TECHNICAL MEMORANDUM ON THE OPTIMIZATION FOR STUDY AREA 17 NTC ORLANDO FL

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CH2M HILL

Optimization Report for Study Area 17, Former Naval Training Center, Orlando, Florida

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Introduction

The Department of the Navy's (DON) environmental restoration mission is to protect human health and the environment while supporting the defense mission by ensuring continued use of lands necessary for military operations at active Navy sites (DON, 2003). This mission is supported, in part, by an ongoing effort to improve the performance and cost effectiveness of the Installation Restoration (IR) program. This Optimization Report supports this ongoing effort by incorporating remedy optimization concepts in the remedy selection phase of the Environmental Restoration program.

This work is being performed under the Remedial Action Contract No. N62467-01-D-0331, Contract Task Order (CTO) 0004 at the former Naval Training Center (NTC) Orlando, Florida

This report provides the following information necessary to optimize the remedy at Study Area (SA) 17:

- Background of the site and latest understanding of site conditions
- Uncertainty in site understanding
- Areas that require treatment
- Goals of the remedial action, by specifying remedial action objectives and performance objectives
- Alternatives that can be used to remediate the site
- Recommendation of the alternative to implement at SA 17

- Other recommendations necessary to address the uncertainties presented in this Optimization Report

The report is organized into nine sections:

- Background
- Conceptual Site Model
- Remedial Action Objectives
- Target Treatment Zone(s)
- Treatment Technology Evaluation
- Performance Objectives
- Optimization and Exit Strategies
- Recommendations
- References

Tables and figures are provided at the end of the text, followed by Attachments.

This report was prepared using *Guidance for Optimizing Remedy Evaluation, Selection, and Design* (NAVFAC, 2004), conclusions from the November 23, 2004, Technical Review Meeting, as well as previous findings and conclusions for SA 17.

Background

SA 17 is located at NTC Orlando, a former Navy facility located in the city of Orlando, Florida. SA 17 occupies approximately 25 acres in the central part of the McCoy Annex. The site includes Buildings 7178, 7191, and 7193, and the adjacent area that formerly served as the Defense Property Disposal Office (DPDO) complex for the McCoy Annex.

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. (ABB). Findings from that investigation indicated exceedance of screening criteria for polynuclear aromatic hydrocarbons (PAHs) in soil and chlorinated volatile organic compounds (CVOCs) in groundwater. Subsequently, the Orlando Partnering Team (OPT) requested that Harding Lawson Associates (HLA) perform supplemental screening investigations to evaluate and characterize the CVOC contamination at the site.

Results of the supplemental screening investigation indicated that the suspected source of CVOC-contaminated groundwater at the site is related to operations at the former motor pool area. The highest total CVOC concentration detected during the investigation was 65,000 micrograms per liter (µg/L).

CH2M HILL Phase I and II Confirmatory Sampling

The OPT requested that CH2M HILL perform an Interim Remedial Action (IRA), consisting of confirming site conditions, developing an IRA approach, and implementing an appropriate IRA. CH2M HILL collected groundwater data and the results of those Phase I and II confirmatory sampling activities are documented in the technical memorandum entitled *Phase I and II Data Report for Study Area 17, NTC Orlando* (CH2M HILL, 2000).

The objectives of the Phase I and 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. Site characterization activities using a direct-push technology (DPT) rig were conducted at the site from March 21 to April 7, 2000. Following the DPT sampling activities, additional monitoring wells were installed at the SA 17 site. During the Phase II site characterization, media and groundwater samples from contaminated areas at the site were collected and provided to potential IRA subcontractors for bench scale treatability testing. The results of the Phase I and II site characterization activities are documented in the technical memorandum entitled *Phase I and II Data Report for Study Area 17, NTC Orlando* (CH2M HILL, 2000).

CVOCs adversely impacted the groundwater throughout the surficial aquifer and in isolated areas within the upper part of the intermediate aquifer of the Hawthorn Group sediments. Given the contaminant distribution pattern, the plume appeared 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, compounds detected at the highest concentrations were cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride, with a maximum concentration of 400 µg/L. In the eastern source area, trichloroethene (TCE) was the predominant compound detected, with a maximum concentration of 65,000 µg/L. The highest contaminant concentrations were detected at the water table interface in the source areas and along the upper surface of a silty sand layer that is located between 15 and 25 feet below land surface (bls). This layer and another somewhat deeper layer of silty sand act as leaky aquitards that divide the surficial aquifer into three units—shallow, intermediate, and deep.

As a result of the Phase I and II site characterization, the interpreted areal extent of the CVOC plume was defined as extending from the water table interface of both source areas for a distance of approximately 50 to 100 feet in the direction of groundwater flow (east-southeast). In the intermediate unit of the surficial aquifer, the plume extends approximately 250 feet downgradient, and in the deep unit of the aquifer, the plume extends approximately 300 feet from the source areas.

