA implementation, a construction documentation report will be prepared to describe the details of the chemical oxidation injection and groundwater monitoring activities. The construction documentation report will also include applicable record drawings sealed by a registered Florida Professional Engineer.

TABLES

NO.

1 Project Personnel Directory for NTC Orlando

2 Sampling and Laboratory Analytical Summary

TABLE 1
Project Personnel Directory for NTC Orlando

Contact	Role	Address	Phone No.	Fax No.	E-Mail
Barbara Nwokike	Navy Remedial Project Manager	U.S. Naval Facilities Engineering Command Southern Division, Code 1873 2155 Eagle Drive N. Charleston, SC 29406	(843) 820-5566	(843) 820-5563	nwokikebr@efdsouth.navfac.navy.mil
Wayne Hansel	BRAC Environmental Coordinator	U.S. Naval Facilities Engineering Command Southern Division, Code 18B7 2155 Eagle Drive N. Charleston, SC 29406	Charleston (843) 820-5572 Orlando (407) 895-6714	Charleston (843) 820-5563 Orlando (407) 894-4992	Hanselwj@efdsouth.navfac.navy.mil
Bill Jacobs	Site Caretaker	Caretaker Site Office 2850 Seabee Street Orlando, FL 32806	407) 895-9103	(407) 894-4992	
Scott Newman	Program Manager	CCI 115 Perimeter Center Place, N.E., Suite 700 Atlanta, GA 30346-1278	Atlanta (770) 604-9182 x 519 Charleston (843) 746-8882	(770) 604-9182	snewman@ch2m.com
Bob Nash	Health & Safety Manager	CH2M HILL 115 Perimeter Center Place, N.E., Suite 700 Atlanta, GA 30346-1278	(770) 604-9182 x 341	(770) 604-9182	rnash@ch2m.com
Mike Rossman	Contracts Administrator/ Project Controls	CCI 115 Perimeter Center Place, N.E., Suite 700 Atlanta, GA 30346-1278	(770) 604-9182 x 421	(770) 604-9182	mrossman@ch2m.com
Theresa Rojas	Program Quality Control	CCI 115 Perimeter Center Place, N.E., Suite 700 Atlanta, GA 30346-1278	(770) 604-9182 x 568	(770) 604-9182	trojas@ch2m.com
Lisa Schwan	Project Chemist	CCI 115 Perimeter Center Place, N.E., Suite 700 Atlanta, GA 30346-1278	(770) 604-9182 x 561	(770) 604-9182	Lschwan@ch2m.com
Steve Tsangaris	Project Manager	4350 W. Cypress Street, Suite 600 Tampa, FL 33607	(813) 874-0777 x 4305 Cellular phone (727) 492-7467	(813) 874-3056	Stsangar@ch2m.com
Craig Haas	Site Supervisor	4350 W. Cypress Street, Suite 600 Tampa, FL 33607	(813) 874-0777 x 4305 Cellular phone (904) 237-3038	(813) 874-3056	Chaas@ch2m.com
Jennifer Ottoson	Field Hydrogeologist/ QC Manager	205 Indian River Dr. Cocoa, Fl 32922	321-636-7575	321-636-7522	jottoson@ch2m.com
Fernando Ferreira	Field Hydrogeologist / Site Health & Safety Coordinator	1328 Richwood Circle Rockledge, FL 32955	(321) 693-0169		fferreir@ch2m.com
Dan Byrant	Project Manager/Geo-Cleanse International	Geo-Cleanse International, Inc. 4 Mark Road, Suite C Kenilworth, NJ 07033	(908) 206-1250	(908) 206-1251	dbryant@geocleanse.com

TABLE 2
Sampling and Laboratory Analytical Summary

Sample Task	Sample Point	Matrix	Approx Sample No	Sampling Method (Note 1)	Sampling Equipment (Note 1)	TAT[1]	DQO Level/ Data Package Reqmnt	Required Analysis	Analytical Method	Holding Time	Sample Preservtn[1]	Containers
SA-17 Pre- Injection Groundwater Sampling												
Groundwater Sampling	2 Groundwater Monitoring Wells and 20 Injectors at SA-17 as described in Workplan	Water	22 + 10% Dup + 5% MS/MSD	Grab	Teflon Bailer	Various (see Note 2 below)	DQO Level III, CCI Level C	Volatiles	8260B (25 ml purge)	14 days	HCl pH< 2; Cool to 4°C	(2) 40 ml vial
								Chloride	315.1	28 days	Cool to 4°C	(1) 0.5L HDPE
								TAL Metals	6010/700	6 months	HNO3 pH<2 Cool to 4oC	(1) 0.5L HDPE
	Pre-cleaned Equipment Rinsate Blank	Water	2	Prepared in the Field	N/A	Various (see Note 2 below)	DQO Level III, CCI Level C	Volatiles	8260B (25 ml purge)	14 days	HCl pH< 2; Cool to 4°C	(2) 40 ml vial
								Chloride	315.1	28 days	Cool to 4°C	(1) 0.5L HDPE
								TAL Metals	6010/700	6 months	HNO3 pH<2 Cool to 4oC	(1) 0.5L HDPE
	Field Blank	Water	2	Prepared in the Field	N/A	Various (see Note 2 below)	DQO Level III, CCI Level C	Volatiles	8260B (25 ml purge)	14 days	HCl pH< 2; Cool to 4°C	(2) 40 ml vial
	Trip Blank	Water	2	Prepared by Lab	N/A	Various (see Note 2 below)	DQO Level III, CCI Level C	Volatiles	8260B (25 ml purge)	14 days	HCl pH< 2; Cool to 4°C	(2) 40 ml vial
SA-17 Concurrent-Injection Groundwater Sampling												
Groundwater Sampling	2 Groundwater Monitoring Wells and 20 Injectors at SA-17 as described in Workplan	Water	22 + 10% Dup + 5% MS/MSD	Grab	Teflon Bailer	Various (see Note 2 below)	DQO Level III, CCI Level C	Volatiles	8260B (25 ml purge)	14 days	HCl pH< 2; Cool to 4°C	(2) 40 ml vial
								Chloride	315.1	28 days	Cool to 4°C	(1) 0.5L HDPE
	Pre-cleaned Equipment Rinsate Blank	Water	2	Prepared in the Field	N/A	Various (see Note 2 below)	DQO Level III, CCI Level C	Volatiles	8260B (25 ml purge)	14 days	HCl pH< 2; Cool to 4°C	(2) 40 ml vial
								Chloride	315.1	28 days	Cool to 4°C	(1) 0.5L HDPE
	Field Blank	Water	2	Prepared in the Field	N/A	Various (see Note 2 below)	DQO Level III, CCI Level C	Volatiles	8260B (25 ml purge)	14 days	HCl pH< 2; Cool to 4°C	(2) 40 ml vial
	Trip Blank	Water	2	Prepared by Lab	N/A	Various (see Note 2 below)	DQO Level III, CCI Level C	Volatiles	8260B (25 ml purge)	14 days	HCl pH< 2; Cool to 4°C	(2) 40 ml vial

Notes
1) In accordance with NTC Orlando POP

Sample Task	Sample Point	Matrix	Approx Sample No	Sampling Method (Note 1)	Sampling Equipment (Note 1)	TAT[1]	DQO Level/ Data Package Reqmnt	Required Analysis	Analytical Method	Holding Time	Sample Preservtn[1]	Containers
SA-17 Post-Injection Groundwater Sampling												
Groundwater Sampling	2 Groundwater Monitoring Wells and 20 Injectors at SA-17 as described in Workplan	Water	22 + 10% Dup + 5% MS/MSD	Grab	Teflon Bailer	Various (see Note 2 below)	DQO Level III, CCI Level C	Volatiles	8260B (25 ml purge)	14 days	HCl pH< 2; Cool to 4°C	(2) 40 ml vial
								Chloride	315.1	28 days	Cool to 4°C	(1) 0.5L HDPE
								TAL Metals	6010/700	6 months	HNO3 pH<2 Cool to 4oC	(1) 0.5L HDPE
	Pre-cleaned Equipment Rinsate Blank	Water	2	Prepared in the Field	N/A	Various (see Note 2 below)	DQO Level III, CCI Level C	Volatiles	8260B (25 ml purge)	14 days	HCl pH< 2; Cool to 4°C	(2) 40 ml vial
								Chloride	315.1	28 days	Cool to 4°C	(1) 0.5L HDPE
								TAL Metals	6010/700	6 months	HNO3 pH<2 Cool to 4oC	(1) 0.5L HDPE
	Field Blank	Water	2	Prepared in the Field	N/A	Various (see Note 2 below)	DQO Level III, CCI Level C	Volatiles	8260B (25 ml purge)	14 days	HCl pH< 2; Cool to 4°C	(2) 40 ml vial
	Trip Blank	Water	2	Prepared by Lab	N/A	Various (see Note 2 below)	DQO Level III, CCI Level C	Volatiles	8260B (25 ml purge)	14 days	HCl pH< 2; Cool to 4°C	(2) 40 ml vial

Notes
1) In accordance with NTC Orlando POP

Sample Task	Sample Point	Matrix	Approx Sample No	Sampling Method (Note 1)	Sampling Equipment (Note 1)	TAT[1]	DQO Level/ Data Package Reqmnt	Required Analysis	Analytical Method	Holding Time	Sample Preservtn[1]	Containers
SA-17 Disposal Sampling												
Disposal of Aqueous Waste Sampling, and Decon Activities	Drums	Water	7	Grab	Drum thief or dip jar	7 days	DQO Level III, CCI Level A	TCL Volatiles	8260B	14 days	HCl pH< 2; Cool to 4°C	(2) 40 ml vial
								TCL Semi-volatiles	8270C	14 days ext; 40 days analysis	Cool to 4°C	(3) 1L amber glass
								TCL Pesticides	8081A	14 days ext; 40 days analysis		
								Herbicides	8151A	7 day extr; 40 day analysis		
								TCL PCBs	8082	14 days ext; 40 days analysis		
								TAL Metals	6010B/7470A	180 days; Hg = 28 days	HNO3 pH< 2; Cool to 4°C	(1) 500ml HDPE
								Cyanide	335.3	14 days	Cool to 4°C NaOH pH>12	(1) 200ml glass
								Reactivity	9045B	ASAP	Cool to 4°C	(1) 500ml HDPE
								Ignitability	1010/1020A	ASAP		
								Corrosivity	Chapter 7.3	ASAP		
Disposal of Solid Waste Drilling, Sampling, and Decon Activities	Drums	Soil	3	Composite	Dig to approx 12" for sample	7 days	DQO Level III, CCI Level A	TCLP Volatiles	1311/8260B	14 day TCLP extr; 14 day analysis	Cool to 4°C	(1) 4 oz amber glass
								TCLP Semi-Volatiles	1311/8270C	14 day TCLP extr; 7 day extr; 40 day analysis	Cool to 4°C	(1) 16 oz amber glass
								TCLP Pesticides	1311/8081A	14 day TCLP extr; 7 day extr; 40 day analysis		
								TCLP Herbicides	1311/8151A	14 day TCLP extr; 7 day extr; 40 day analysis		
								TCLP Metals	6010B, 7470A	6 month TCLP extr; 6 month analysis Hg: 28 day TCLP extr; 28 day analysis	Cool to 4°C	(2) 16 oz amber glass
								PCBs	8082	14 day extr; 40 day analysis		
								Ignitabiltiy	1030	ASAP		
								Corrosivity	9045A	ASAP		
								Reactivity	Chapter 7.3	ASAP		

Notes:

1) In accordance with the Orlando POP

2) Pre-Injection TAT: 3 day TAT for VOC; 7 day TAT for chloride and TAL metals (prelims)

Concurrent-Injection TAT: 24 hour TAT for VOC; 7 day TAT for chloride (prelims)

Post-Injection TAT: 3 day TAT for VOC; 7 day TAT for chloride and TAL metals (prelim)

Notes

1) In accordance with NTC Orlando POP

FIGURES

NO.