IRA Using In Situ Chemical Oxidation

Subsequent to completion of the Phase I and II site characterization activities, CH2M HILL issued a Request for Bid to implement an IRA consisting of in situ chemical oxidation (ISCO) using Fenton's Chemistry for source control/reduction of the chlorinated solvent plume at the SA 17. CH2M HILL contracted with Geo-Cleanse International (GCI) to implement the IRA. ISCO injections at SA 17 were divided into two distinct phases. Phase I consisted of two injection events conducted from November 2000 through January 2001. Phase II consisted of three injection events conducted from March 2002 through September 2002. A summary of the field activities and findings from each phase are provided in the *Construction Documentation Report for the Interim Remedial Action at SA 17* (CH2M HILL, 2003).

The remedial goal of the IRA was to reduce the contaminant source area mass and volume to the extent possible. A total CVOC concentration of 500 µg/L was established as the treatment objective. Total CVOC concentration is a summation of TCE, cis-1,2-DCE; 1,1-dichloroethene (1,1-DCE), 1,1-dichloroethane (1,1-DCA), and vinyl chloride.

Monitoring well data were used to evaluate the effectiveness of the ISCO IRA at SA 17. The data analysis showed dissolved phase concentration reductions of 89 percent TCE and 87 percent CVOCs were achieved as a result of the ISCO IRA conducted at SA 17, as measured in 2003.

Post-IRA Site Evaluation

Based on the data generated during two post-treatment sampling events completed in January and June 2003, concentrations of TCE greater than 1 percent of the maximum solubility in water have been detected in two deep injectors (D-25 and D-33) and two monitoring wells (OLD-17-23A and OLD-17-24B). The maximum solubility of TCE in water is approximately 1,100 milligrams per liter (mg/L). Concentrations greater than 1 percent of solubility (in the case of TCE, this concentration is 11,000 µg/L) are considered a likely indicator of the presence of a dense non-aqueous phase liquid (DNAPL) source area near the monitored location. As a result of these elevated TCE concentrations, CH2M HILL recommended a focused investigation to better characterize the localized areas of elevated concentration.

The investigation included a Membrane Interface Probe (MIP) investigation and collection of discrete soil and groundwater samples. As a result of this investigation, the location and depths of the most contaminated soil and groundwater were identified at SA 17. The findings from this investigation were reported in *CVOC Source Area Investigation and Focused Feasibility Study* (CH2M HILL, 2004).

Most of the historical site investigations focused on investigation and remediation of the source area. In an effort to address SA 17 as a whole, CH2M HILL recommended a more comprehensive investigation of the site to provide information necessary for the development of the overall closure strategy. In August 2004, CH2M HILL completed a comprehensive sampling effort that involved the collection of groundwater samples for CVOC and MNA analysis. The results of this investigation, as reported in *Summary of Data Collection Activities, Study Area SA 17, Former Naval Training Center Orlando* (CH2M HILL, 2005), concluded that high levels of contaminants are present in the source area and that natural attenuation activity is observed in the downgradient portions of the plume.

In addition to the above reports and findings, an additional technical effort was performed to support this optimization study. Two models were evaluated for the purposes of estimating the Time of Remediation (TOR) and Time of Stabilization (TOS) of the groundwater plume. The TOR estimates the timeframe required to achieve a pre-determined cleanup level at the source of contamination. TOS refers to the time required to achieve a pre-determined compliance or target concentration at a fixed distance downgradient of the source area.

The two different models were used to support TOR estimates; results are discussed in Attachment A. Overall, the results of the TOR efforts concluded that only removal of a substantial percentage of the mass from the source area will result in any noticeable reduction of TOR. These findings are discussed in further detail in Attachment A and the following sections.

Conceptual Site Model

Figures 1 and 2 present a conceptual site model (CSM) in plan and profile view. Figure 3 presents a geologic cross-section of the site. Based on historical information and current understanding of the site, the following information about the CSM for SA 17 can be concluded:

- Contaminant Source and Release Information
  - TCE appears to have entered the ground at a surface location and migrating began vertically downward.
  - TCE continued to move downward until it encountered a horizontal zone of lesser permeability (at approximately 10 to 15 feet and again at approximately 25 to 30 feet).
  - When TCE encountered lithology of lesser permeability, it would accumulate and spread out over the feature and also fill the pore space of the less permeable material.
  - In some instances, the horizontal feature may have been thin, or discontinuous, and allowed a vertical migration pathway to be established that allowed TCE to continue its downward vertical migration.
  - In other instances, the TCE encountered a horizontal feature that was able to further retard downward migration of contaminants.
  - Dense non-aqueous phase liquid (DNAPL) was not observed in any of the sampling efforts but is suspected to be present based on the 1 percent rule of thumb (that is, TCE concentrations exceed 1 percent of its solubility in water [11,000 µg/L]), most likely present as ganglia representing small volumes of liquid in pore space.
- Geologic and Hydrologic Information
  - The upper 30 feet of sediments consists primarily of fine sand with the exception of two thin (approximately 5- to 10-feet) discontinuous layers of silty sand. The upper layer of the silty sand lies at about 10 to 15 feet bls and appears to dip to the east and northeast.
  - The lower layer of silty sand lies at about 25 to 30 feet bls and appears to be continuous across the site.
  - Below the lower layer of silty sand is an interval of fine- to coarse-grained sand that extends from about 30 to 50 feet bls. Because of its green coloration, this layer marks the upper part of the Hawthorn Group of sediments. This interval is underlain by another silty-sand layer that extends from 50 to 55 feet bls, which is in turn underlain by approximately 10 feet of sandy, silty clay. This clay is considered to be the bottom of the surficial aquifer and is underlain by fine- to coarse-grained sand of the Hawthorn Group sediments.
  - Water lies at approximately 6 feet bls across the site, with a variation of 2 feet.

  - The surficial aquifer extends to a depth of about 55 feet and the uppermost Hawthorn clay layer.
  - Groundwater elevation data indicate radial flow away from a groundwater high located across the central portion of SA 17.
  - The location of a buried water-supply line that runs across SA 17 suggests that leakage from the line may have been responsible for the localized groundwater high and resulting radial discharge observed in past investigations. This water line has since been turned off.
  - The groundwater flow direction in the intermediate portion of the aquifer, between the upper two silty-sand intervals (15 to 30 feet bls) suggests that local recharge may also influence this interval. Flow in the intermediate zone is toward the ditch to the south, but a component of flow also exists to the east.
  - Groundwater flow direction in the deep portion of the aquifer, below the lower silty-sand interval (>30 feet), suggests that local recharge has no influence in this interval. Flow in the deep zone is toward the south and east. Contaminant migration indicates a northerly component to the deep groundwater flow further east from the site.
  - Groundwater flow across the site has a strong downward component.
  - Groundwater velocities at the site are low, ranging from approximately 3 to 7 feet/year depending on depth.
  - Groundwater flow direction in the A and B zones (south and southeast respectively) is governed primarily by the ditch that runs south of the site. The C zone follows a more regional gradient (northeast).

- Contaminant Distribution, Fate, and Transport
  - The residual TCE in subsurface acted/acts as a source and through advection and dispersion, dissolved phase TCE is carried downgradient from the source area.
  - As TCE moves downgradient, it establishes an equilibrium with the aquifer media. The chemical equilibrium is dynamic and controls the amount of TCE sorbed versus TCE in the dissolved phase. This process retards the migration of CVOCs, which results in the CVOCs generally moving slower than groundwater.
  - A calculated concentration of potential DNAPL concentrations in soil is 342 milligrams per kilogram (mg/kg) (DNAPLANAL). The highest concentration of TCE reported in soil is 168 mg/kg. Although this value does not exceed the potential DNAPL calculated value, it does indicate the potential for elevated concentrations of TCE in soil act as a continuing source of contamination.
  - Based on the 1 percent rule-of-thumb, there exists the potential of TCE DNAPL to be present based on concentration of TCE exceeding 11,000 µg/L.
  - Reducing conditions are evident in the source area, as well as downgradient of the source area, as site data points to evidence of predominantly iron reducing

conditions, but some degree of sulfate reducing and methanogenic conditions at the site. These conditions are favorable for natural attenuation.

- The presence of TCE daughter products cis-DCE and vinyl chloride in downgradient wells relatively near the residual TCE source area indicates that reductive dechlorination is occurring readily at the site. The relatively high ratio of daughter products to parent compound (TCE) indicates a high degree of biotransformation is occurring. This is favorable for natural attenuation.
- Dehalococcoides have been detected at the site at two locations, which is highly favorable for natural attenuation, as Dehalococcoides organisms have been shown to be capable of complete reductive dechlorination of TCE and its daughter products to ethane. It is likely that Dehalococcoides can become established at other areas if additional carbon source is added.