1 Location of Study Area 17

2 Monitoring Well and DPT Location Plan

3 Direct Push Sampling Results

4 Shallow Groundwater Contour Map, SA17

5 Intermediate Groundwater Contour Map, SA17

6 Deep Groundwater Contour Map, SA17

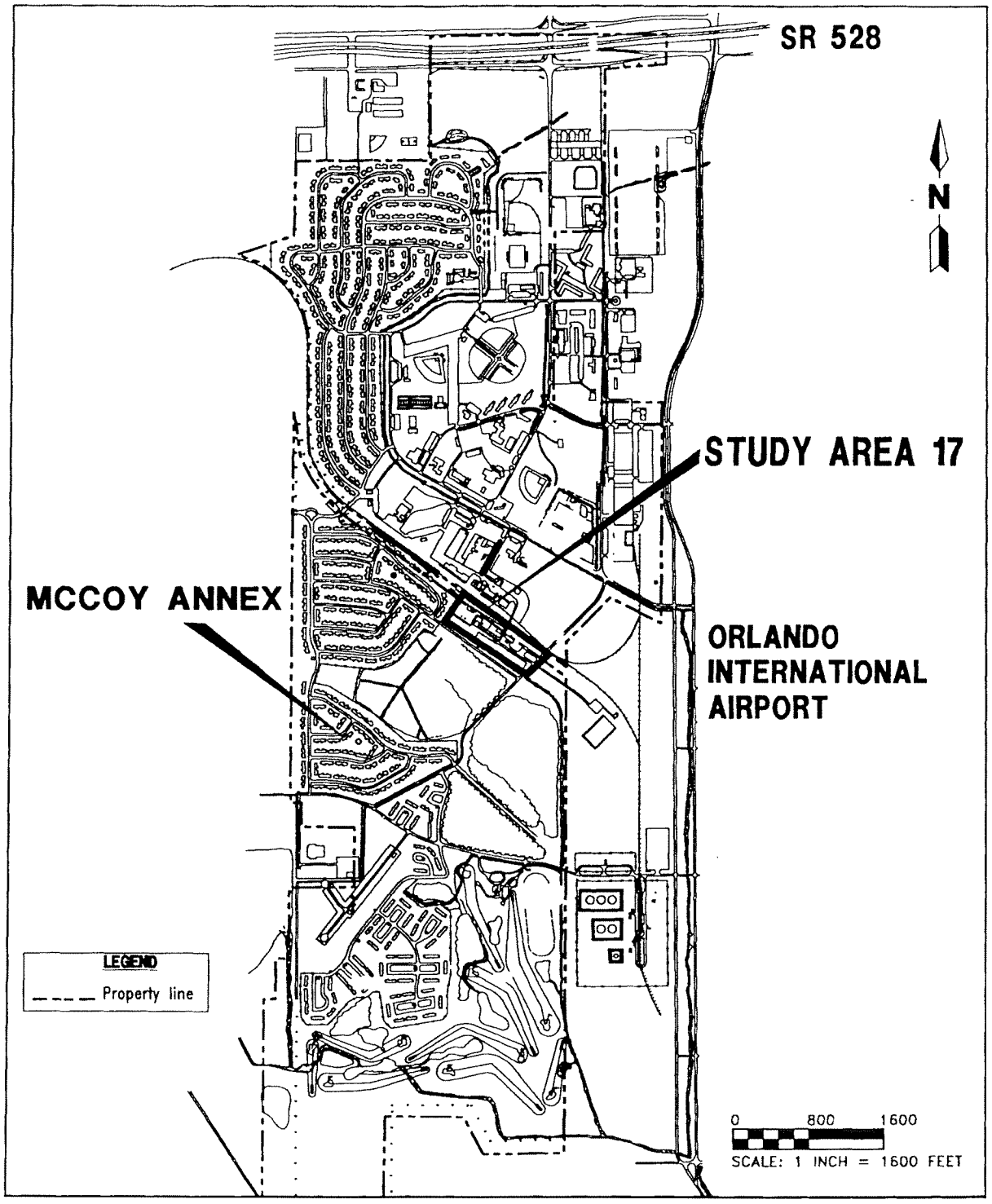


FIGURE 1
Location of Study Area 17
Naval Training Center,
Orlando, Florida

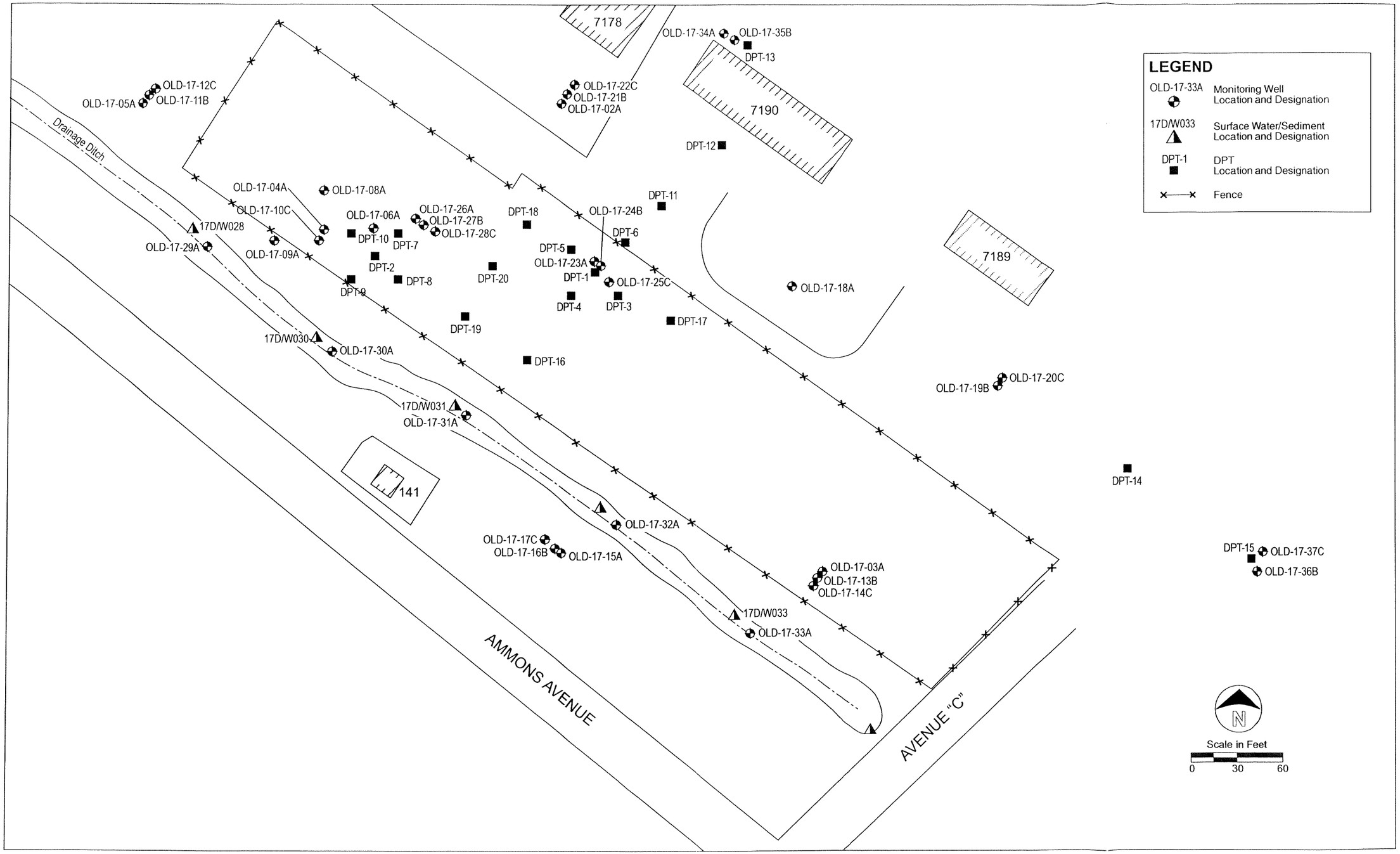
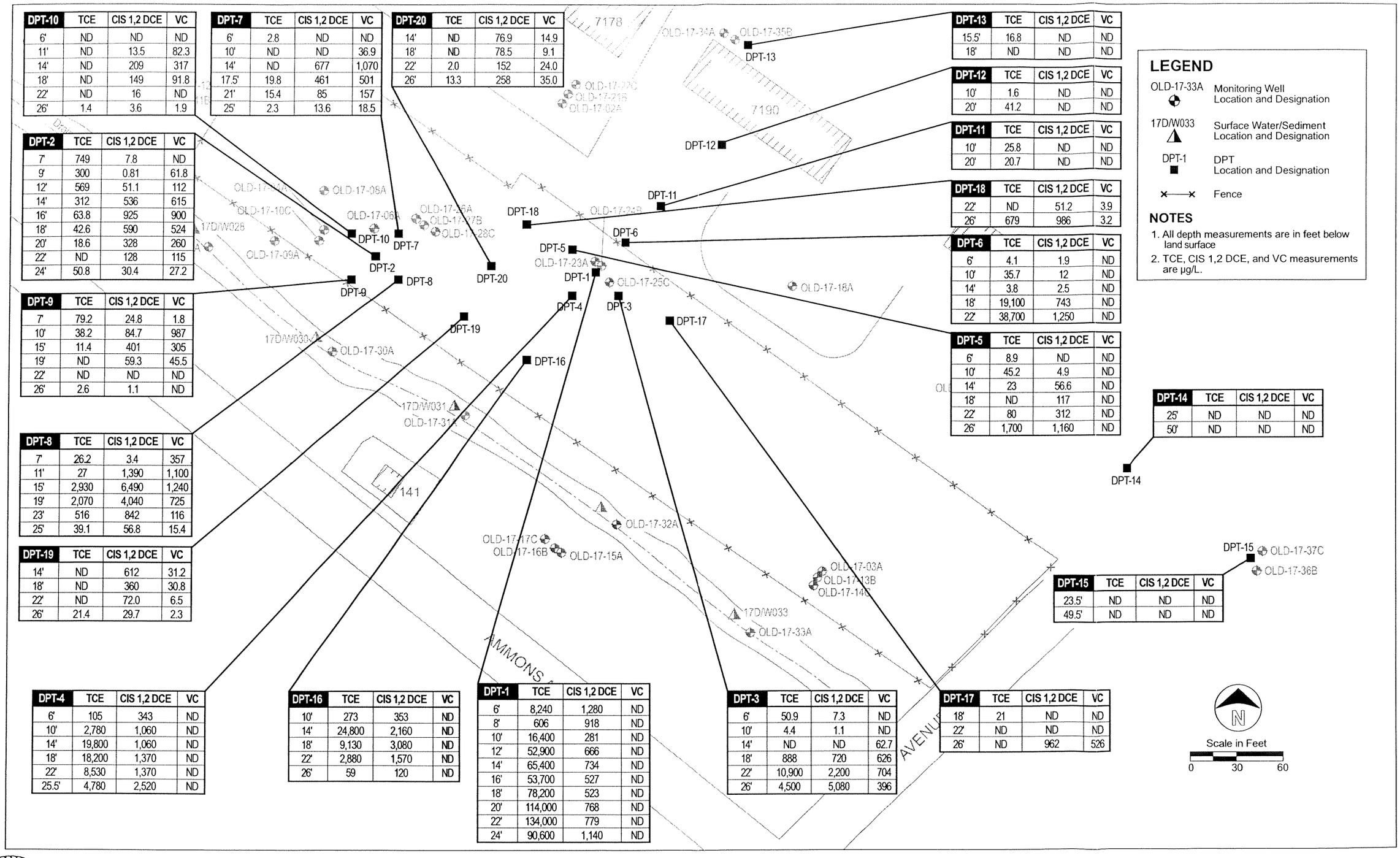


FIGURE 2
Monitoring Well and DPT Location Plan
Study Area 17, Naval Training Center, Orlando, Florida



DPT-10	TCE	CIS 1,2 DCE	VC
6'	ND	ND	ND
11'	ND	13.5	82.3
14'	ND	209	317
18'	ND	149	91.8
22'	ND	16	ND
26'	1.4	3.6	1.9

DPT-7	TCE	CIS 1,2 DCE	VC
6'	2.8	ND	ND
10'	ND	ND	36.9
14'	ND	677	1,070
17.5'	19.8	461	501
21'	15.4	85	157
25'	2.3	13.6	18.5

DPT-20	TCE	CIS 1,2 DCE	VC
14'	ND	76.9	14.9
18'	ND	78.5	9.1
22'	2.0	152	24.0
26'	13.3	258	35.0

DPT-13	TCE	CIS 1,2 DCE	VC
15.5'	16.8	ND	ND
18'	ND	ND	ND

DPT-12	TCE	CIS 1,2 DCE	VC
10'	1.6	ND	ND
20'	41.2	ND	ND

DPT-11	TCE	CIS 1,2 DCE	VC
10'	25.8	ND	ND
20'	20.7	ND	ND

DPT-18	TCE	CIS 1,2 DCE	VC
22'	ND	51.2	3.9
26'	679	986	3.2

DPT-6	TCE	CIS 1,2 DCE	VC
6'	4.1	1.9	ND
10'	35.7	12	ND
14'	3.8	2.5	ND
18'	19,100	743	ND
22'	38,700	1,250	ND

DPT-5	TCE	CIS 1,2 DCE	VC
6'	8.9	ND	ND
10'	45.2	4.9	ND
14'	23	56.6	ND
18'	ND	117	ND
22'	80	312	ND
26'	1,700	1,160	ND

DPT-14	TCE	CIS 1,2 DCE	VC
25'	ND	ND	ND
50'	ND	ND	ND

DPT-15	TCE	CIS 1,2 DCE	VC
23.5'	ND	ND	ND
49.5'	ND	ND	ND

DPT-2	TCE	CIS 1,2 DCE	VC
7'	749	7.8	ND
9'	300	0.81	61.8
12'	569	51.1	112
14'	312	536	615
16'	63.8	925	900
18'	42.6	590	524
20'	18.6	328	260
22'	ND	128	115
24'	50.8	30.4	27.2

DPT-9	TCE	CIS 1,2 DCE	VC
7'	79.2	24.8	1.8
10'	38.2	84.7	987
15'	11.4	401	305
19'	ND	59.3	45.5
22'	ND	ND	ND
26'	2.6	1.1	ND

DPT-8	TCE	CIS 1,2 DCE	VC
7'	26.2	3.4	357
11'	27	1,390	1,100
15'	2,930	6,490	1,240
19'	2,070	4,040	725
23'	516	842	116
25'	39.1	56.8	15.4

DPT-19	TCE	CIS 1,2 DCE	VC
14'	ND	612	31.2
18'	ND	360	30.8
22'	ND	72.0	6.5
26'	21.4	29.7	2.3

DPT-4	TCE	CIS 1,2 DCE	VC
6'	105	343	ND
10'	2,780	1,060	ND
14'	19,800	1,060	ND
18'	18,200	1,370	ND
22'	8,530	1,370	ND
25.5'	4,780	2,520	ND

DPT-16	TCE	CIS 1,2 DCE	VC
10'	273	353	ND
14'	24,800	2,160	ND
18'	9,130	3,080	ND
22'	2,880	1,570	ND
26'	59	120	ND

DPT-1	TCE	CIS 1,2 DCE	VC
6'	8,240	1,280	ND
8'	606	918	ND
10'	16,400	281	ND
12'	52,900	666	ND
14'	65,400	734	ND
16'	53,700	527	ND
18'	78,200	523	ND
20'	114,000	768	ND
22'	134,000	779	ND
24'	90,600	1,140	ND

DPT-3	TCE	CIS 1,2 DCE	VC
6'	50.9	7.3	ND
10'	4.4	1.1	ND
14'	ND	ND	62.7
18'	888	720	626
22'	10,900	2,200	704
26'	4,500	5,080	396

DPT-17	TCE	CIS 1,2 DCE	VC
18'	21	ND	ND
22'	ND	ND	ND
26'	ND	962	526

LEGEND

OLD-17-33A — Monitoring Well Location and Designation

17D/W033 — Surface Water/Sediment Location and Designation

DPT-1 — DPT Location and Designation

Fence

NOTES

1. All depth measurements are in feet below land surface
2. TCE, CIS 1,2 DCE, and VC measurements are µg/L.

FIGURE 3
Direct Push Sampling Results
Study Area 17, Naval Training Center, Orlando, Florida

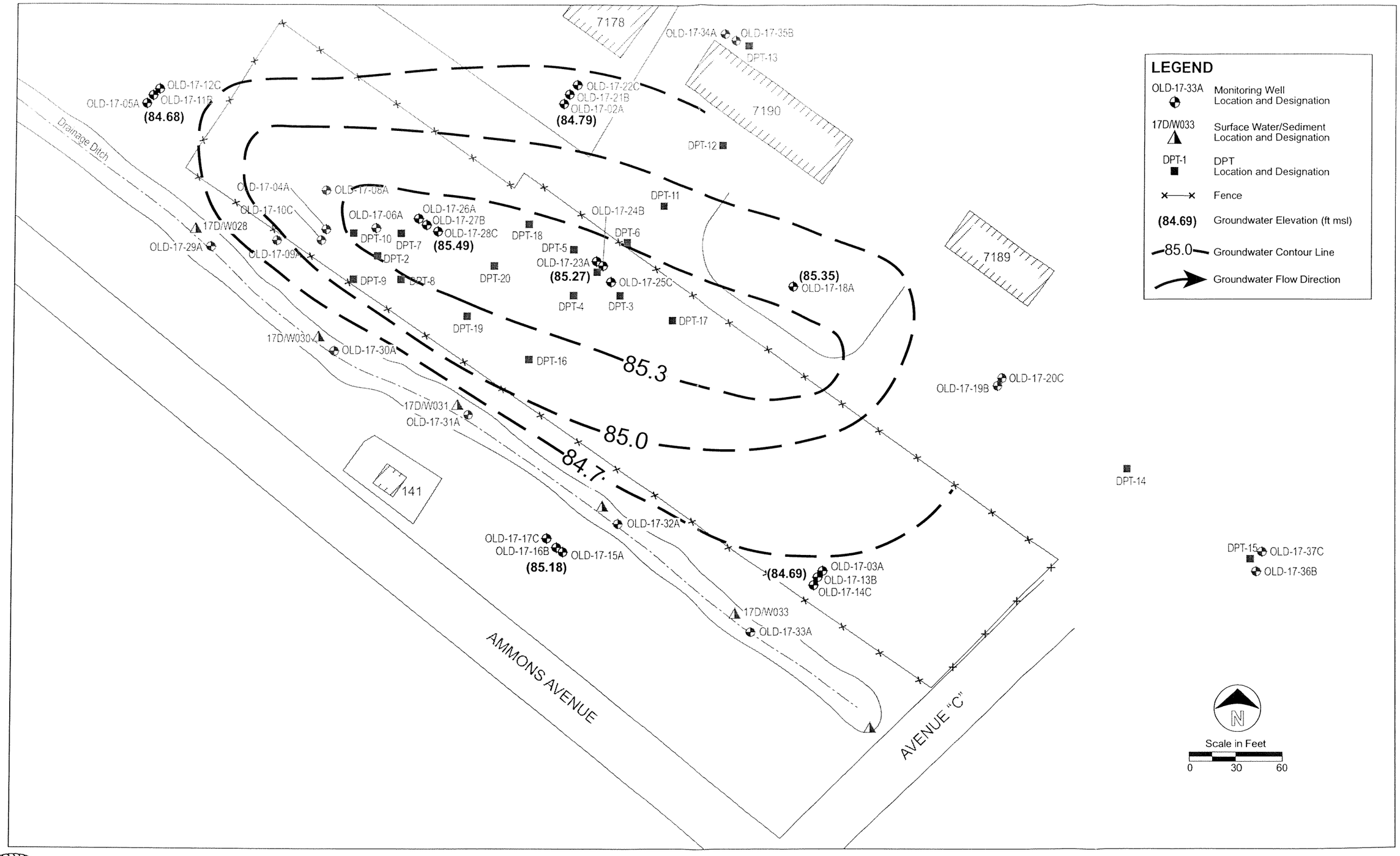


FIGURE 4
Shallow Groundwater Contour Map, SA17
April 28, 2000
Study Area 17, Naval Training Center, Orlando, Florida

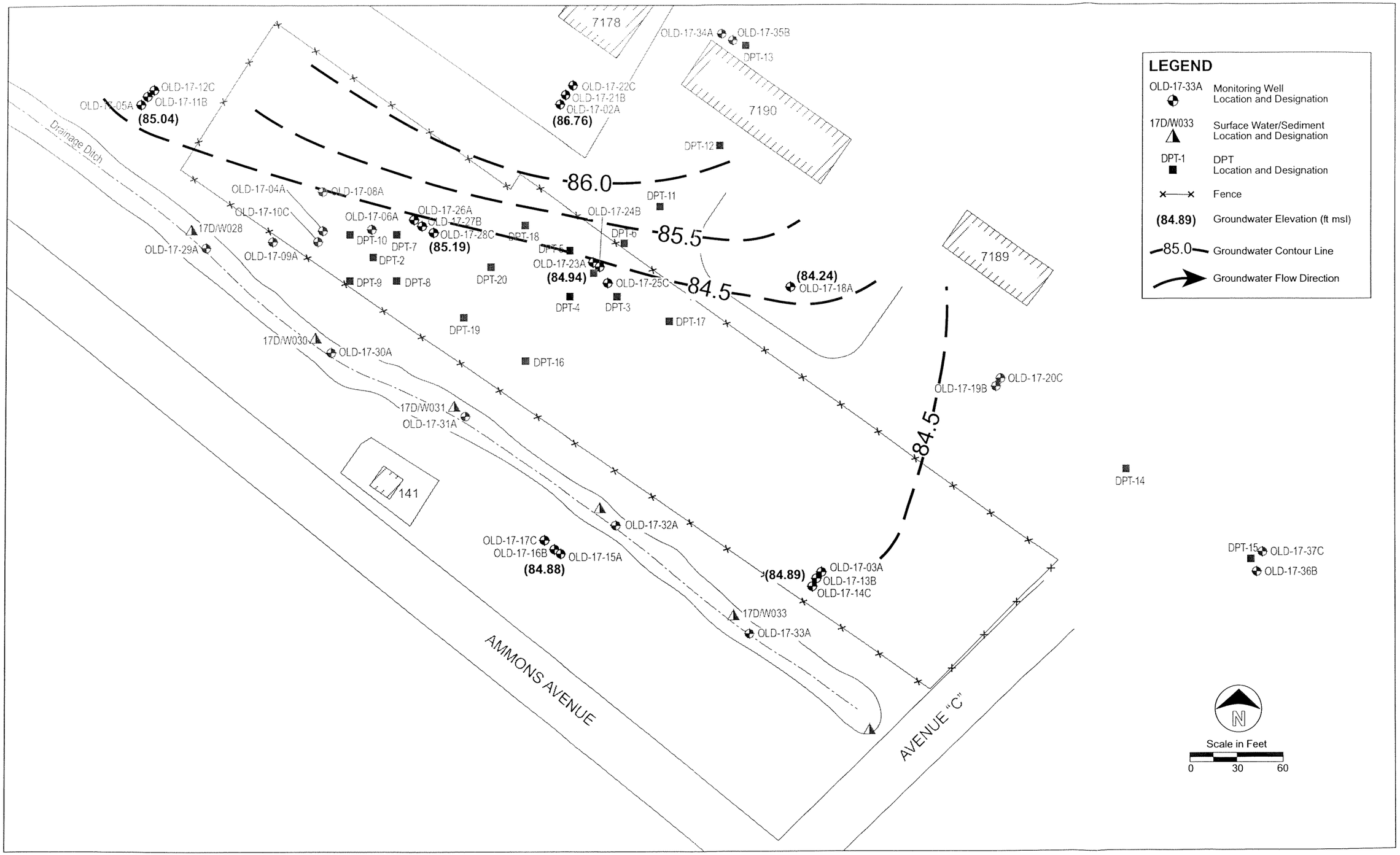


FIGURE 5
Intermediate Groundwater Contour Map, SA17
April 28, 2000
Study Area 17, Naval Training Center, Orlando, Florida

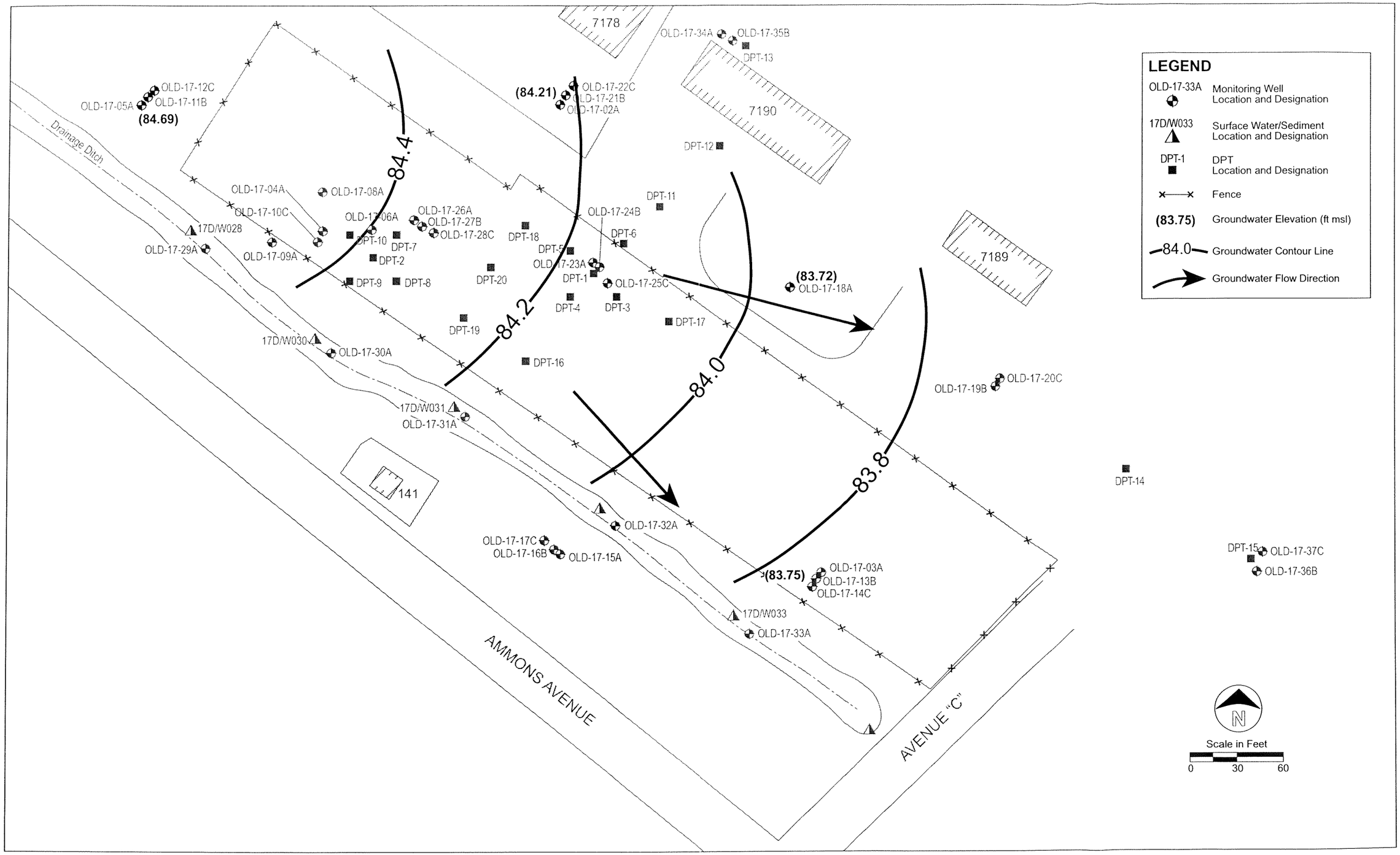


FIGURE 6
Deep Groundwater Contour Map, SA17
April 28, 2000
Study Area 17, Naval Training Center, Orlando, Florida

ATTACHMENTS

NO.

1 Draft Injection Work Plan, Geo-Cleanse Treatment Program

Geo-Cleanse International, Inc.

Draft Injection Work Plan
Geo-Cleanse® Treatment Program

Study Area 17
Orlando Naval Training Center
Orlando, Florida

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1. INTRODUCTION

Geo-Cleanse International, Inc. (GCI) has been awarded a contract from CH2M Hill Constructors, Inc. (CH2M Hill) under Request for Bid CTO 17-246, to perform an in-situ chemical oxidation treatment program using the Geo-Cleanse® Process to address volatile organic constituents (VOCs) in groundwater at Study Area 17 (SA 17), Naval Training Center (NTC) Orlando. The treatment program will be implemented by GCI in collaboration with Harding/ESE, Inc. (Harding/ESE). GCI and Harding/ESE will design and implement the in-situ chemical oxidation treatment and will conduct process monitoring during the treatment program. CH2M Hill will conduct pre- and post-test site characterization in preparation for, and performance monitoring of, the in-situ chemical oxidation treatment.

Reports detailing the site conditions upon which the Geo-Cleanse® Treatment Program was designed are:

- Harding Lawson Associates. *Base Realignment and Closure Environmental Site Screening Report, Study Area 17, Naval Training Center, Orlando, Florida.* Dated March 1999.
- CH2M Hill Constructors, Inc. *Phase I and II Data Report for Study Area 17, NTC, Orlando.* Dated May 15, 2000.

These reports form the basis for design of the Geo-Cleanse® Treatment Program and for the facility and geologic summaries presented below. Based upon review of these documents, its understanding of the geologic and hydrogeologic conditions of the affected areas, and the chemical properties of the VOCs reported present at the site, GCI believes that in-situ chemical oxidation using the Geo-Cleanse® Process offers an appropriate remedial approach for SA 17. This draft work plan summarizes site geologic and hydrogeologic setting, nature and extent of VOC contamination, basis of the Geo-Cleanse® Process, treatment program objectives, treatment design, injection methods and equipment, process monitoring, and performance sampling.

The remainder of this work plan is organized as follows:

Section 1, Introduction (this section)— Further in Section 1 is a brief description of the background of the site including history, surface features, geologic and hydrogeologic setting, nature and extent of VOC contamination, and treatment objectives.

Section 2, Summary of the Geo-Cleanse® Process— Describes the basic chemical reactions involved, treatment of specific contaminants identified at the site, and equipment used for the Geo-Cleanse® Process.

Section 3, Implementation of the Geo-Cleanse® Process— Describes design elements for the Geo-Cleanse® Treatment at the site, including monitoring, injector design and installation, and sequence of events.

Section 4, Project Schedule— Presents a list of milestones and target task completion dates for major aspects of the treatment program.

Section 5, References— Presents a bibliographic list of references cited in the text.

1.1. FACILITY DESCRIPTION

Study Area (SA) 17 of the Naval Training Center (NTC) Orlando occupies approximately 25 acres in the central part of the McCoy Annex (Figure 1-1). The site includes Buildings 7178, 7190, 7191, 7193, and an adjacent area that served as the Defense Property Disposal Office complex (Figure 1-2). The buildings within SA 17 were constructed between 1952 and 1965. Each building previously had an associated above ground or underground storage tank for fuel oil, and hazardous material storage areas were identified in several locations. Southwest of Building 7190 is a relatively flat, grass-covered area enclosed by a fence. This area formerly served as a motor pool area, and several drums of waste fuel, oil, and ethylene glycol were previously stored there. A vehicle wash rack is also identified just outside the northern fence line. Additional details regarding the individual buildings are provided in the *Base Realignment and Closure Environmental Site Screening Report*.

1.2. SITE FEATURES

1.2.1. Site Topography

The targeted treatment area (generally within the central portion of the fenced area identified in Figure 1-2) has a flat topography at approximately 90 feet above sea level. A drainage canal (approximately 5 feet deep) borders the treatment area along the southwest margin of the site, outside the fence.

1.2.2. Geologic and Hydrogeologic Setting

The soils in the area of Building 81 are typically tan to gray, fine-grained, quartz sand to silty quartz sand, extending to a depth of approximately 30 feet below grade. The sand layers comprise a shallow surficial aquifer overlying the Hawthorn Group, which is encountered at approximately 30 feet below grade and distinguished by a transition to light green, silty, poorly-sorted fine to coarse sand with phosphate nodules and shell fragments. For this work plan, the portion of the aquifer within the sand unit overlying the Hawthorn Group is referred to as the surficial aquifer.

Groundwater is initially encountered at approximately 5 feet below grade. Within the shallowest levels of the surficial aquifer (less than 14 feet below grade), groundwater has a mound centered near Old-17-04A with a radial flow pattern (Figure 1-3). Within the intermediate and deep portions of the surficial aquifer (21 to 31 feet below grade), the groundwater has a southerly gradient (Figure 1-4). The average gradients range from 0.004 feet/foot in the shallowest portion of the surficial aquifer to 0.003 feet/foot in the intermediate and deeper depths of the surficial aquifer. A downward vertical hydraulic gradient of 0.007 to 0.020 feet/foot exists within the surficial aquifer except near the drainage canal, where groundwater discharges to the canal and an upward gradient of approximately 0.25 feet/foot exists. Hydraulic conductivity in the surficial aquifer ranges from 0.5 to 1.5 feet/day with lower conductivity in the deeper intervals of the surficial aquifer.

1.3. NATURE AND EXTENT OF GROUNDWATER CONTAMINATION

This section describes the most recent site characterization data, primarily from the *Phase I and II Data Report for Study Area 17*. Additional data (primarily for monitoring wells not sampled during the Phase I and II program) were taken from the *Base Realignment and Closure Environmental Site Screening Report*. The groundwater data are collected from monitoring wells and from discrete-depth sampling via direct-push technology (DPT). In addition to these data, two of the

existing monitoring wells will be replaced in order to install stainless steel screens (with otherwise identical construction), and the replacement wells plus 20 of the injector points will be sampled immediately prior to the injection program in order to provide additional site characterization data (see below). These data will be reported in a post-treatment effectiveness evaluation report.

Isoconcentration maps of the total chlorinated volatile organic compound concentration (taken as the sum of the trichloroethene, cis-1,2-dichloroethene, and vinyl chloride concentrations) as a function of depth are summarized in Figures 1-5 through 1-7. The isoconcentration maps are presented as total chlorinated VOCs rather than as individual compounds, because the treatment objective is based upon the total concentration of the chlorinated VOCs rather than upon the concentration of an individual component (see below). Maps indicating the compound-specific analytical results are provided in the *Base Realignment and Closure Environmental Site Screening Report* and the *Phase I and II Data Report for Study Area 17*. The primary contaminant reported at the site is trichloroethene (TCE), with a maximum reported concentration of 134,000 μg/L from location DPT-1 at a depth of 22 feet below grade. Cis-1,2-dichloroethene (CIS) is reported from the site with a maximum concentration of 6,490 μg/L from location DPT-8 at a depth of 15 feet below grade. Vinyl chloride (VC) is reported from the site with a maximum concentration of 1,240 μg/L from location DPT-8 at a depth of 15 feet below grade.

The groundwater isoconcentration map for the shallow groundwater (6-14 feet below grade) indicates a primary source area near DPT-1 and extending southwesterly towards DPT-16 (Figure 1-5). The isocontours indicate an area of relatively high contamination (exceeding 5,000 mg/L) extending southeasterly from DPT-16, but few data are available to constrain the VOC concentration in the southeasterly direction (additional data will be collected from the pre-injection sampling round). The isocontours also highlight a lobe of groundwater contamination extending northwesterly from DPT-16 to DPT-10. The same pattern of isocontours is repeated in the intermediate (15-19 feet below grade) and deep groundwater (20 to 26 feet below grade) (Figures 1-6 and 1-7).

1.4. TREATMENT AREA SUMMARY

The targeted treatment area is indicated in Figure 1-8. In general, the treatment area encompasses the primary source area near DPT-1, extending southwest past DPT-16 to the fence line, and northwest to incorporate the portion of the plume extending to DPT-10. This is intended to incorporate the area in which total VOCs in groundwater exceeds 500 μg/L. The southeasterly boundary of the treatment area is not well delineated and will be confirmed based upon the pre-

injection sampling. The vertical extent of the treatment area extends from the water table to a depth of approximately 26 feet below grade based upon delineation data provided by CH2M Hill that indicates the presence of an aquitard layer at approximately 26 feet below grade that significantly inhibits downward migration of VOCs below that depth. The treatment area may be expanded or contracted in vertical or horizontal dimensions based upon the pre-injection sampling data.

1.5. TREATMENT GOALS

The treatment objective for this project is 500 μg/L or less of total volatile organic concentration in any monitoring point within the treatment area for a period of 6 months following completion of all phases of work.

2. SUMMARY OF THE GEO-CLEANSE® PROCESS

The Geo-Cleanse® Process is a patented technology to simultaneously inject hydrogen peroxide and trace quantities of metallic salts under pressure to the subsurface in order to destroy organic contaminants in soil and groundwater. U.S. patents 5,525,008 and 5,611,642 protect the technology. The Geo-Cleanse® Process delivers a calculated charge of hydrogen peroxide and catalyst to the contaminated region via specially designed injection equipment consisting of mixing heads and subsurface injectors. The injection methodology and equipment are the keys to the Geo-Cleanse® Process. The chemistry involved is based upon Fenton's reagent. Fenton's reagent oxidizes organic contaminants to carbon dioxide and water, plus chloride (in the case of chlorinated compounds). The basics of Fenton's reagent chemistry and application to site-specific contaminants are described in the following sections.

2.1. FENTON'S REAGENT CHEMISTRY

In 1894, H.J.H. Fenton reported that malic acid was rapidly oxidized by hydrogen peroxide in the presence of iron salts. Haber and Weiss (1934) identified the oxidation mechanism resulting from mixtures of hydrogen peroxide and ferrous iron (referred to as Fenton's reagent) as a hydroxyl free radical (OH·) formed by the reaction:

$$H_2O_2 + Fe^{+2} \rightarrow Fe^{+3} + OH\cdot + OH^- \qquad (1)$$

where H_2O_2 is hydrogen peroxide, Fe^{+2} is ferrous iron, Fe^{+3} is ferric iron, OH· is hydroxyl free radical, and OH^- is hydroxyl ion. Fenton's reagent chemistry is complex, involving a number of additional reactions producing both oxidants and reductants that contribute to contaminant destruction (e.g., Watts et al., 1999):

$$OH\cdot + Fe^{+2} \rightarrow OH^- + Fe^{+3} \qquad (2)$$

$$Fe^{+3} + H_2O_2 \rightarrow H^+ + HO_2\cdot + Fe^{+2} \qquad (3)$$

$$Fe^{+2} + HO_2\cdot \rightarrow Fe^{+3} + HO_2^- \qquad (4)$$

$$Fe^{+3} + HO_2\cdot \rightarrow Fe^{+2} + O_2 + H^+ \quad (5)$$

$$OH\cdot + H_2O_2 \rightarrow H_2O + HO_2\cdot \quad (6)$$

where $HO_2\cdot$ is hydroperoxyl radical, HO_2^- is hydroperoxyl anion, O_2 is molecular oxygen, H^+ is hydronium ion, and H_2O is water. Additional reactions occur with organic compounds. The suite of reactions associated with Fenton's reagent is complex, but very effective at destroying many organic compounds dissolved in groundwater, sorbed to soil particles, or existing as non-aqueous phase liquids in subsurface environments.

The hydroxyl free radical generated by Fenton's reagent is a powerful, non-selective oxidant. Oxidation of an organic compound by Fenton's reagent is a rapid and exothermic (heat-producing) reaction. Rate constants for reactions of hydroxyl free radical with common environmental pollutants are typically in the range of 10^7 to 10^{10} $M^{-1}s^{-1}$ (e.g., Buxton et al., 1988; Haag and Yao, 1992), and 100% mineralization is generally complete in minutes. Intermediate compounds are primarily naturally occurring carboxylic acids. The end products of oxidation are primarily carbon dioxide and water, plus chloride (in the case of chlorinated compounds) and nitrate (in the case of nitroaromatic compounds). None of the injected reagents pose an environmental hazard. Unconsumed hydrogen peroxide naturally degrades to oxygen and water within a few days of injection.

2.2. TREATMENT OF SITE-SPECIFIC ORGANIC CONSTITUENTS

Site characterization data provided by CH2M Hill indicate that the primary organic contaminants present at the site are chlorinated solvents, including TCE and its natural degradation products CIS and VC. Fenton's reagent oxidizes chlorinated aliphatic compounds such as TCE and its natural degradation products to substituent carbon dioxide, water, and chloride, via an oxidation pathway that involves carboxylic acids. The oxidation pathway is not a dehalogenation process like natural biodegradation, and additional CIS or VC is not produced by Fenton's reagent oxidation. Reported rate constants for reaction of $OH^\cdot$ with TCE range from 4.0-4.3 x 10^9 $M^{-1}s^{-1}$ (Buxton et al., 1988), indicating an extremely rapid reaction. Oxidation of TCE ($Cl_2C{=}CHCl$) by Fenton's reagent produces dichloroacetic acid ($CHCl_2COOH$) as the only significant intermediate product, which is further oxidized to formic acid (HCOOH) and finally to water (H_2O), carbon dioxide (CO_2), and chloride (Cl^-) (Figure 2-1):

$$Cl_2C{=}CHCl + OH^- + H_2O \rightarrow CHCl_2COOH + 2H^+ + Cl^- \quad (7)$$

$$CHCl_2COOH + 2OH^- \rightarrow HCOOH + 2H^+ + 2Cl^- + CO_2 \quad (8)$$

$$HCOOH + 2OH^- \rightarrow 2H_2O + CO_2 \quad (9)$$

Fenton's reagent effectively and completely oxidizes TCE and its related compounds to stoichiometric quantities of carbon dioxide, water, and chloride in soil and groundwater under laboratory-simulated conditions (e.g., Ravikumar and Gurol, 1994; Gates and Siegrist, 1995) and in GCI field experience (e.g., Bryant and Wilson, 1998, 1999; Levin et al., 2000; Maughon et al., 2000).

2.3. GEO-CLEANSE INJECTION EQUIPMENT

GCI will stage a mobile treatment unit at the site. A schematic of a typical mobile treatment unit is provided in Figure 2-2. Hydrogen peroxide is staged at the site in a tanker. Additional support services at the site include water (typical garden hose supply with at least 40 pounds per square inch pressure) and power (a 60 kilowatt generator).

The GCI mobile treatment unit includes tanks, pumps, gauges and flow control valves to deliver reagents safely and effectively to mixing heads installed on the injectors. Safety features include redundant check valves to control reagent flow, construction materials to withstand the reagents and pressures encountered, and eyewashes and safety showers (safety features are described further in the Site-Specific Health and Safety Plan). Reagent injection to the subsurface is conducted via specially designed mixing heads that are attached to the riser pipe of the injector (Figure 2-3). The mixing heads are designed with redundant safety features including check valves, pressure gauges and flow-control ball valves and are constructed of stainless steel to withstand the reagents.

The entire system, from the peroxide tanker to the mobile treatment unit, and from the mobile treatment unit to the injector head, is entirely closed and there is no exposure to the hydrogen peroxide. The entire system is leak-checked prior to operation. Procedures to address spills are provided in the Site-Specific Health and Safety Plan. In summary, in the event of a small spill (tens of gallons or less), the spill is addressed by spraying the area with water until the hydrogen peroxide is diluted. In the event of a catastrophic spill (such as from a tank truck failure), the area must be evacuated, local fire department authorities notified, and a 24-hour FMC Emergency Hotline is available at (609) 924-6677.

3. IMPLEMENTATION OF THE GEO-CLEANSE® PROCESS

3.1. PERFORMANCE AND PROCESS MONITORING

The overall monitoring program consists of both performance and process monitoring. Performance monitoring refers to pre-, during, and post-test analyses of groundwater samples collected within and adjacent to the treatment area, for target VOC compounds, to evaluate overall treatment effectiveness. CH2M Hill will conduct the performance monitoring as outlined in Sections 3.3, 3.4.5, 3.5. GCI will conduct process monitoring. Process monitoring refers to analyses of groundwater and offgas samples collected within and adjacent to the treatment area, during implementation of the in-situ chemical oxidation treatment, for purposes of determining if appropriate geochemical conditions are established in the aquifer, reagents are distributed effectively, and an efficient oxidation reaction is occurring. The types of analyses conducted during process monitoring are groundwater quality measurements and are described Section 3.4.4.

3.2. INJECTOR INSTALLATION

3.2.1. Treatment Area and Injector Locations

The targeted treatment area is indicated in Figure 1-8. In general, the treatment area is roughly an L-shaped area encompassing the primary source area near DPT-1, extending southwest past DPT-16 to the fence line, and northwest to incorporate the portion of the plume extending to DPT-10. The vertical extent of the treatment area extends from the water table to a depth of approximately 26 feet below grade. This depth is based upon delineation data provided by CH2M Hill that indicates the presence of an aquitard layer at approximately 26 feet below grade that significantly inhibits downward migration of VOCs below that depth. A total of 69 injectors will be installed in three vertical levels. One level consisting of 9 injectors will be installed and screened from 10 to 13 feet below grade (shallow injectors). The second level consisting of 30 injectors will be installed and screened from 16-19 feet below grade (intermediate injectors). The third level consisting of 30 injectors will be installed and screened from 22 to 25 feet below grade (deep injectors). The deep injectors are screened at 25 feet below grade, rather than 26 feet below grade, to ensure that the aquitard layer is not penetrated. Targeted injector locations are indicated in Figure 3-1.

3.2.2. Utility Identification and Clearance

The location of known utilities within and adjacent to the treatment area are identified in Figure 3-2. Water mains are identified crossing the site. There are no identified sewer, power, or other underground utilities identified at the site. Injector locations that are near the identified underground utilities will be initially dug with a posthole digger to a depth of at least 4 ft below grade to ensure that the drilling location is clear. There are no overhead utilities at the site.