- Impacts of IRA on Site
  - The IRA was conducted in a small area of the overall SA 17 site. Only those locations where injection occurred have been affected by the IRA.
  - The IRA was effective at reducing dissolved contaminant levels and likely also reduced the concentration of TCE adsorbed to the surface media. However, the IRA was not successful at penetrating deep into the pore structure of the aquifer media (diffusion limited) in the treatment zone, and resulted in rebound of contaminants in the source area.
  - Concentrations of TCE in groundwater will increase with time as more TCE leaches from the pore space to the bulk-phase liquid.
  - As a result of the ISCO process, substantial amounts of iron (through ferrous sulfate catalyst) and sulfate (through ferrous sulfate catalyst and sulfuric acid) were added to the treatment zone.
- Uncertainty
  - In the horizontal perspective, the extent of the groundwater plume has been characterized in most directions. The exception is the southern component of the plume, toward the ditch.
  - The ditch south of the site appears to locally control the direction of groundwater flow. It has been several years since surface water has been sampled at this location. It is unknown if the contaminant plume is discharging into the surface water.
  - The depth of contamination at the SA 17 source area has not been confirmed at locations where the highest levels of TCE have been reported in groundwater. The deepest groundwater samples were collected in this area at approximately 39 feet bls, where TCE was reported at a concentration of 48,800 μg/L. Elevated MIP responses (that is, greater than 1E+06) were noted between this depth and the top of Hawthorn depth (approximately 50 feet bls).

Remedial Action Objectives

A substantial effort in source area treatment has already been completed and it is believed that the practical limits of cost effective remediation for the purposes of complete removal of the source have been exhausted. This conclusion is supported by modeling estimates which show that even substantial reduction in the source area does not significantly alter the time of remediation for the site (Attachment A). The important conclusions from the modeling effort are:

- Further source reduction does not provide a benefit in protection of human health and the environment and does not significantly affect the overall time of remediation.
- Given the SA 17 source area is approximately 600 feet from the property boundary, the model results indicate that the source will not cause offsite groundwater concentrations to exceed Florida Department of Environmental Protection (FDEP) Groundwater Cleanup Target Levels (GCTLs) at any point in the future.
- Given the current distribution of contaminants at the site (that is, known contaminant concentrations downgradient), no location downgradient of the source area at SA 17 is anticipated to yield an offsite exceedance of GCTLs at some point in the future.

Based on these conclusions, achieving a pre-defined source mass reduction or concentration reduction is not a component of the recommended remedial action objective (RAO) for this site. However, it is important that the implemented alternative involve management of source area to prevent further groundwater migration away from the source and contamination in the zone already treated by the IRA.

Figure 1 shows a plan view of SA 17. The three main areas to consider when developing RAOs for SA 17 are:

- **Area 1—**the source area
- **Area 2—**contaminated groundwater between the source area and the property boundary
- **Area 3—**groundwater at the property boundary

RAOs have been designed for each of the areas described below.

Area 1

This area contains the highest concentrations of TCE at SA 17. TCE is present at high concentrations and is likely present as a DNAPL and, as evidenced by the results of aggressive ISCO treatment, will be difficult to remove. Three dimensional kriging of the area shows this area to be approximately 50 feet by 50 feet in area (approximate footprint of soil and groundwater exceeding 10,000 parts per billion [ppb]). High levels of CVOCs were documented down to 39 feet bls. Groundwater samples were not collected at depths greater than this, but MIP responses from this area indicate that CVOCs could be present, based on electron capture detector (ECD) responses greater than 1E+06 at depths between 40 and 50 feet).

The RAOs for this area are to:

- Apply treatment that can reduce source contaminant concentrations while minimizing CVOC migration from the area,
- Prevent plume expansion in the IRA treatment area.
- Prevent exposure of contaminants to human health and the environment.

Area 2

Area 2 represents the area between Area 1 (source area) and the downgradient property boundary. This area is not expected to have DNAPL TCE (based on 1 percent rule of thumb) but may have high concentrations of TCE and other CVOCs.

The RAOs for this area are to:

- Reduce contaminant concentrations to a level that do not threaten human health or the environment at the downgradient property boundary.
- Prevent exposure of contaminants to human health and the environment.

Area 3

Area 3 represents the area of the SA 17 site immediately near the property boundary and is characterized by groundwater with low concentrations of CVOCs.

The RAOs for this area are to:

- Prevent contaminants from crossing the property boundary at concentrations that threaten human health and the environment.
- Prevent exposure of contaminants to human health and the environment.

Target Treatment Zones

Two target treatment zones (TTZs) are recommended for the site. TTZ-1 represents Area 1 (Figure 4) and TTZ-2 represents Area 2 (the area outside of TTZ-1 but within the footprint of the contaminant plume, see Figure 2). Although investigations have not been performed to the top of the Hawthorn formation, it is assumed that groundwater contamination extends to the top of the Hawthorn (approximately 50 feet) based on the high concentrations of TCE reported at a depth of 39 feet in four samples and elevated ECD response using the MIP, in the 45- to 50-foot depth range. The depth of TTZ-1 is from the water table to the top of the Hawthorne formation.

TTZ-1 encompasses all groundwater contamination reported with TCE greater than 10,000 µg/L. However, elevated concentrations of TCE still exist outside the TTZ, as presented on Figure 4 and in the table below.