3.2.3. Injector Construction

Example construction details for shallow, intermediate and deep injectors are provided in Figures 3-3 through 3-5. Injectors are constructed of materials intended to withstand elevated temperatures and pressures, and exposure to the reagents utilized during the Geo-Cleanse® Process. The injectors are constructed with 0.010-slot stainless steel screens and Schedule 80 steel riser pipe and couplings. The pipe and screen diameters are 1.25". The injectors will be installed with a 3-ft screen. The relatively short screen length is intended to provide greater hydraulic control over reagent injection depths and to prevent formation of preferred reagent pathways through the formation. The injectors are built and placed into the soil boring through the hollow stem auger. The augers will be systematically extracted as completion materials are added to ensure that materials do not bridge within the auger. The borehole with the injector will be backfilled with filter pack sand to a level approximately one foot above the top of the screen. Sand may be added by tremie pipe with approved water if necessary for adequate settling. Next, a one-foot thick layer of bentonite (medium pellets or 3/8-inch chips) will be added and allowed 15 minutes to hydrate. Hydration water for the bentonite should not be necessary because the targeted intervals are all within the saturated zone. However, 4 gallons of approved water will be added to hydrate the bentonite if no water is present within the augers. The injectors will then be sealed to grade with a cement/bentonite grout mix. A cement/bentonite mix is selected to provide a more competent seal (important for injection) than high-solids bentonite slurry. The grout mix will be added by tremie pipe with side discharge to ensure complete displacement of water within the augers and competent distribution. The grout is a non-shrinking mix consisting of Portland Type I cement, bentonite powder and water in the ratio of 94 pounds Portland Type I cement : 5 pounds bentonite powder : 7 gallons water. The target mixture weighs approximately 15 pounds per gallon. The grout will be allowed to settle after completion and additional grout will be added as necessary to fill the borehole. Construction details will be recorded on the soil boring log maintained for each boring (Figure 3-6).

3.2.4. Monitoring Well Replacement

Monitoring wells Old-17-23A (1,359 μg/L VOCs) and Old-17-24B (29,008 μg/L VOCs) are located within the most contaminated portion of the plume and treatment area (Figures 1-5 through 1-7). Both wells are constructed with 2-inch diameter Schedule 40 PVC. Schedule 40 PVC is susceptible to degradation and softening in the presence of moderately high concentrations of chlorinated VOCs, and dense non-aqueous phase liquids (DNAPLs) composed of chlorinated VOCs, such as those identified or suspected at SA 17 (McCaulou et al., 1995). Additionally, the Geo-Cleanse® Process may result in elevated temperatures in the aquifer (typically 10 to 15°F above ambient), which could further degrade PVC that has been softened by exposure to chlorinated VOCs. Accordingly, both of these monitoring wells will be replaced at the time of injector installation with materials more suitable for the conditions encountered at SA 17.

The casing and screen will be mechanically extracted mechanically. The boring will then be cleared by overdrilling with a nominal 8¼-inch outside diameter hollow stem auger. The monitoring wells will be replaced with 2-inch diameter, stainless steel, 0.010-slot screens and riser pipe. Monitoring well Old-17-23A-R will be constructed with a 10-foot screened interval from 1.5 to 11.5 feet below grade (Figure 3-7). Monitoring well Old-17-24B-R will be constructed with a 5-foot screened interval from 15 to 20 feet below grade (Figure 3-8). The installation method will be identical to that described for the injectors (Section 3.2.3). A detailed soil boring log with well construction detail will be maintained (Figure 3-6). Both reinstalled wells will be developed and sampled as part of the pre-injection site characterization (Section 3.3).

Monitoring wells Old-17-25C and Old-17-06A, also within the treatment area will not be reinstalled. Old-17-25C is screened from approximately 78 to 83 feet below grade, much deeper than the targeted treatment interval from approximately 6 to 25 feet below grade. Old-17-25C is grouted with concrete throughout the target treatment interval, and is therefore not susceptible to damage from either the CVOCs or further degradation by the in-situ chemical oxidation treatment. Old-17-06A is a ½-inch diameter microwell installed by TerraProbe, and is not appropriate for replacement.

3.2.5. Investigation Derived Waste Management

Soil cuttings and fluids resulting from installation of the injection and replacement monitoring wells and from sampling will be containerized and staged onsite. The cuttings will be screened by photoionization detector (PID) and the drums temporarily labeled by drilling location, date and PID reading. CH2M Hill personnel will sample the drums for waste characterization. Drums

that meet regulatory standards will be dumped and the soil spread onsite, while those that exceed the standards will be disposed of appropriately.

3.3. PRE-TREATMENT BASELINE SAMPLING

Prior to injection, 20 of the injector wells and the two replacement monitoring wells will be developed and sampled to provide further site characterization data. The targeted wells are identified in Figure 3-9. The wells will be developed by GCI by gently surging and pumping the well, until either the purge water is clear and the well is free of sediment or until 35 gallons of water is purged (more than 3 times the cumulative volume of the well and filter pack sand), whichever occurs first. CH2M Hill personnel will sample groundwater from the targeted wells for VOCs via U.S. Environmental Protection Agency, SW-846 Method 8260.

3.4. TREATMENT PROGRAM PROCEDURES

Performance and process monitoring will be coordinated between CH2M Hill and GCI as described in Section 3.1. Process monitoring to be conducted by GCI during the injection is further described in Section 3.4.4, and performance monitoring to be conducted by CH2M Hill during injection is described in Section 3.4.5. Post-treatment performance sampling to be conducted by CH2M Hill is summarized in Section 3.5.

3.4.1. Sequence of Events

The treatment program phases include mobilization, treatment and demobilization. Mobilization normally requires one day of onsite activities. Tasks required for mobilization include positioning the GCI mobile treatment unit, hydrogen peroxide tanker and generator; establishing an exclusion zone; constructing the safety shower and hydrogen peroxide transfer station; connect treatment unit to the water source and power generator; and leak- and safety-check all hosing and fittings. A health and safety meeting with all personnel is normally conducted on the first day.

Each day of injection typically begins with a tailgate health and safety meeting. Injection of catalyst and hydrogen peroxide solutions is then conducted through the course of the day, with monitoring as prescribed in Section 3.4.4. Normal workdays are 10 hours or available daylight (whichever is shorter). At the end of each day, the mixing heads and lines will be returned to the

mobile treatment unit, the hydrogen peroxide tanker will be locked, generator or power supply turned off and the site secured for the night.

Demobilization activities include clearing the site of any fluids or debris resulting from injection activities, dismantling the hydrogen peroxide transfer station and safety shower, disconnecting from water and power supplies, and securing the mobile treatment unit, hydrogen peroxide tanker and generator. Demobilization activities typically require a half-day of onsite activities.

3.4.2. Duration of Treatment

The primary phase of the Geo-Cleanse® Treatment Program at the SA 17 is anticipated to require 24 days of onsite activities, including mobilization, injection and demobilization. Injector installation is anticipated to require 15 days of drilling activities. An estimated 215,000 lbs (21,586 gal) of 50% hydrogen peroxide are anticipated for injection (50% concentration hydrogen peroxide is staged at the site for economic reasons; maximum injected concentration is 25%). A similar volume of catalyst solution is also anticipated for injection. A polish treatment will be conducted if necessary (see Section 3.4.6).

3.4.3. Reagents

The reagents used in the Geo-Cleanse® Process, and their purpose, injected concentrations and fate, are summarized as follows.

Hydrogen peroxide: 50% technical grade, used as oxidizing agent. Injected into groundwater and soils with a maximum 25% concentration, with resultant concentrations to groundwater of less than 1%. This concentration quickly falls to less than 25 ppm within several hours following injection and typically is completely consumed within 2 to 3 days.

Ferrous sulfate: 100-ppm aqueous solution of food grade reagent, used as catalyst. This concentration is typically diluted in groundwater to less than 10 ppm. The ferrous iron is oxidized in the subsurface to ferric iron and precipitates as an iron oxide or iron hydroxide. Ferrous sulfate may not be used if sufficient natural iron (greater than 25 mg/L) is present in groundwater.

Sulfuric acid: 66° (98%) technical grade, diluted prior to injection in water to a pH of approximately 4. This is used in the catalyst solution to inhibit oxidation of ferrous iron to ferric iron in the catalyst solution prior to injection, and to adjust pH of the groundwater to the optimal range for Fenton's reagent (<6). Groundwater pH will return to ambient background conditions within a few days of injection. This reagent may not be utilized depending upon site-specific conditions. Sulfuric

acid may not be used if either the groundwater pH is already acidic (<6) or if a more stabilizing catalyst solution is desired (in which case phosphoric acid may be used).

Phosphoric acid: 85% technical grade, diluted prior to injection in water to a pH of approximately 4. This is used in the catalyst solution to inhibit oxidation of ferrous iron to ferric iron in the catalyst solution prior to injection, and to adjust pH of the groundwater to the optimal range for Fenton's reagent (<6). Groundwater pH will return to ambient background conditions within a few days of injection. This reagent may not be utilized depending upon site-specific conditions. Phosphoric acid may not be used if either the groundwater pH is already acidic (<6) or if a more reactive catalyst solution is desired (in which case sulfuric acid may be used).

Calcium phosphate: 10-ppm aqueous solution of food grade reagent, used to stabilize the Fenton's reagent. This concentration is diluted in groundwater to less than 1 ppm. The calcium remains dissolved in solution and the phosphate is either precipitated or is utilized as a nutrient in biological reactions. This reagent may not be utilized depending upon site-specific conditions. Calcium phosphate may be used if additional phosphate is desired for stabilization, without additional acidity.

3.4.4. Process Monitoring Parameters

As part of the process monitoring, GCI will collect field measurements during the injection to ensure that appropriate subsurface conditions exist for Fenton's reagent, that an efficient reaction is occurring, and to monitor the reaction progress. Parameters that are monitored include both groundwater quality and liberated gas measurements. At least two rounds of groundwater samples are collected each day, including one in the morning prior to beginning the injection and one in the afternoon prior to concluding injection for the day. Gas measurements are conducted at approximately 2-hour intervals throughout the day. Monitoring is performed only in the active treatment area (i.e., the entire site is not monitored during every round). Additional analyses may be performed as dictated by site conditions, but not at prescribed time intervals. Parameters that are monitored, and their purpose, method, resolution and range are as follows.

pH: Groundwater pH is monitored to ensure that appropriate pH conditions (pH <6) are established. A Hach test kit model 17-F is used. The test is a colorimetric method using bromothymol blue as an indicator. The range is 5.5 to 8.5 with resolution of ±0.1 units. The pH measurements may be supplemented with test strips (0 to 6 with resolution of ±0.5 units) if necessary. A pH meter is not used because the electrodes are damaged by hydrogen peroxide.

Alkalinity: Alkalinity affects Fenton's reagent treatment because dissolved bicarbonate (the predominant component of groundwater alkalinity) is an efficient hydroxyl free radical scavenger. A target value of <100 mg/L is desired. Alkalinity is also related to pH, because groundwater pH controls bicarbonate equilibrium and the capacity of the groundwater to contain bicarbonate. A Hach test kit model AL-AP/MG-L is used. The test is a titration method using a sulfuric acid reagent. The range is 0 to 100 mg/L (as $CaCO_3$) with resolution of ±5 mg/L, or 20 to 400 mg/L with resolution of ±20 mg/L.

Dissolved Chloride: Chloride is produced as an oxidation product of chlorinated hydrocarbons (see Section 2.2). A Hach test kit model 8-P is used. The test is a titration method using a silver nitrate indicator. The range is 5 to 100 mg/L (as Cl^-) with ±5 mg/L resolution, or 20 to 400 mg/L (as Cl^-) with ±20 mg/L resolution.

Dissolved Iron: Dissolved iron (either as ferrous or ferric forms) is a catalyst for Fenton's reagent. A minimum of 10 mg/L is desired in groundwater, and dissolved iron monitoring determines if ferrous sulfate is used in the catalyst blend. A Hach test kit model IR-18B is used. The test is a colorimetric method using phenanthroline reagent. The range is 0 to 10 mg/L with resolution of ±0.2 mg/L.

Hydrogen Peroxide: Hydrogen peroxide is monitored to ensure that reagents are distributed throughout the treatment area. Hydrogen peroxide is measured with Merckoquant colorimetric test strips (E.M. Science, Gibbstown, NJ) with a measurable range of 0 to 100 mg/L. The test strips have indicators labeled at 0, 1, 3, 10, 30, and 100 mg/L peroxide, and intermediate concentrations can be interpolated.

Carbon dioxide: Oxidation of organic compounds yields carbon dioxide (see Section 2.2), which is liberated from the subsurface through adjacent injectors and monitoring wells. Carbon dioxide production is a sensitive measure of the efficiency and progress of the treatment. At sites impacted by chlorinated aliphatics such as TCE, carbon dioxide production typically reach maximum levels of approximately 7 to 10% in the early stages (first 2 to 4 days) of injection then decrease asymptotically to zero over the course of the treatment as the subsurface organic contaminants are destroyed. Carbon dioxide concentration is measured in headspaces of injectors and monitoring wells within and adjacent to the treatment area. The measurement is performed with a GasTech GT series carbon dioxide/oxygen meter. The meter uses a non-dispersive infrared absorbance detection method. Resolution is ±0.1% and range is 0 to 20%.

Oxygen: Reaction of hydroxyl free radicals with hydrogen peroxide, other radicals, or other non-organic compounds produces oxygen. Oxygen is liberated from the subsurface through adjacent

injectors and monitoring wells. At sites impacted by chlorinated aliphatics such as TCE, oxygen production is typically low in the first few days of injection (approximately 10 to 15%) then increases to >30% over the course of the treatment as the subsurface organic contaminants are destroyed. Oxygen concentration is measured in headspaces of injectors and monitoring wells within and adjacent to the treatment area. The measurement is performed with a GasTech GT series carbon dioxide/oxygen meter. The meter uses an electrochemical detection method. Resolution is ±0.1% and range is 0 to 30%.

Volatile Organic Compounds: Fenton's reagent produces offgases, which pass through potentially contaminated water prior to liberation via adjacent wells. Gases passing through a contaminated groundwater may entrain relatively low concentrations of volatile organic compounds. Henry's Law predicts the maximum concentration of a volatile organic compound in a gas that has passed through a contaminated water sample. As a rule of thumb (supported by GCI field experience), the maximum concentration of a VOC in the offgas is approximately the same order of magnitude as the concentration of the VOC in groundwater. Thus the concentration of VOCs in offgases is typically a maximum in the initial stages (one to two days) of injection and then decreases over the course of the treatment. Volatile organic compounds are monitored with a PID meter. The PID meter reads a concentration in parts per million (ppm) by volume, however that reading does not correspond exactly to a concentration of VOCs in the air sample. The PID response varies among organic compounds, and the PID also responds to water vapor (resulting in a PID reading that is much higher than the actual VOC concentration in the offgas). PID readings are measured in headspaces of injectors and monitoring wells within and adjacent to the treatment area. The measurement is performed with a ThermoEnvironmental 580B PID meter with a 10.6 eV lamp. Resolution is ±0.1 ppm and range is 0 to 2,500 ppm.

3.4.5. Performance Monitoring During Treatment

CH2M Hill will collect one round of groundwater samples for VOC analysis during the treatment program. These samples will be collected near the end of the primary injection (approximately the 18th day of the treatment) and analyzed with an expedited (24-hour) turnaround time. The purpose of this sampling event is to evaluate the progress of the treatment program prior to conclusion, to reallocate remaining oxidant, and to determine if additional injection is needed to achieve the treatment objectives prior to demobilizing from the site.

3.4.6. Polishing Phase

Due to the relatively high concentrations of VOCs, likely presence of a DNAPL phase, and the inherent uncertainty of working in the subsurface, polishing treatment(s) may be conducted in order to target any areas that may require additional treatment to achieve the treatment objectives. The necessity of the polish treatment will be determined based upon post-treatment sampling following the primary phase. One or more polishing treatments will be conducted if the 7-day or the 30-day post-treatment performance sampling conducted by CH2M Hill indicates that the treatment goal of 500 μg/L has not been achieved across the site. The polish treatment may include installation of up to 12 new injectors and injection of 20,000 lbs (2,008 gal) of 50% hydrogen peroxide plus a similar volume of catalyst solution.

3.5. POST-TREATMENT PERFORMANCE MONITORING

CH2M Hill will conduct post-treatment performance monitoring. An initial round of groundwater samples will be collected approximately 7 days after primary injection operations cease. Based upon these results, additional polishing treatment may be conducted if necessary (see Section 3.4.6). If polishing is conducted, another round of groundwater samples will be collected 7 days after polishing treatment ceases. Once the treatment objectives have been achieved (based upon the 7-day post injection samples), an additional round of groundwater samples will be collected approximately 30 days after injection. The purpose of this sampling round is to monitor potential rebound and determine if additional polishing injection is necessary.

3.6. REPORTING

Verbal updates will be provided to the Navy and CH2M Hill as requested during the course of the treatment program. All field notes will be recorded in a permanent field notebook. Types of information recorded in the field notebook include date, personnel onsite, health and safety issues or discussions, injection locations, quantities and rates, monitoring data, and other pertinent observations of the GCI field crew. Photographs will be permanently archived with the field notebook.

At the conclusion of the injection program and upon receipt of post-injection confirmatory sampling results from CH2M Hill, a report will be prepared by GCI describing the observations, activities, and results of the injection. This report will be submitted to CH2M Hill.