Station	TCE (µg/L)	Date Collected
17-I-12	3910	20040809
17-VD-62	3160	20040809
17-VD-58	2910	20040810
17-VD-69	2250	20040804
17-S-01	2200	20040809
17-D-03	827	20040810
17-S-04	422	20040806
17-VD-64	401	20040810
17-D-20	366	20040805
17-I-04	285	20040803
17-VD-71	283	20040811

With respect to TTZ-2, this area is characterized by the contaminant plume increasing in depth as it migrates from the source. In most cases, the most shallow groundwater in TTZ-2 is not contaminated; however, there is currently inadequate data to define the precise depth interval requiring treatment in TTZ-2.

Technology Selection

This section focuses on technology selection for TTZ-1. TTZ-2 has demonstrated to be effective in showing natural attenuation is occurring at the site. As presented in *Summary of Data Collection Activities, Study Area SA 17, Former Naval Training Center Orlando* (CH2M HILL, 2005) and based on the modeling results presented in Attachment A, no additional treatment is warranted for TTZ-2.

TTZ-1 has been the focus of numerous ISCO applications with Fenton's reagent. The Construction Completion Report concluded that, while Fenton's regent was effective in reducing CVOC concentrations, the site is still susceptible to contaminant rebound due to the presence of CVOCs in high concentrations in the source area.

Based on the meeting between NAVFAC EFD SOUTH and CH2M HILL on November 23, 2004, two alternatives were considered viable options for SA 17:

1. **Alternative 1 -** Excavation
2. **Alternative 2 -** Enhanced Reductive Dechlorination (ERD). For the purposes of this technical evaluation, this alternative has been broken down to represent two different delivery methods:
   a. **Alternative 2A:** Substrate is applied to TTZ in recirculation mode
   b. **Alternative 2B:** Substrate is applied to TTZ via injection wells

Numerous commercial substrates are available to facilitate ERD. For the purposes of this evaluation, it has been assumed that emulsified oil substrate (EOS®) will be used. EOS® is used only to represent the class of substrates and its use in this evaluation is not intended as a definitive recommendation that this substrate will be used if the alternative is selected.

The alternatives are described below.

Alternative 1—Excavation, Onsite Treatment, and Backfill of Treated Soil

Alternative 1 provides for the removal of source contamination to a depth of approximately 50 feet bls. This includes the installation of a sheetpile retaining cell, excavation of soil within this cell, treatment of the excavated soil, and backfill of the excavation with treated soil. The remedial action objectives are met under Alternative 1 by providing removal of significant amounts of source contamination (TCE) and replacing it with soil that is cleaner as a result of ex situ treatment. This methodology is expected to remove the most significant portion of the contaminant source and also result in a substantial decrease in the amount of TCE migrating from the source area.

To remove the source contamination identified in the investigations, a circular sheetpile cell would be constructed to approximately 56 feet in diameter and driven to a minimum depth of 60 feet to retain the subsurface soil during excavation. It is estimated that approximately 4,600 cubic yards (CY) of contaminated soil would be excavated using a clamshell attached to a crane or similar piece of equipment. Excavated soil will be placed on a lined stockpile area adjacent to the excavation. The stockpile pad would be constructed so that excess water from the soil will be contained and allowed to drain back into the excavation.

The soil would be treated using an ex situ chemical oxidation process that destroys CVOCs by converting them into carbon dioxide and water.

This proposal assumes treatment of contaminated soil in a batch mix operation using a pugmill or other suitable mixing equipment. Potassium permanganate and other additives will be mixed with the contaminated soil at a ratio of approximately 14 pounds (lbs) of treatment reagent per ton of contaminated soil. Potassium permanganate will comprise approximately one half of the 14 lbs of treatment reagent per ton of contaminated soil. Vendor (Soil Savers) experience with this technology shows that TCE can be removed to levels below analytical detection limits.

Treated soil will be staged in stockpiles and sampled/tested approximately 2 days after treatment to verify cleanup goals. Confirmation sampling will be conducted to verify treatment effectiveness. Groundwater that remains in the excavation area after the soils have been removed will be treated by mixing with potassium permanganate and confirmatory samples will be collected to verify treatment effectiveness.

Soils treated successfully by the ex situ process will be backfilled in the open excavation, after the excavation water has been treated. The treated soil will be placed in the excavation by mobile equipment. The material placed below the water table will be placed without any compaction effort. Once the backfill reaches an elevation greater than the water table, the backfilled material would be compacted at pre-selected lift intervals (to be defined in the remedial design phase of work). Following backfilling of the excavation, the sheetpiling will be removed and disturbed surfaces will be graded to match the natural contours of the area and then vegetated.