4. PROJECT SCHEDULE

A tentative project schedule broken down by task (with responsible organization identified) is outlined as follows:

Task / Milestone	Begin Date	End Date
Injector and Monitoring Well Installation (GCI)	September 11, 2000	October 6, 2000
Pre-injection Baseline Sampling (CH2M Hill)	September 25, 2000	September 26, 2000
Primary Injection (GCI)	October 16, 2000	November 10, 2000
Sampling During Injection (CH2M Hill)	October 30, 2000	October 31, 2000
First Post-Injection Sampling (CH2M Hill)	November 17, 2000	November 17, 2000
Polishing Mobilization (GCI)	November 27, 2000	December 2, 2000
Second Post-Injection Sampling (CH2M Hill)	December 8, 2000	December 8, 2000
30-Day Post-Injection Sampling (CH2M Hill)	January 2, 2001	January 2, 2001
Submit Draft Report (GCI)	February 1, 2001	N/A
Submit Final Report (GCI)	March 15, 2001	N/A

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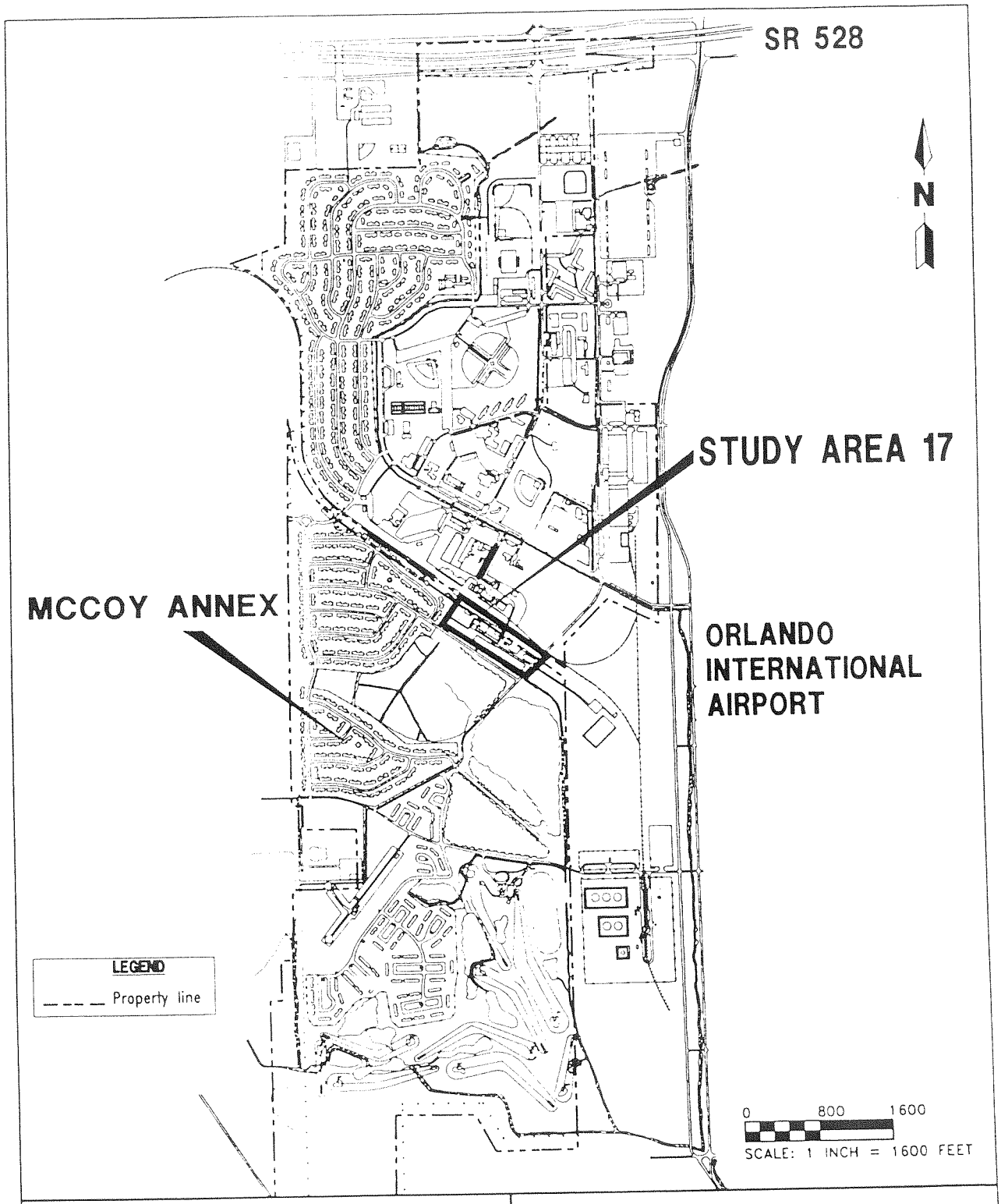

FIGURE 1-1
LOCATION OF STUDY AREA 17

BRAC ENVIRONMENTAL
SITE SCREENING REPORT
STUDY AREA 17

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

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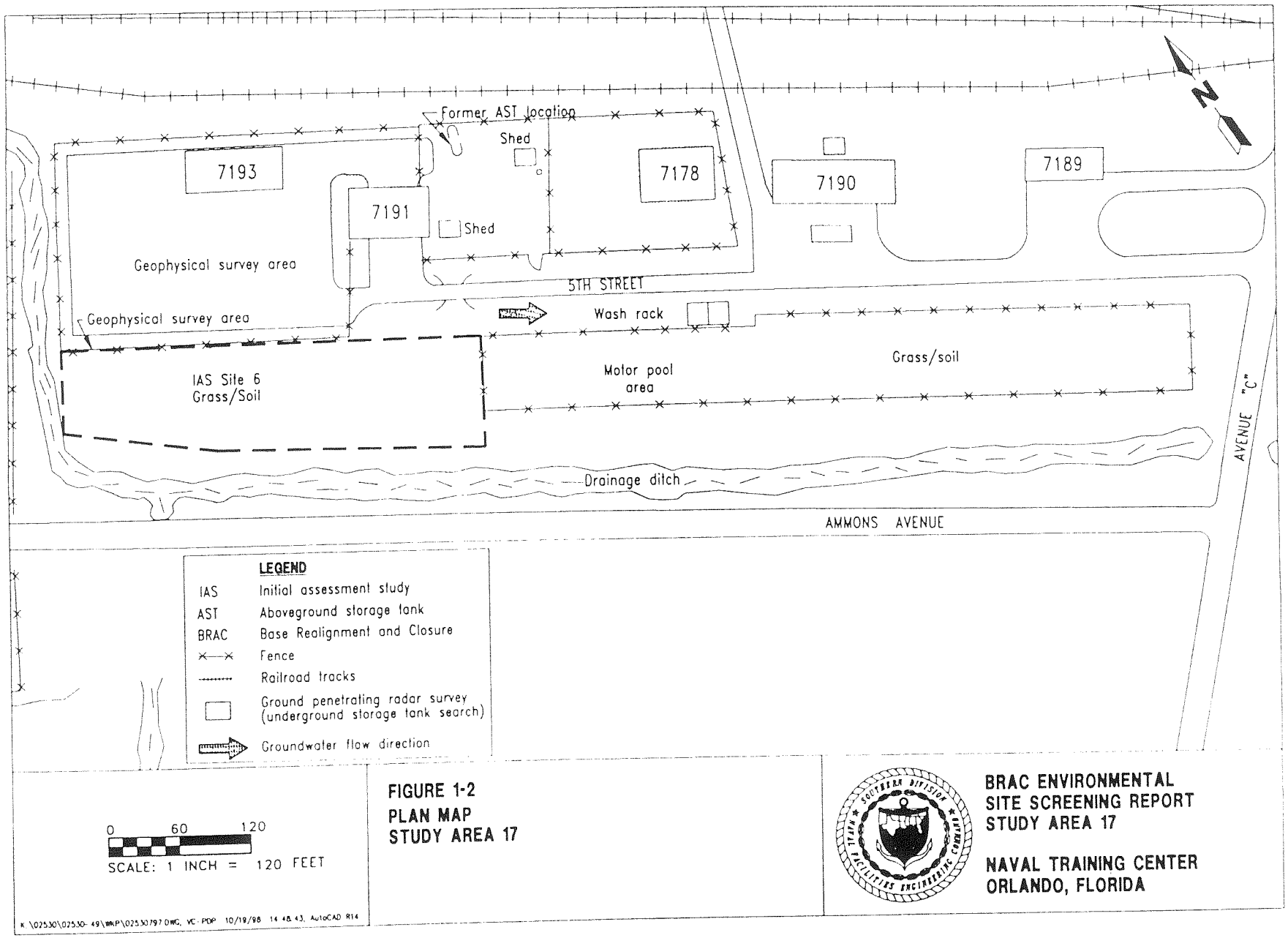

FIGURE 1-2
PLAN MAP
STUDY AREA 17

BRAC ENVIRONMENTAL
SITE SCREENING REPORT
STUDY AREA 17

NAVAL TRAINING CENTER
ORLANDO, FLORIDA

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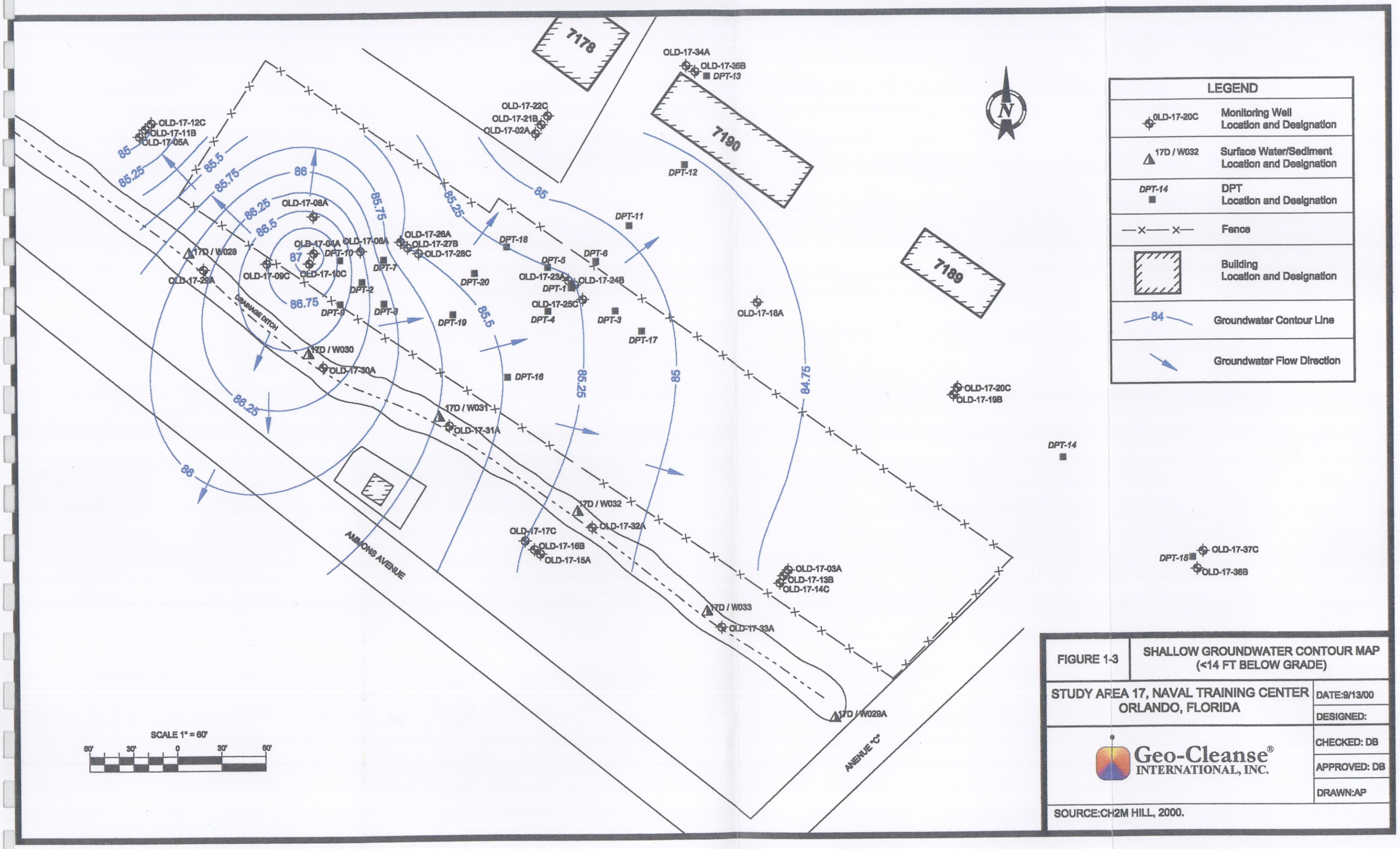


LEGEND	
OLD-17-20C	Monitoring Well Location and Designation
17D / W032	Surface Water/Sediment Location and Designation
DPT-14	DPT Location and Designation
—×—×—	Fence
	Building Location and Designation
84	Groundwater Contour Line
	Groundwater Flow Direction

FIGURE 1-3	SHALLOW GROUNDWATER CONTOUR MAP (<14 FT BELOW GRADE)
STUDY AREA 17, NAVAL TRAINING CENTER ORLANDO, FLORIDA	DATE:9/13/00
	DESIGNED:
Geo-Cleanse® INTERNATIONAL, INC.	CHECKED: DB
	APPROVED: DB
	DRAWN:AP
SOURCE:CH2M HILL, 2000.	

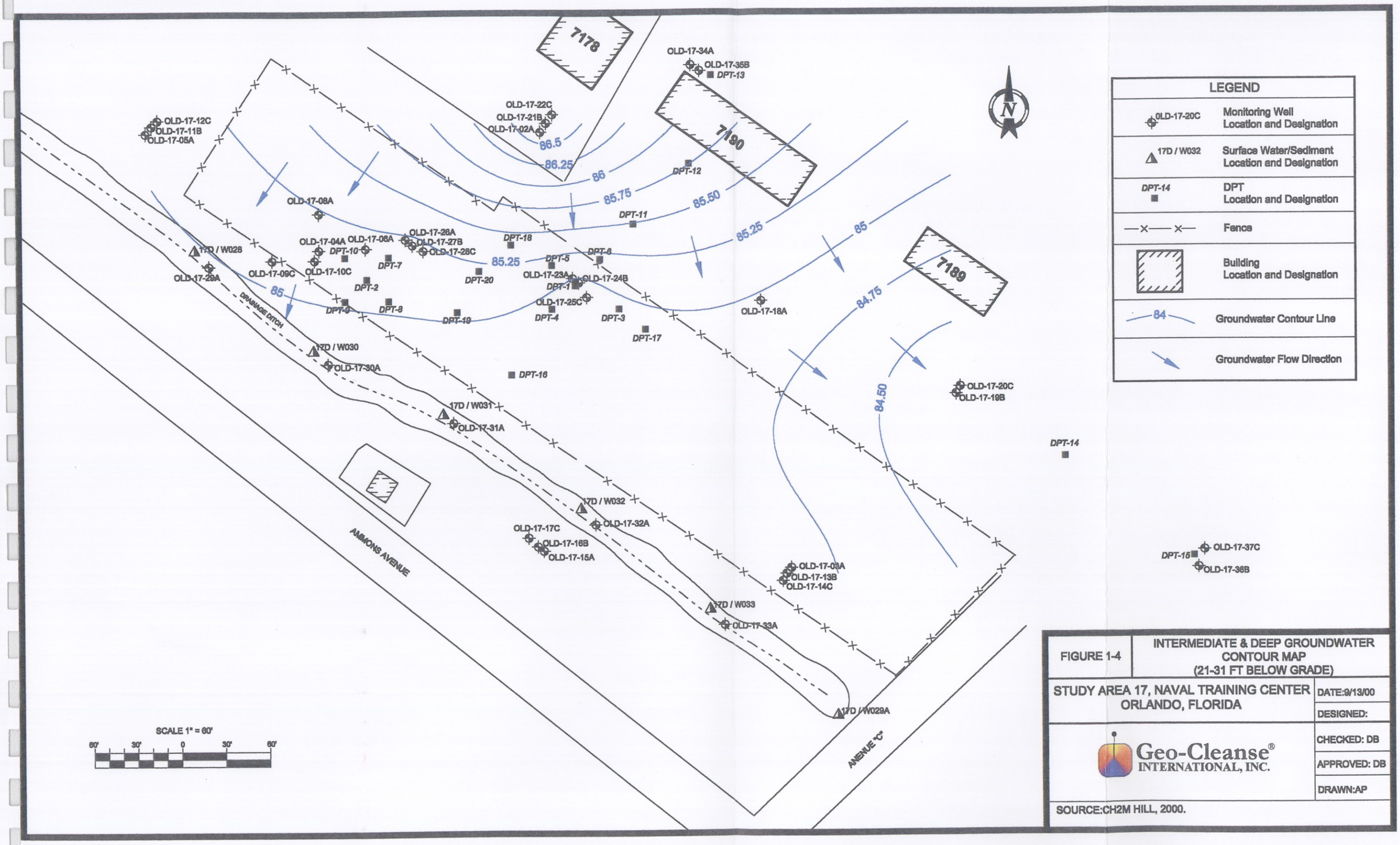
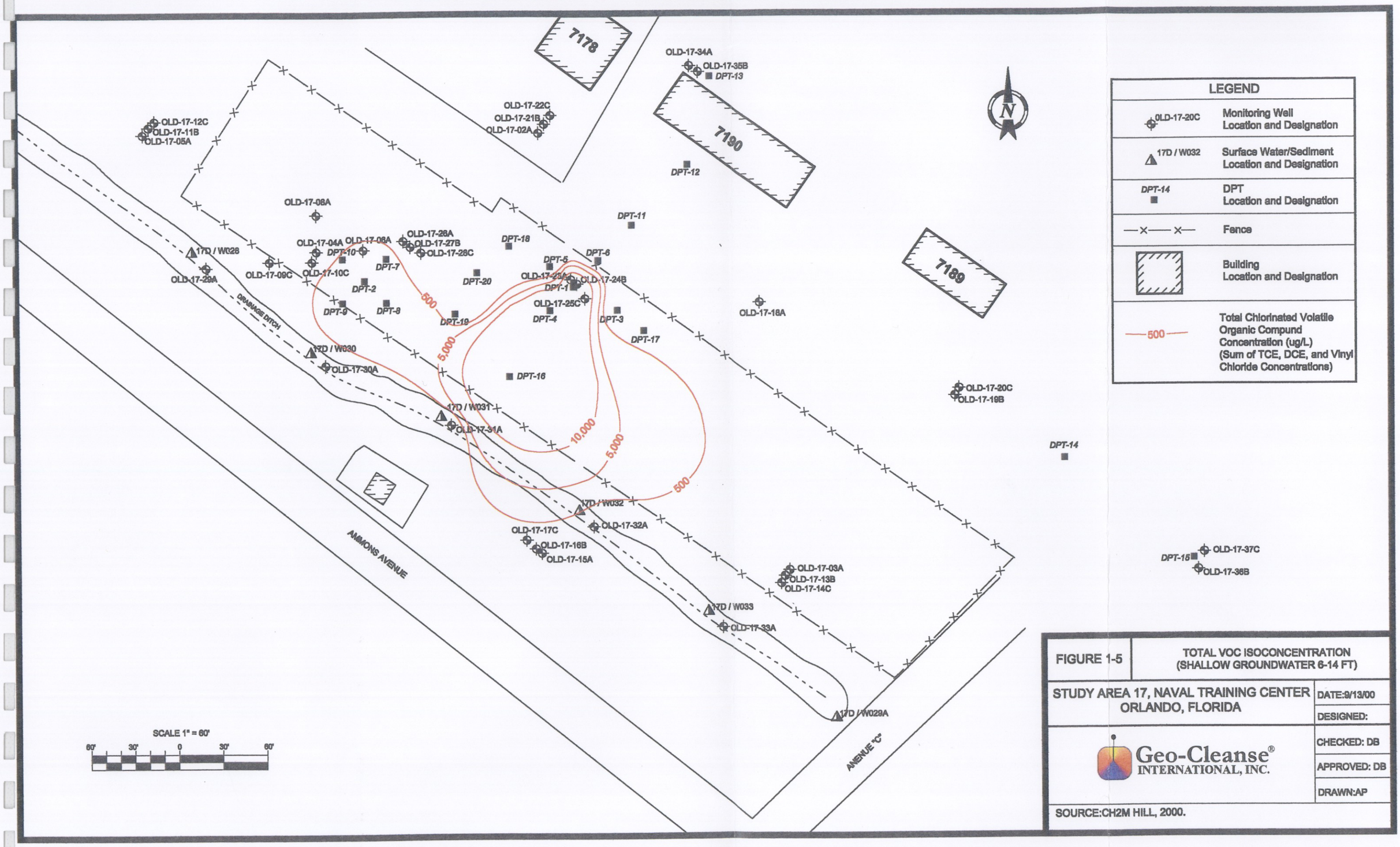


FIGURE 1-4	INTERMEDIATE & DEEP GROUNDWATER CONTOUR MAP (21-31 FT BELOW GRADE)
STUDY AREA 17, NAVAL TRAINING CENTER ORLANDO, FLORIDA	DATE:9/13/00
	DESIGNED:
Geo-Cleanse® INTERNATIONAL, INC.	CHECKED: DB
	APPROVED: DB
	DRAWN:AP
SOURCE:CH2M HILL, 2000.	



LEGEND	
OLD-17-20C	Monitoring Well Location and Designation
17D / W032	Surface Water/Sediment Location and Designation
DPT-14	DPT Location and Designation
—×—×—	Fence
	Building Location and Designation
—500—	Total Chlorinated Volatile Organic Compund Concentration (ug/L) (Sum of TCE, DCE, and Vinyl Chloride Concentrations)

FIGURE 1-5	TOTAL VOC ISOCONCENTRATION (SHALLOW GROUNDWATER 6-14 FT)
STUDY AREA 17, NAVAL TRAINING CENTER ORLANDO, FLORIDA	DATE:9/13/00
	DESIGNED:
Geo-Cleanse® INTERNATIONAL, INC.	CHECKED: DB
	APPROVED: DB
	DRAWN:AP
SOURCE:CH2M HILL, 2000.	

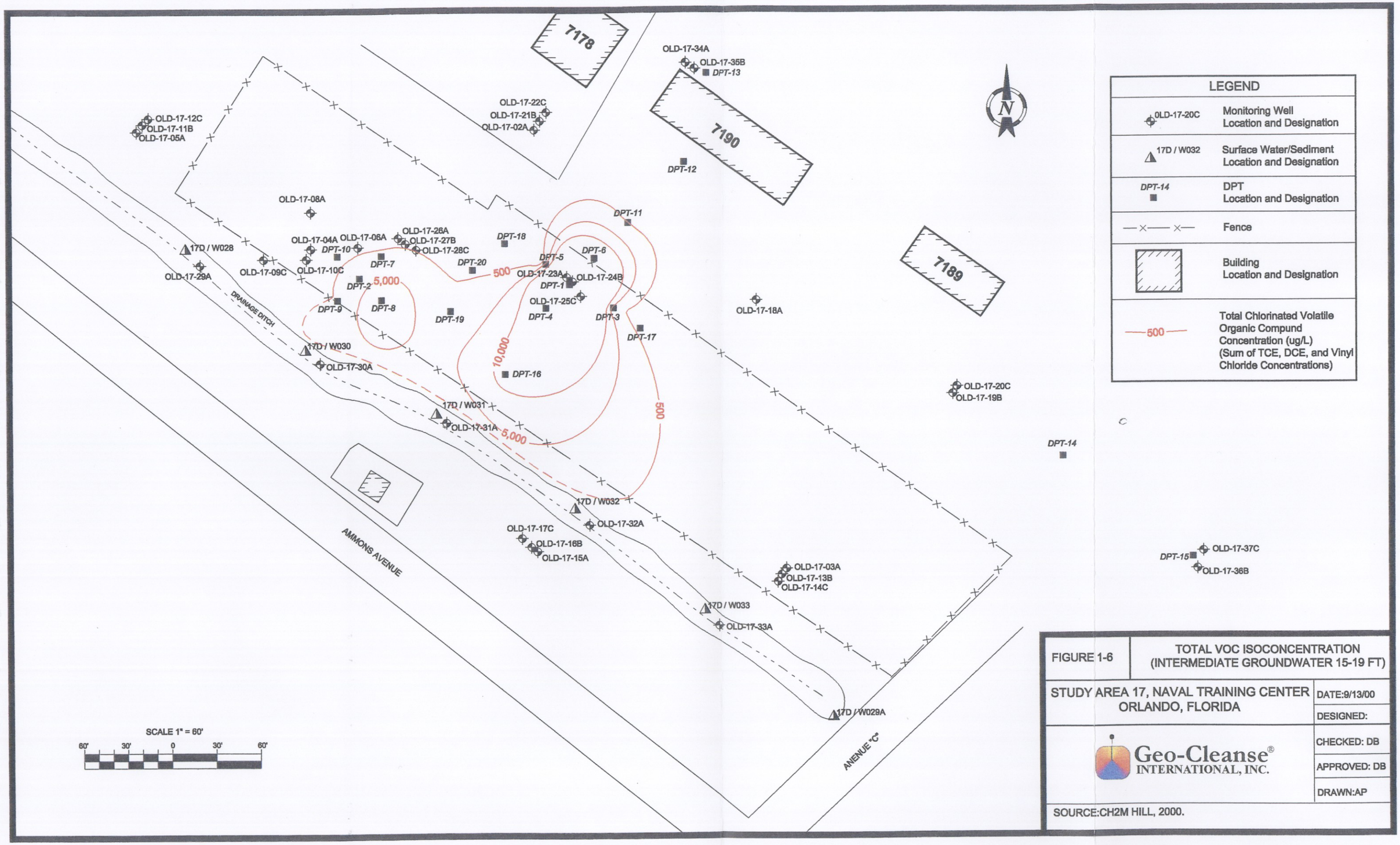
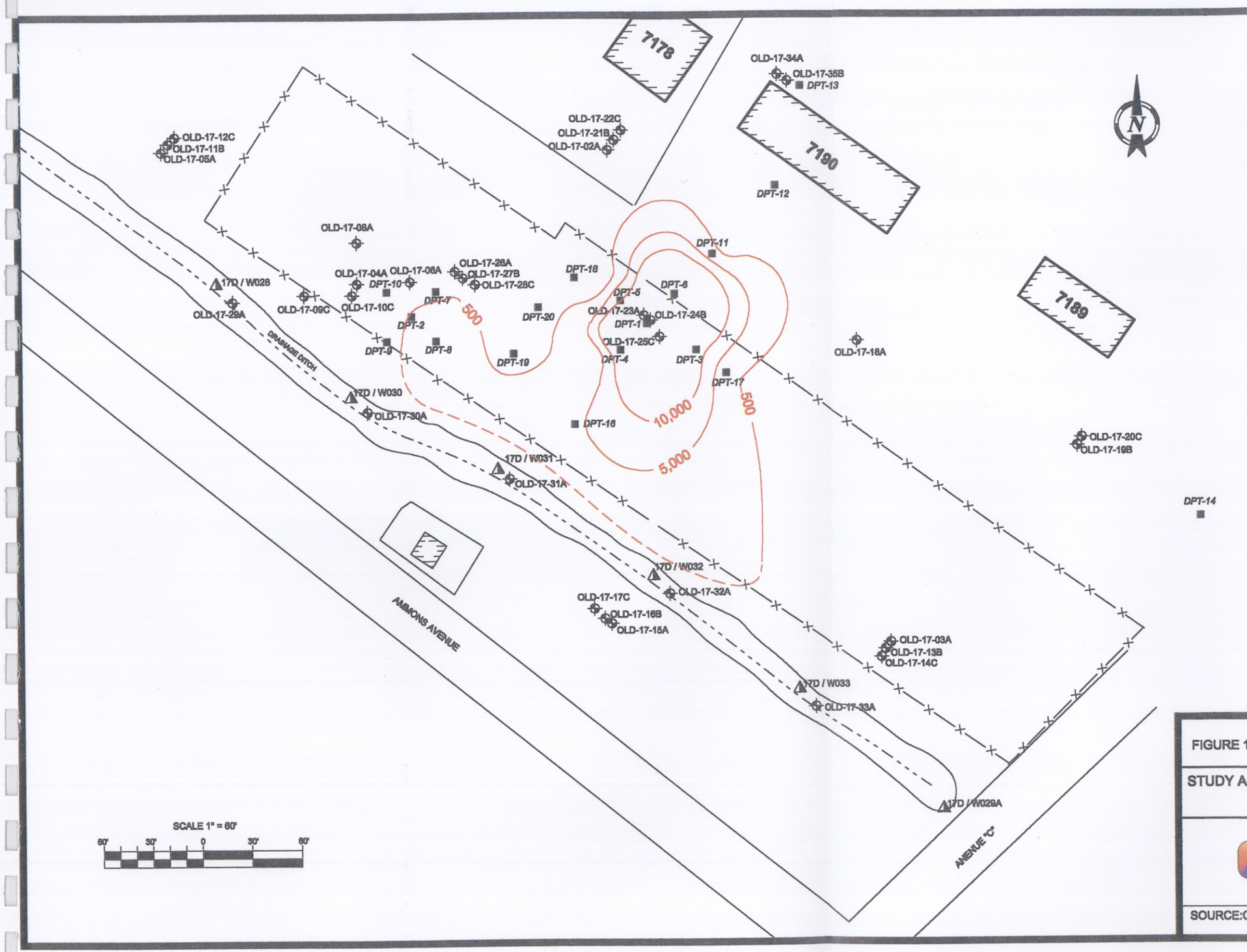


FIGURE 1-6	TOTAL VOC ISOCONCENTRATION (INTERMEDIATE GROUNDWATER 15-19 FT)
STUDY AREA 17, NAVAL TRAINING CENTER ORLANDO, FLORIDA	DATE:9/13/00
	DESIGNED:
Geo-Cleanse® INTERNATIONAL, INC.	CHECKED: DB
	APPROVED: DB
	DRAWN:AP
SOURCE:CH2M HILL, 2000.	



LEGEND	
OLD-17-20C	Monitoring Well Location and Designation
17D / W032	Surface Water/Sediment Location and Designation
DPT-14	DPT Location and Designation
—×—×—	Fence
	Building Location and Designation
—500—	Total Chlorinated Volatile Organic Compund Concentration (ug/L) (Sum of TCE, DCE, and Vinyl Chloride Concentrations)

FIGURE 1-7	TOTAL VOC ISOCONCENTRATION (DEEP GROUNDWATER 20-26 FT)
STUDY AREA 17, NAVAL TRAINING CENTER ORLANDO, FLORIDA	DATE:9/13/00
	DESIGNED:
Geo-Cleanse® INTERNATIONAL, INC.	CHECKED: DB
	APPROVED: DB
	DRAWN:AP
SOURCE:CH2M HILL, 2000.	

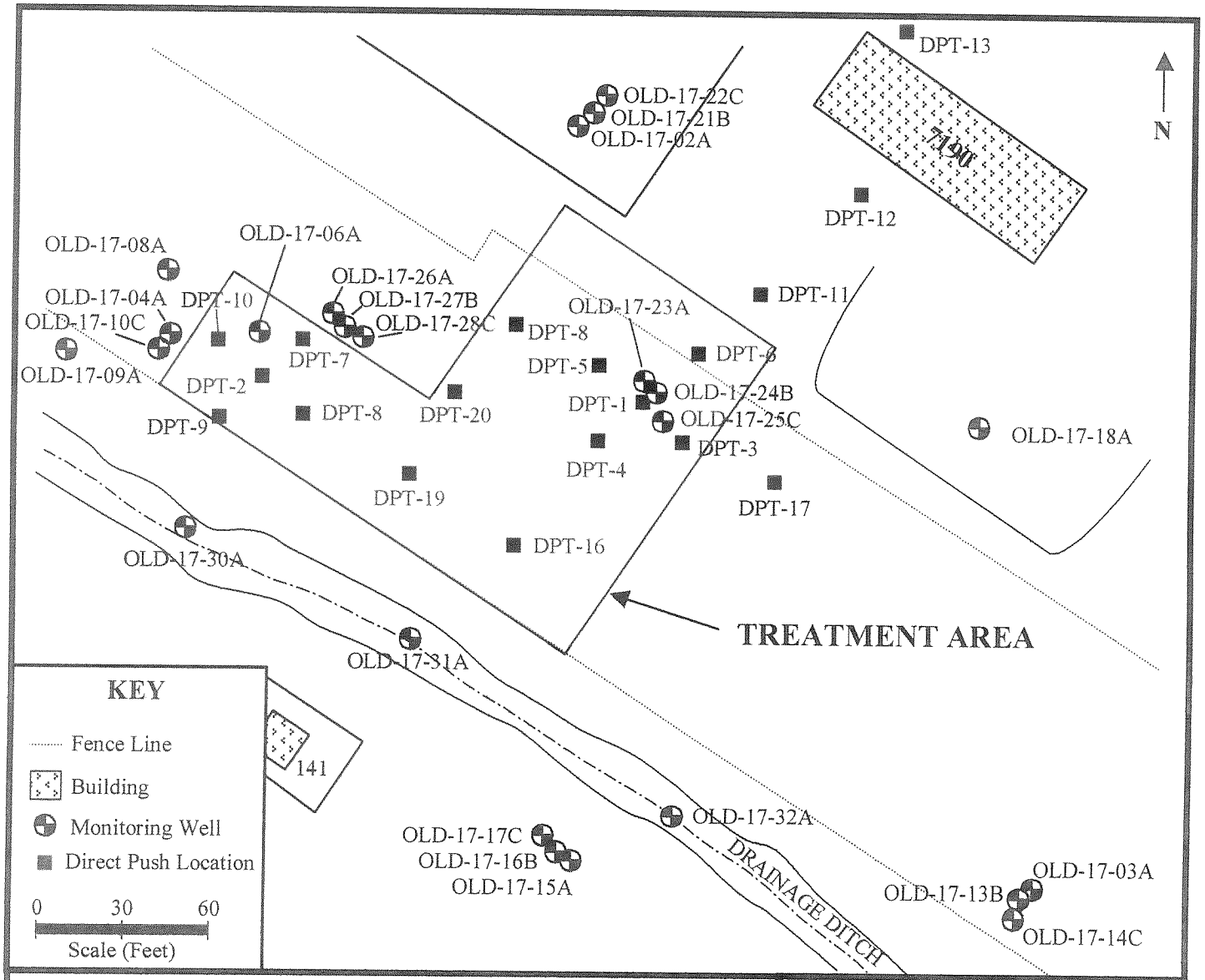
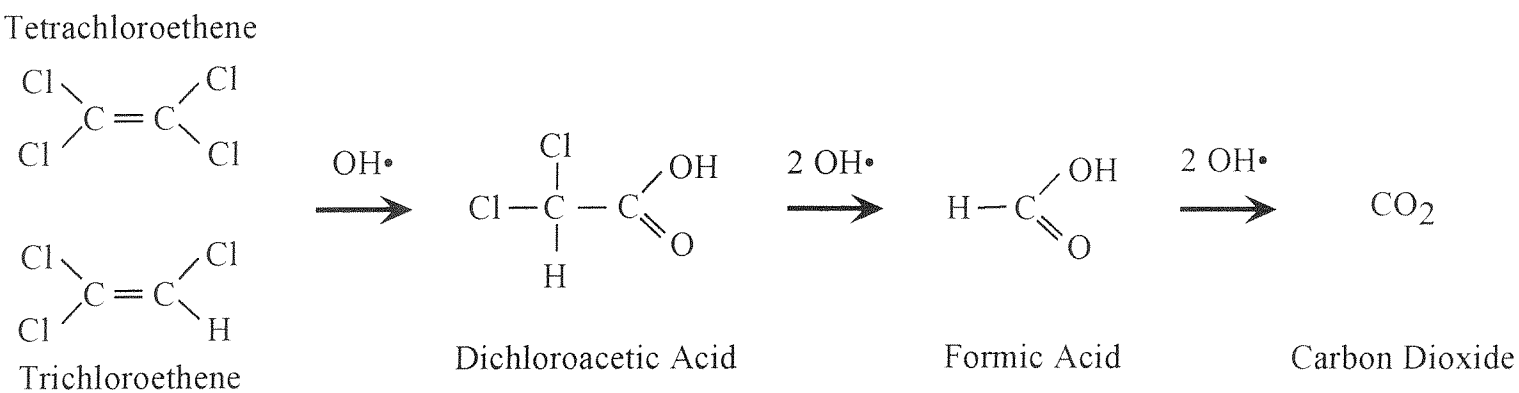


FIGURE 1-8. Target Treatment Area

Geo-Cleanse®
International, Inc.

Tetrachloroethene & Trichloroethene Oxidation Pathway



References: Leung et al. 1992; Sato et al. 1993

FIGURE 2-1. FENTON'S REAGENT OXIDATION PATHWAY FOR TETRACHLOROETHENE AND TRICHLOROETHENE

Geo-Cleanse International, Inc.
4 Mark Road, Suite C
Kenilworth, NJ 07033

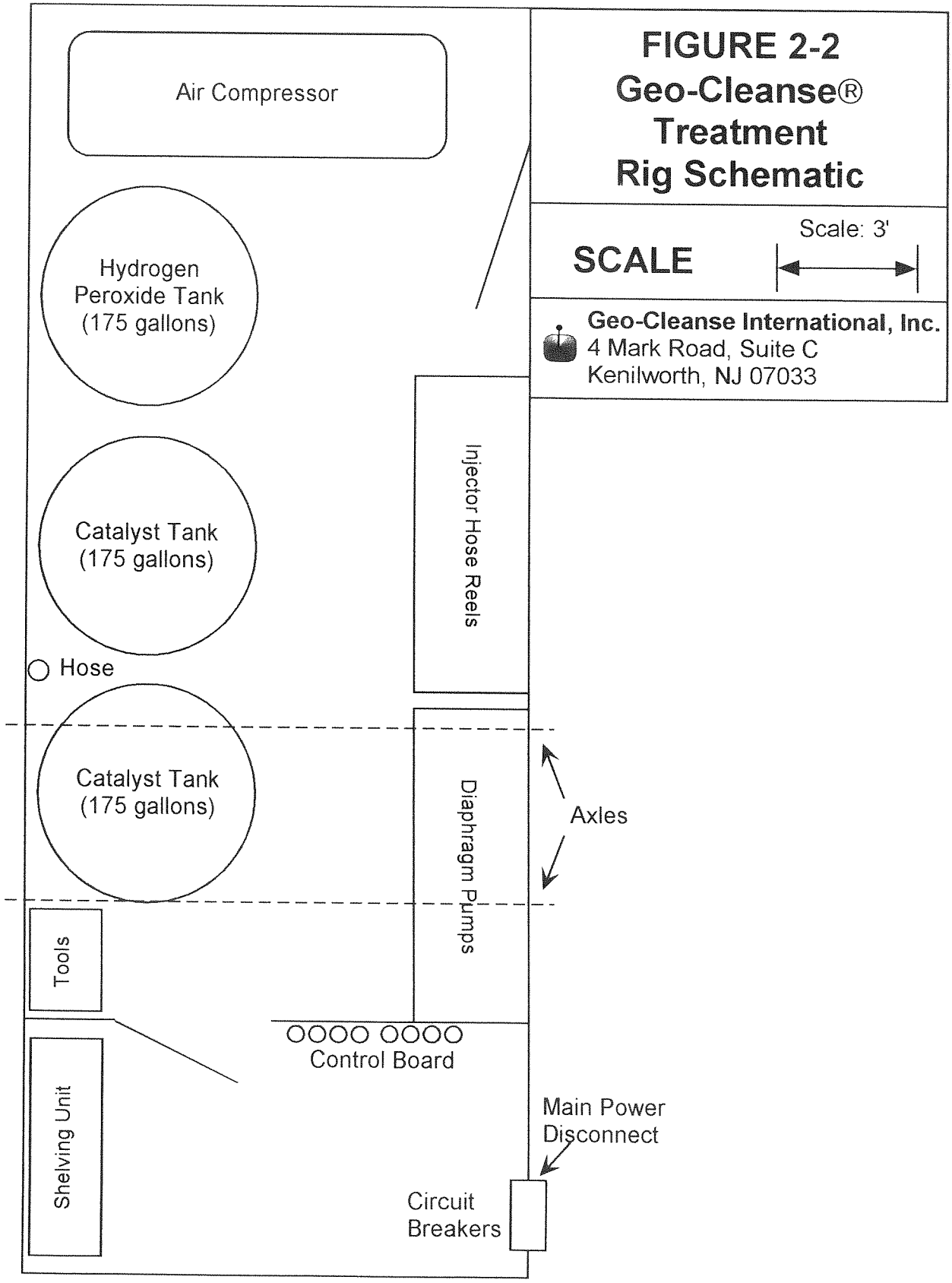


FIGURE 2-2
Geo-Cleanse®
Treatment
Rig Schematic
SCALE
Scale: 3'
Geo-Cleanse International, Inc.
4 Mark Road, Suite C
Kenilworth, NJ 07033
Air Compressor
Hydrogen
Peroxide Tank
(175 gallons)
Catalyst Tank
(175 gallons)
Hose
Catalyst Tank
(175 gallons)
Injector Hose Reels
Diaphragm Pumps
Axles
Tools
Shelving Unit
Control Board
Main Power
Disconnect
Circuit
Breakers