Alternatives 2A and 2B—Enhanced Reductive Dechlorination Using Emulsified Oil Substrate

Two alternative methods of applying enhanced ERD technology have been evaluated in this report and their cost estimates are included as Alternatives 2A and 2B.

Alternative 2A is injection of EOS® in conjunction with recirculation of groundwater, and Alternative 2B is injection of EOS® followed by introduction of chase water to propagate the EOS® injectate further out into the subsurface.

EOS® Alternative Description

The ERD approach being proposed for the TTZ at SA 17 involves the injection of emulsified oil substrate (EOS®) into the subsurface in three sub-zones of the TTZ, the shallow zone (approximately 5 feet to 15 feet bls), intermediate zone (approximately 15 to 30 ft bls), and the deep zone (approximately 30 to 50 feet bls).

EOS® is a patented substrate that consists of emulsified soybean oil, with oil droplets small enough to pass through most pores in the soil. It is a biodegradable, non-hazardous substrate with low viscosity, and is expected to be a long-lasting natural time-release additive to enhance the bioremediation process. The EOS® patent is held by Solutions-IES, Inc., of Raleigh, North Carolina. The methodology of EOS® treatment involves introduction of this food-grade emulsified oil emulsion into the subsurface. The oil emulsion slowly dissolves over time enhancing the long-term anaerobic biodegradation of the chlorinated solvents. Product literature on the EOS® substrate indicates that it can be injected into "hot spots" throughout the plume (as in the case of SA 17) or as a permeable reactive barrier to contaminant migration. The EOS™ process successfully arrests plume migration, reducing additional assessment and remediation expenses, and is expected to lower operation and maintenance costs while being effective in heterogeneous soils.

Alternative 2A – EOS® Injection with Recirculation of Treated Groundwater

Under this alternative, EOS® will be injected into each of the three sub-zones of the shallow aquifer at SA 17. Based on consultations with Solutions-IES, Inc., for the silty sands at SA 17, a radius of influence (ROI) of approximately 15 feet from the injection point has been assumed. The TTZ for the source area has been identified as being 50 feet wide, 50 feet long and 50 feet deep. Based on the ROI of 15 feet, four injection points are required to cover the 50-foot by 50-foot footprint of the TTZ. The injection depths will be selected to provide the best contact of the substrate with areas of high TCE contamination in the subsurface. Based on the depths of the three sub-zones, four injection wells each are being proposed within the shallow zone (5 to 15 feet bls) and the intermediate zone (15 to 30 feet bls). Four nested pairs of injection wells are being proposed within the deep zone (30 to 50 feet bls) due to the greater thickness of this sub-zone. A total of 16 injection wells has been assumed in the cost estimate for this option.

Based on initial assumptions of aquifer characteristics, two 4-inch extraction wells each within the shallow and intermediate zone, and two nested pairs of extraction wells within the deep zone, are being proposed, for a total of eight extraction wells. Based on initial assumptions of the yields in this aquifer, a flow rate of 3 to 5 gallons per minute (gpm) has been assumed as a recirculation flow rate.

The recirculation process will be implemented using a process trailer which includes pumps, tanks, piping, and fittings along with necessary safety appurtenances. Additional aquifer tests may be necessary to gather better data to determine the balance between injection and extraction rates.

An initial dosing of EOS® will be done in the injection wells. The extracted groundwater will be dosed with EOS® and re-injected into the TTZ through the injection wells. The temporary gradient change due to the extraction is expected to aid in better distribution of the substrate in the TTZ. One part of EOS® will be diluted with 4 to 6 parts of water before injection.

Consultations with Solutions-IES, Inc., have indicated that the injected substrate reaches the extraction wells within 1 to 2 weeks of recirculation. After the extraction water indicates the presence of EOS®, the injection and recirculation will be terminated. Based on calculations included in the cost estimate tables, approximately 20 drums of EOS are expected to be required to treat the TTZ at SA 17.

Alternative 2B- EOS® Injection Followed by Chase Water

The elements of this alternative are similar to those of Alternative 2A, but without extraction and recirculation of groundwater, and with the introduction of direct chase water. The chase water would be used to help push the substrate adequately within the subsurface radius of influence of the injection wells.

The number of injection wells and injection flow rates are expected to be similar to those of Alternative 2A. No extraction wells will be installed, and the process trailer will not require vacuum pumps, piping and temporary storage tanks for extracted groundwater. A fire hydrant or other source of fresh water will be identified to supply adequate flow of water.

Figures presented at the end of Attachment B (Attachment B-4) show the proposed locations of the injection wells for Alternatives 2A and 2B, and the extraction wells for Alternative 2A. These locations may be modified during final design of this remedy.

Necessary well installation and underground injection permits will be applied for and secured from FDEP, prior to implementation of these alternatives.

The EOS® injections at SA 17 are being proposed to be performed utilizing 2-inch wells. The feasibility of using DPT borings to introduce the substrate into the subsurface will be evaluated during final design of the bioremediation alternative, should this alternative be chosen as the source control remedy for this site.

Comparison of Alternatives

The alternatives were evaluated on the basis of effectiveness, implementability, cost, uncertainty, and cost. An overview of the alternative evaluation is presented in Table 1.

Effectiveness

On the basis of effectiveness, Alternative 1 provides for an immediate achievement of the RAOs for Area 1, by immediately reducing contaminant levels and migration from the source area. Alternatives 2A and 2B require time for development of microbial communities to be come effective in reducing contaminant concentrations. Alternative 2A is expected to achieve the RAO sooner than Alternative 2B due to the superior substrate delivery system. However, it should be noted that time to achieve RAOs is not a significant factor at this site because the velocity of groundwater is slow at this site (3 to 7 feet/year) and it is not expected that groundwater will ever exceeds GCTLs offsite.

Alternative 1 provides for more certainty in effectiveness than Alternatives 2A and 2B. The RAO for Area 1 will be achieved with the completion of this alternative. Additional applications of substrate may be required in the future to sustain effective ERD.

Alternative 1 is expected to reduce contaminant concentrations in the source area to a greater degree and result in a commensurate decrease in migration over time. The source of contamination is significantly reduced via the ex situ treatment process with Alternative 1, whereas with the other two alternatives, the ERD process will convert the TCE to ethene and ethane over a period of time. There is a potential that the ERD process could be stalled at cis-1,d-dichloroethene or vinyl chloride. The body of literature available on ERD processes for TCE, however, strongly supports the notion that eventually complete dechlorination will occur with ample substrate.

The challenge with in situ treatment at Area 1 is being able to effectively get the treatment process to reduce contaminant levels in small pore spaces where contaminants reside. Even if Alternatives 2A and 2B are unable to do this, the process will result in a “bio-filter” being established around the area to control migration of contaminants. With Alternative 1, the entire TTZ is excavated and treated and the treated material will have substantially less TCE when backfilled.

Implementability

On the basis of implementability, Alternatives 2A and 2B are much simpler and easier to implement than Alternative 1. With Alternative 1, heavy equipment will be brought onsite and sheetpiling will be driven into the ground. Additional testing of the keying layer of the sheet piling may be required to ensure it will adequately support the excavation area. Given the complexity of Alternative 1, there is increased potential for a safety incident onsite. However, with proper engineering and planning, these risks can be mitigated.

Wile the excavation is open, there is a potential for transfer of TCE to air via material handling processing and volatilization of TCE from the water in the open excavation. This activity would have to be monitored prior to implementation to ensure protection of human health during the implementation phase and protection of air quality. It is likely that this work would have to be accomplished with Level B or C personal protective equipment (PPE) of site workers.

All three alternatives are expected to require some type of permitting or monitoring to assure compliance with the zone of discharge variance. Compliance monitoring for Alternative 1 is expected to only consist of metals monitoring, to ensure that the potassium permanganate used in treatment of the water and soil does not cause an exceedance of groundwater standards.

With respect to Alternatives 2A and 2B, the monitoring is more complicated. The specific substrate to be used in the remedy will have specific monitoring requirements. In the case of this report, it has been assumed that EOS will be used. FDEP has indicated that monitoring of an EOS® constituent, Polysorbate 80, will be required. This is not a typical target parameter with a U.S. Environmental Protection Agency (EPA)-approved laboratory method. There are several options for Polysorbate monitoring, including using non-environmental methods for analysis, using more comprehensive analytical methods (for example, those applied to surfactants), or providing FDEP mass balance information to demonstrate compliance with FDEP criteria for Polysorbate 80 in water.

Uncertainty

Alternative 1(Excavation):

The following uncertainties have been identified for Alternative 1:

- Adequacy of keying layer to support sheetpiling
- Monitoring requirements for air
- Level of PPE required for site personal
- Potential air impacts on surrounding area
- Depth of treatment required in TTZ (currently assumed to be 50 feet)

Alternative 2A (ERD using EOS® in Recirculation Mode)

The following alternatives have been identified for Alternative 2A:

- Ability to affectively monitor for Polysorbate 80
- Need for reapplication of substrate in the future
- Depth of treatment required in TTZ (currently assumed to be 50 feet)

Alternative 2B (ERD using EOS® in Direct Injection Mode)

The following alternatives have been identified for Alternative 2B:

- Ability to affectively monitor for Polysorbate 80
- Need for reapplication of substrate in the future
- Depth of treatment required in TTZ (currently assumed to be 50 feet)

Cost

On the basis of costs, Alternatives 2A and 2B are more cost effective than Alternative 1. While Alternative 1 provides for complete removal of contaminants in the source area and achieving RAOs faster, there is little advantage to the incremental increase in contaminant reduction expected with Alternative 1 because the site will require long-term monitoring. On the basis of modeling results presented in Attachment A, monitoring will be required for a long time.