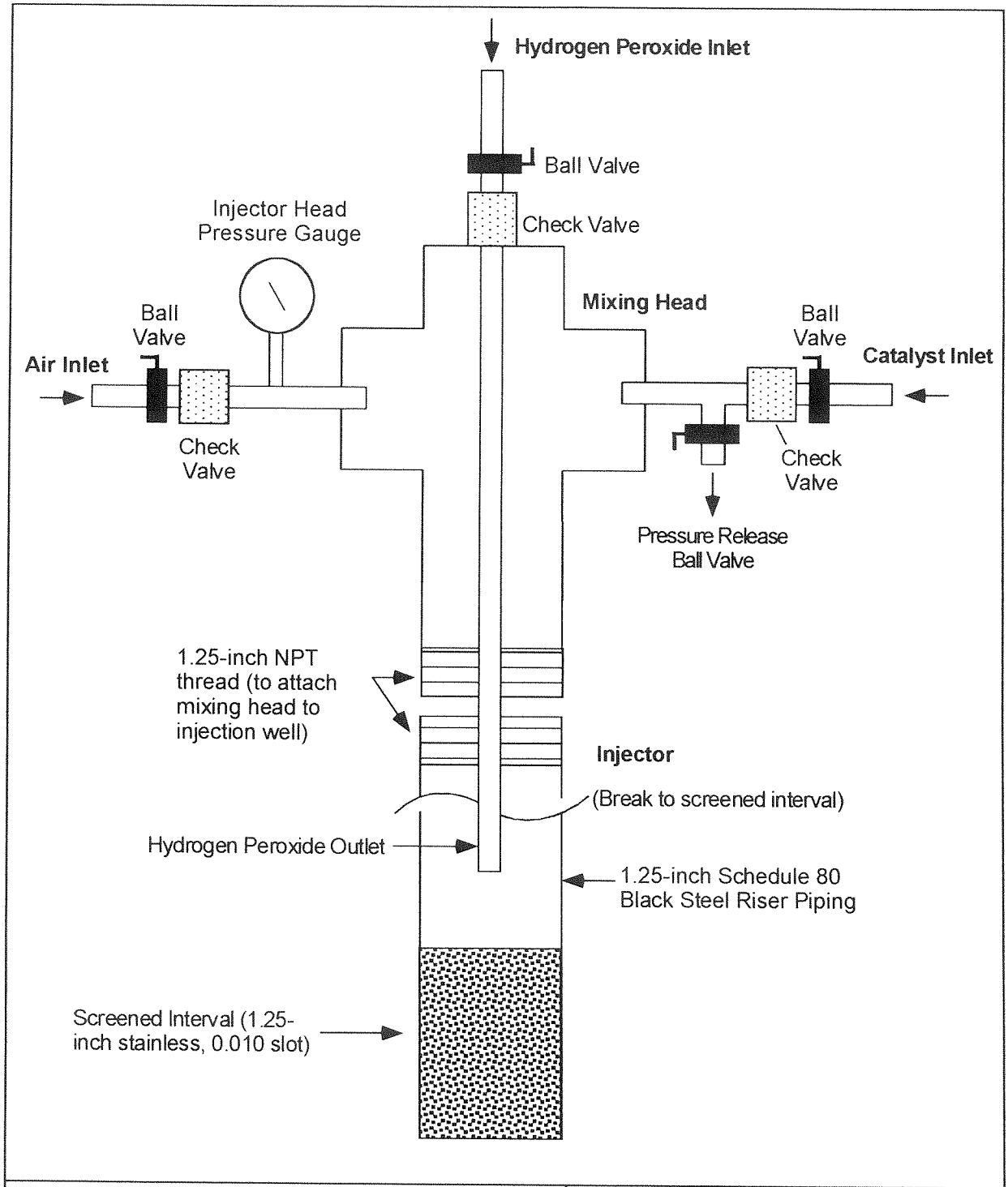


FIGURE 2-3. Geo-Cleanse® Patented Injector and Mixing Head Design Schematic (U.S. Patents 5,525,008 and 5,611,642)

Geo-Cleanse International, Inc.
4 Mark Road, Suite C
Kenilworth, NJ 07033

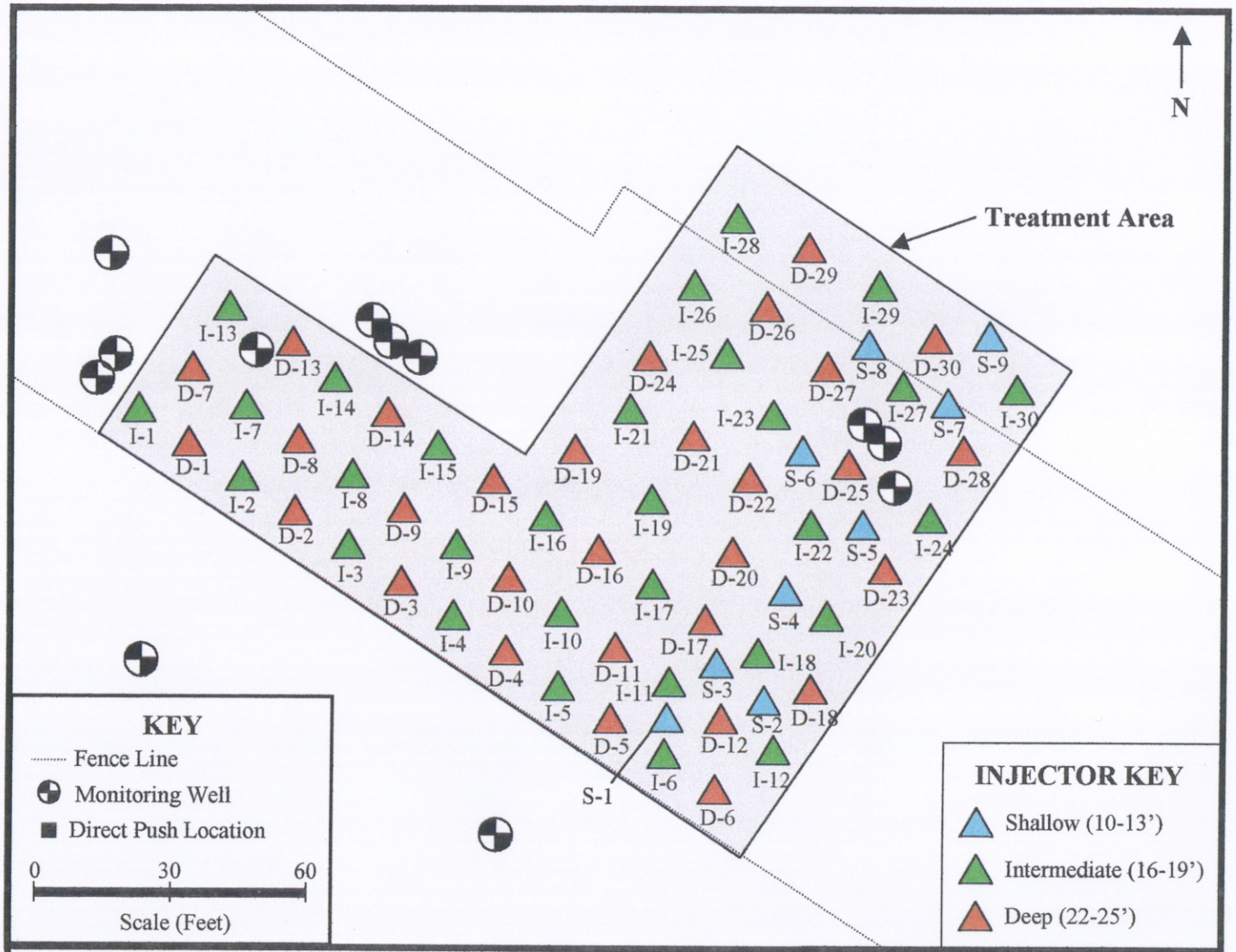
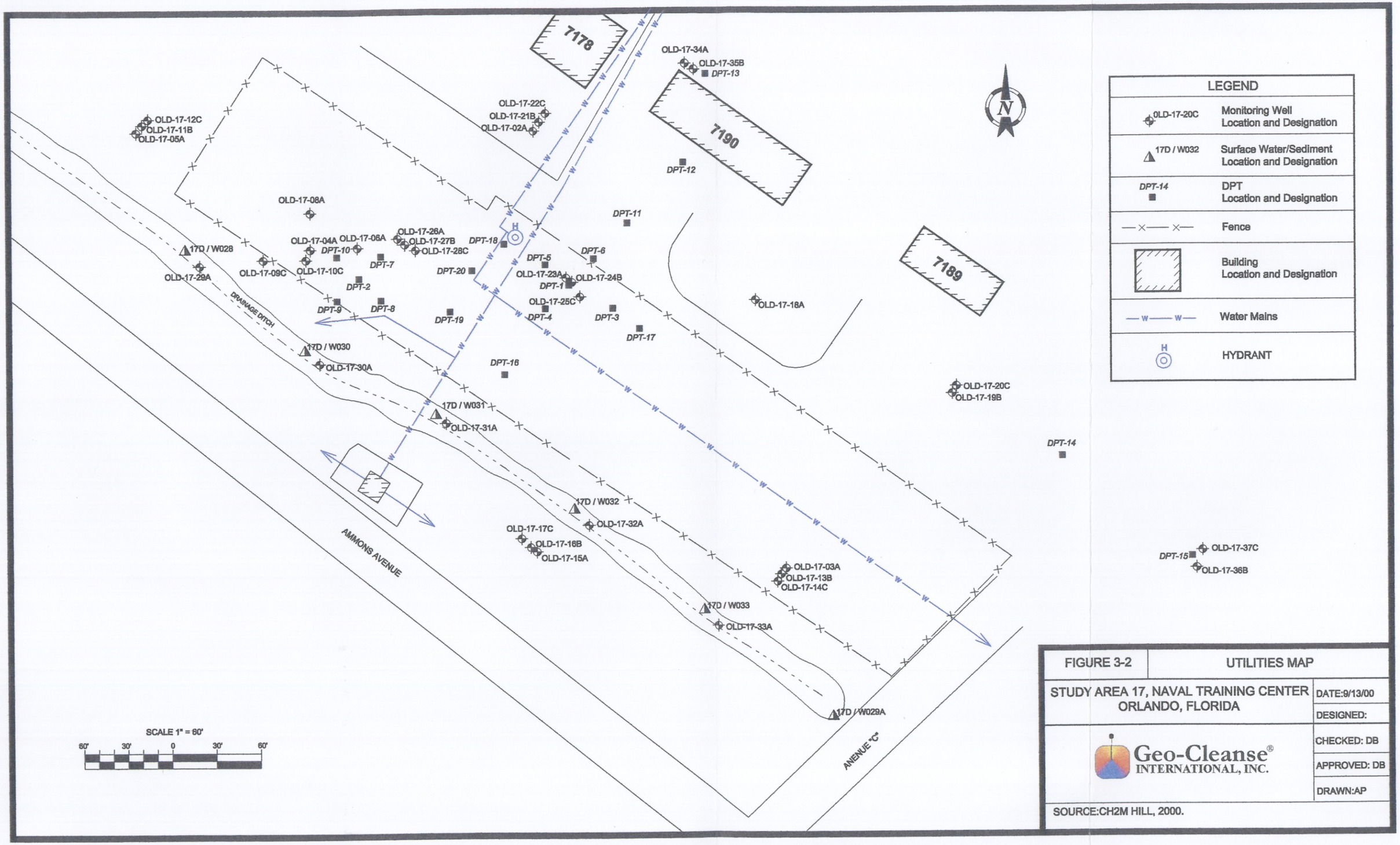


FIGURE 3-1. Injector Locations and Identification

Geo-Cleanse®
International, Inc.


7178
7190
7189
OLD-17-34A
OLD-17-35B
DPT-13
OLD-17-22C
OLD-17-21B
OLD-17-02A
OLD-17-12C
OLD-17-11B
OLD-17-05A
DPT-12
OLD-17-08A
DPT-11
OLD-17-04A
OLD-17-06A
OLD-17-26A
OLD-17-27B
OLD-17-28C
DPT-18
DPT-10
DPT-7
DPT-6
DPT-5
DPT-20
OLD-17-23A
OLD-17-24B
DPT-1
17D / W028
OLD-17-29A
OLD-17-09C
OLD-17-10C
DPT-2
OLD-17-25C
DPT-4
DPT-3
DPT-9
DPT-8
DPT-19
DPT-17
OLD-17-18A
DRAINAGE DITCH
17D / W030
OLD-17-30A
DPT-16
OLD-17-20C
OLD-17-19B
17D / W031
OLD-17-31A
DPT-14
17D / W032
OLD-17-32A
OLD-17-17C
OLD-17-16B
OLD-17-15A
AMMONS AVENUE
OLD-17-03A
OLD-17-13B
OLD-17-14C
DPT-15
OLD-17-37C
OLD-17-36B
17D / W033
OLD-17-33A
17D / W029A
ANENUE "C"
SCALE 1" = 60'
60' 30' 0 30' 60'
N
LEGEND
OLD-17-20C
Monitoring Well Location and Designation
17D / W032
Surface Water/Sediment Location and Designation
DPT-14
DPT Location and Designation
Fence
Building Location and Designation
Water Mains
HYDRANT
FIGURE 3-2
UTILITIES MAP
STUDY AREA 17, NAVAL TRAINING CENTER
ORLANDO, FLORIDA
DATE:9/13/00
DESIGNED:
CHECKED: DB
APPROVED: DB
DRAWN:AP
Geo-Cleanse®
INTERNATIONAL, INC.
SOURCE:CH2M HILL, 2000.

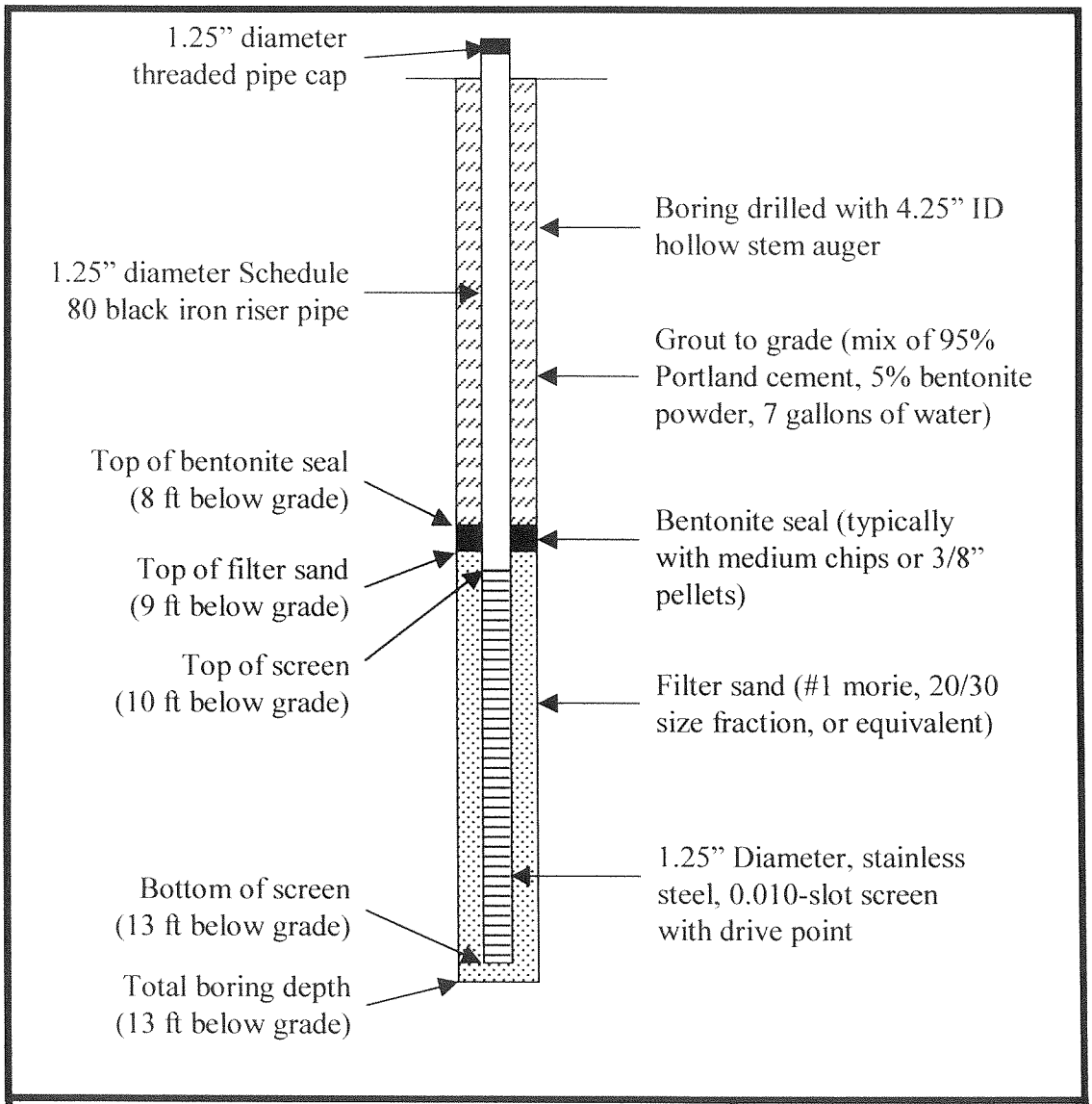


FIGURE 3-3. Example Construction Detail for Shallow Injector

Geo-Cleanse® International, Inc.

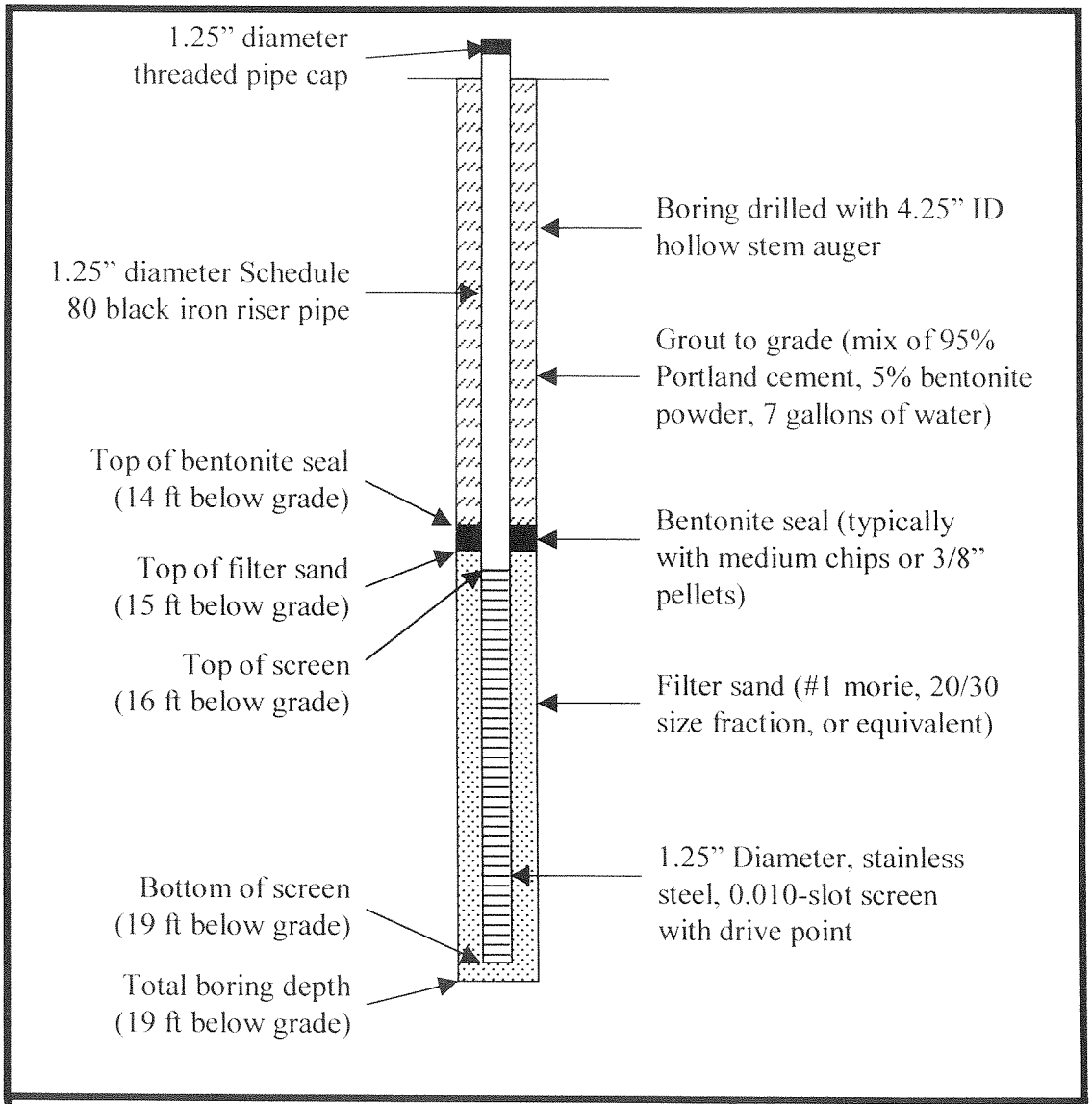


FIGURE 3-4. Example Construction Detail for Intermediate Injector

Geo-Cleanse® International, Inc.

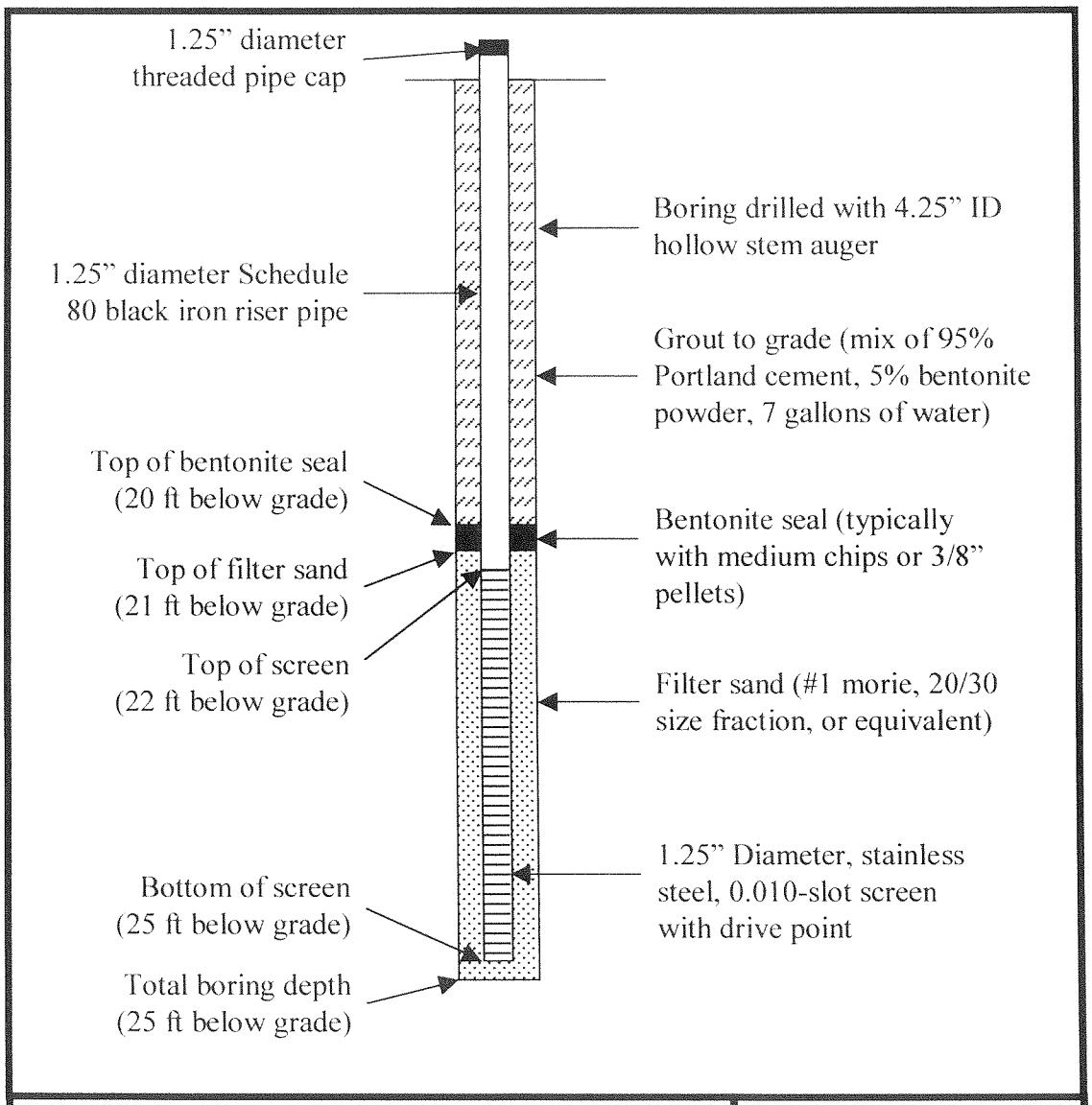


FIGURE 3-5. Example Construction Detail for Deep Injector

Geo-Cleanse® International, Inc.

Figure 3-6. Example Soil Boring and Well Construction Log

Geo-Cleanse International, Inc. • 4 Mark Road, Suite C • Kenilworth, NJ 07033
Telephone (908) 206-1250 • Fax (908) 206-1251 • E-mail geocleanse@earthlink.net

Soil Boring Log	**Project:**	**Page** ___ **of** ___
	Location:	**Date:**

Consultant / Rep(s):	Well No.:	Approx. Location
GCI Rep(s):	Boring No.:	
Drilling Contractor:	Injector No.:	
Driller / Helper:	PID Type:	
Drill Rig / Method:	PID Lamp:	

Depth (feet)	Sample Interval	Recovery (Inches)	Sample ID #	Blows per 6"	PID (ppm)	Moisture Content	Depth of Change	Soil Description	Remarks	Well Construct

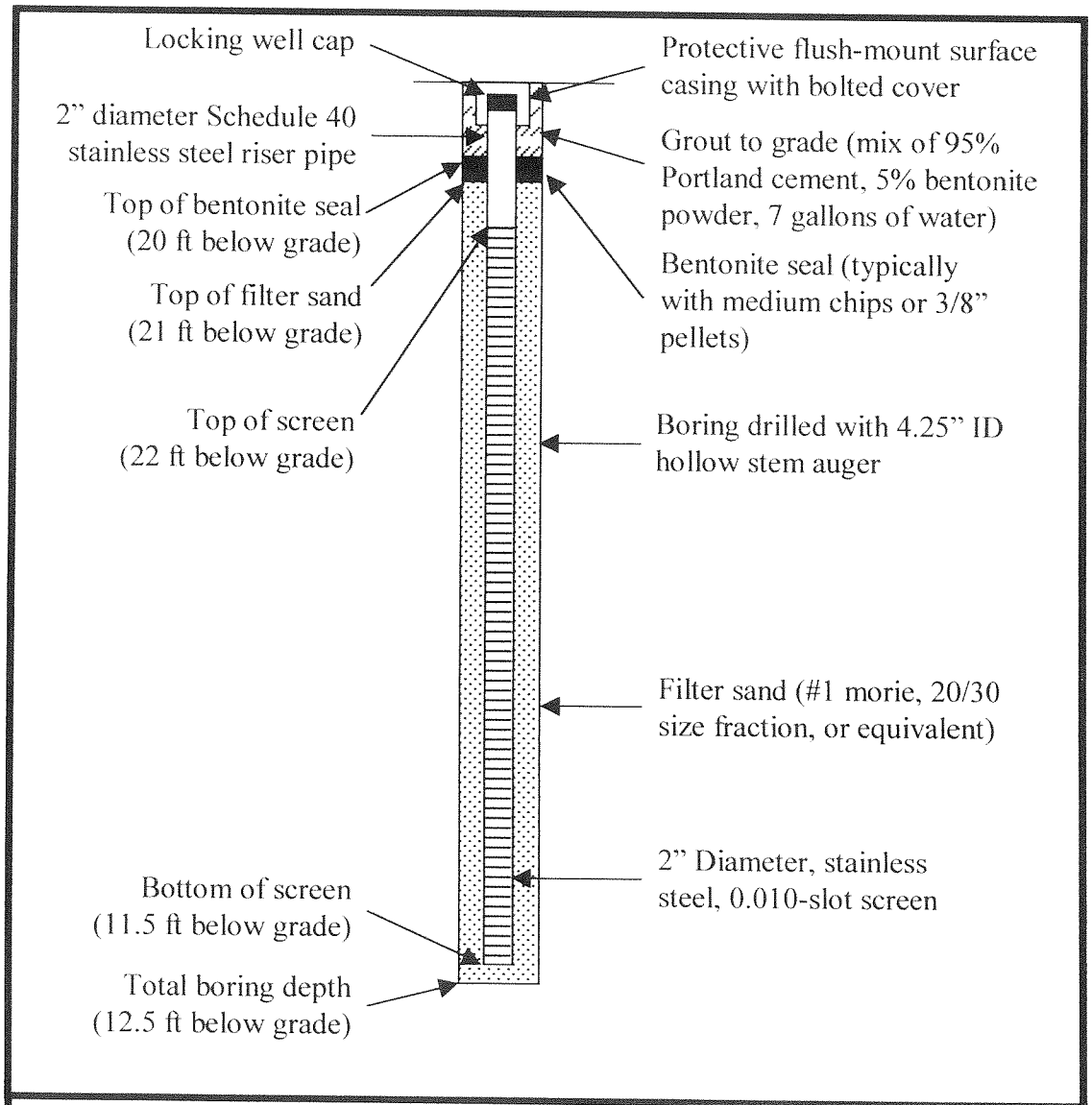


FIGURE 3-7. Construction Detail for Reinstallation of Old-17-23A-R

Geo-Cleanse® International, Inc.

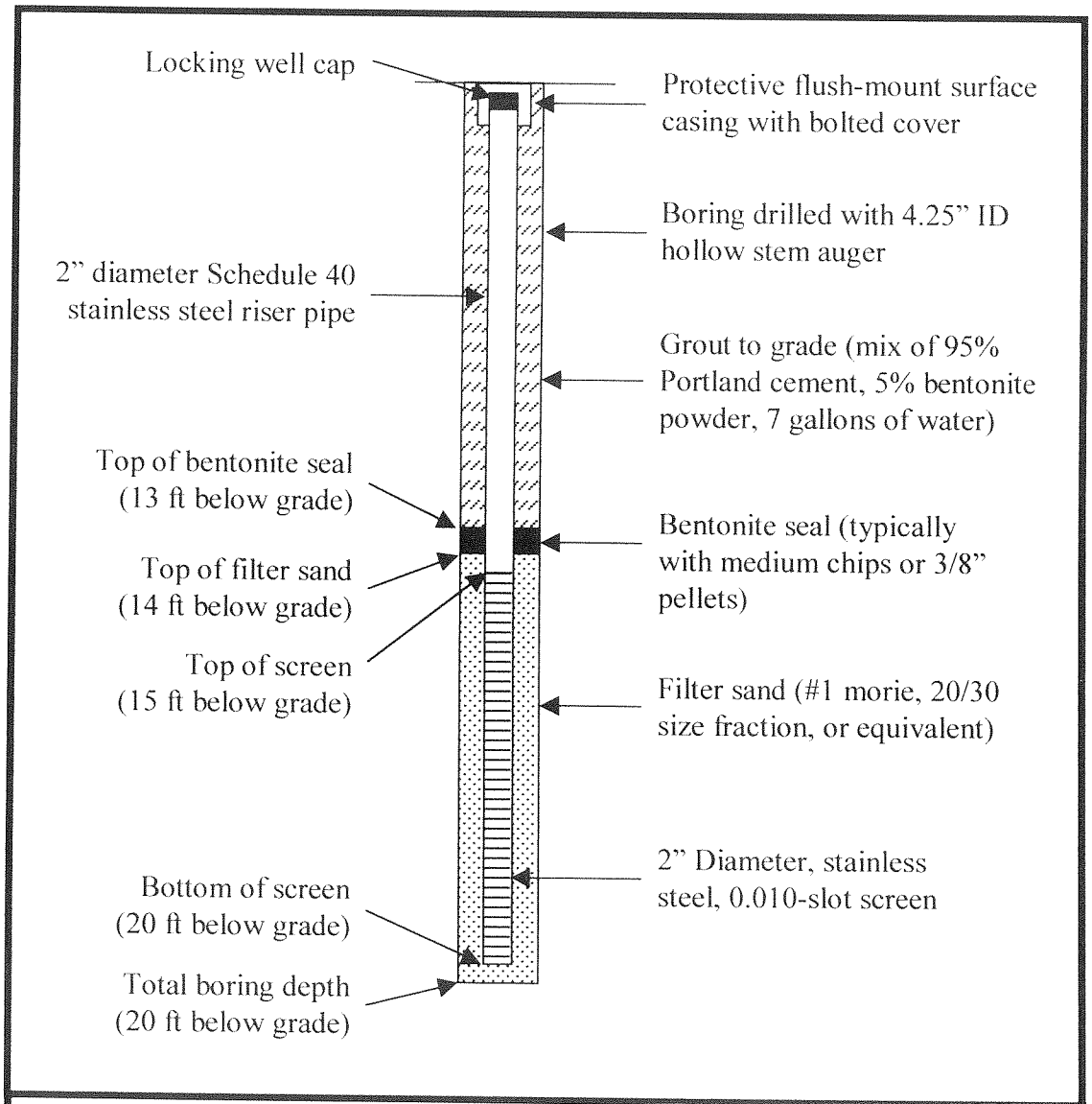


FIGURE 3-8. Construction Detail for Reinstallation of Old-17-24B-R

Geo-Cleanse® International, Inc.

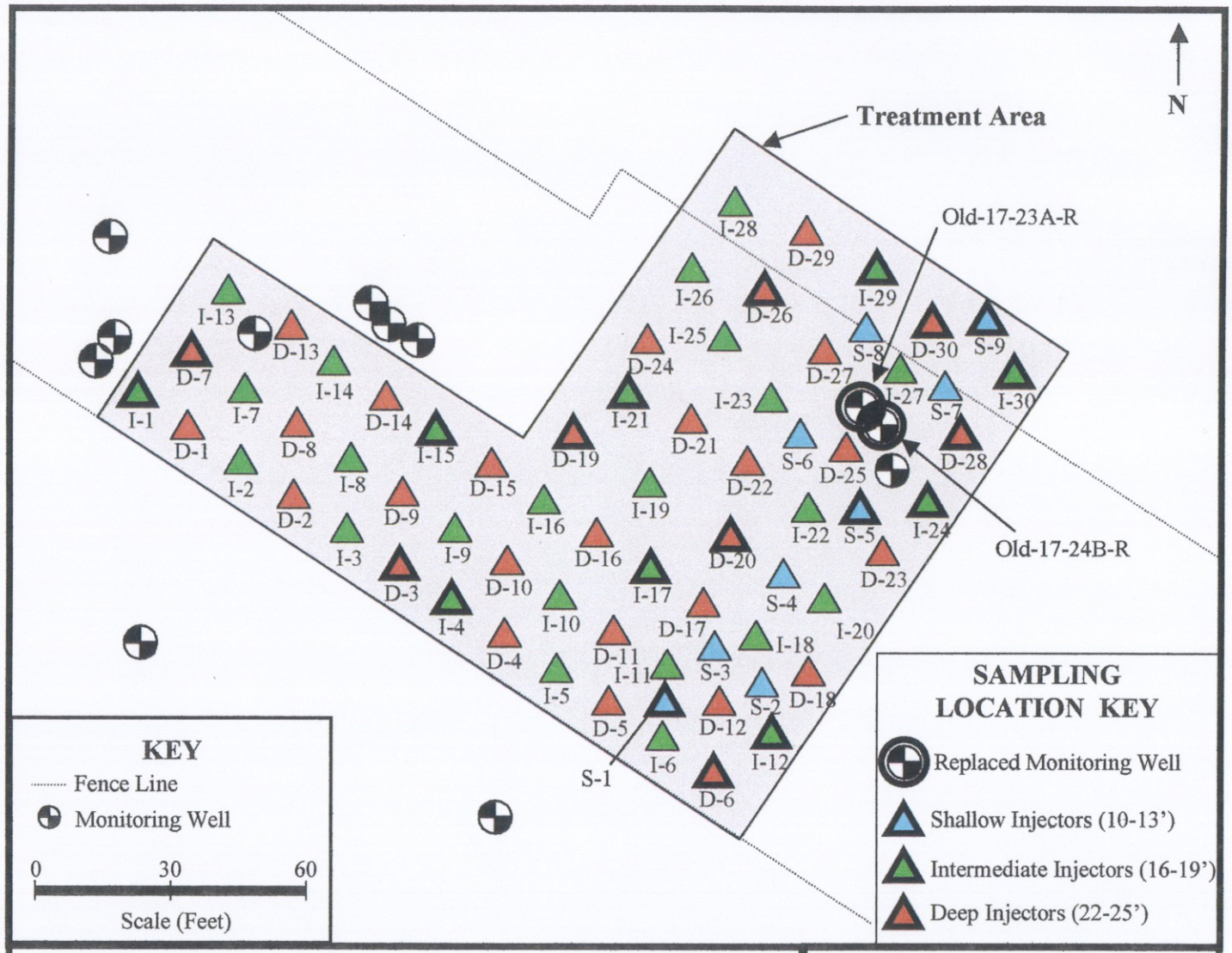


FIGURE 3-9. Sampling Locations and Identification

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International, Inc.