Table 2 summarizes capital costs for each of the three alternatives. Detailed cost estimates are presented in Attachment B (Attachment B-1 and B-2).

Each of the three alternative costs only focus on capital construction costs. The following factors have not been added to the cost estimate because they are considered to be common to all three alternatives and would therefore provide no additional value with respect to assessing cost:

- Long-term monitoring and reporting
- Land-use controls
- Five year reviews
- Future optimization studies

Performance Objectives

Performance objectives for Areas 1, 2, and 3 are described below.

Area 1

Alternative 1

For the excavation alternative, the performance objective is to reduce the TCE soil concentration to non-detectable levels. Prior to backfilling of the excavation with treated soil, it will be tested to ensure the target treatment goals of the soil treatment have been achieved. Post treatment monitoring TTZ-1 will not be required, after the excavation has been filled with treated soil.

Alternatives 2A and 2B

The performance objectives for both Alternatives 2A and 2B are for sustained reduction in contaminant concentrations over time reducing the contaminant flux from the source area. An additional performance objective for Alternative 2A is operation of the recirculation system until EOS® is detected at extraction wells.

When it becomes apparent that the indicator parameters show declined system performance, the application of additional substrate should be considered. It should be noted, however, that several rounds of data are often necessary to make this determination. Alternatives 2A and 2B will be effective as long as it is cost-effective to add substrate to the target treatment area. At some point in the future, it may be more appropriate to simply let natural attenuation continue without the addition of substrate.

Monitoring parameters for Alternatives 2A and 2B will consist of typical MNA parameters as well as occasional microbial analysis.

Area 2

The performance objective for Area 2 is for a continuation of conditions that are favorable for natural attenuation in groundwater. TTZ-2 will be monitored, as required, to evaluate the effectiveness of natural attenuation. Given the slow rate of groundwater movement at the site, and the minimal potential for offsite migration, annual monitoring is recommended at this point. The monitoring parameters will consist of CVOCs, typical MNA parameters, and occasional microbial analysis.

Area 3

The performance objective for Area 3 is to ensure CVOCs do not cross the property boundary at concentrations that threaten human health or the environment. Monitoring will be performed to document compliance with the performance objective for Area 3. As with Areas 1 and 2, annual monitoring is recommended. CVOCs are the only target parameters recommended at this time. Additional monitoring wells will be required to evaluate this performance objective.

Optimization and Exit Strategies

Recommendations on activities for optimization can be provided after the recommended alternative is determined. However, some of the optimization strategies that will be considered are:

- Reducing the frequency of monitoring
- Reducing the target analytes list for monitoring
- Continual future evaluation of the implemented remedy to determine refinements that may be appropriate in the future

There are no practical near term exit strategies for the site. Given the size of the plume, it would be cost-prohibitive to treat the entire plume to the degree necessary to accelerate the time required for long-term monitoring.

Recommendations

Based on the information presented in this report, the following recommendations are provided:

- Alternative 2A should be implemented because it provides for a cost-effective means of meeting the RAOs and allows for an indication of adequate substrate delivery with the recirculation process.

- Monitoring wells should be placed at the downgradient boundary to ensure the RAOs for Area 3 are achieved.

- Several monitoring wells should be placed in Area 1, at a depth of 40 to 50 feet, to evaluate the level of CVOC contamination in this area, prior to finalizing remediation plans.

- Groundwater samples near the ditch and in the ditch should be collected to delineate the extent of contamination. These wells have not been sampled since 1998.

- The need for a risk assessment should be evaluated prior to finalizing the Record of Decision. It is expected that the risk assessment would not change the recommendations of this optimization report. However, as the evaluation of risks is a substantive component of a Record of Decision (ROD), some level of quantitative risk evaluation would be necessary to support a final ROD for SA17.

- Groundwater monitoring wells south of the SA 17 site should be collected to evaluate for potential groundwater contamination in this area.
- Surface water samples should be collected from the ditch south of SA 17 to determine if there is an exposure pathway for contaminated groundwater in this area.
- The monitoring well network should be upgraded to replace wells that are inadequate.

References

CH2M HILL. 2000. *Phase I and II Data Report for Study Area 17, NTC Orlando.* May.

CH2M HILL. 2003. *Construction Documentation Report for the Interim Remedial Action at SA 17.*

CH2M HILL. 2004. *CVOC Source Area Investigation and Focused Feasibility Study*.

CH2M HILL. 2005. *Summary of Data Collection Activities, Study Area SA 17, Former Naval Training Center Orlando.*

Department of the Navy. 2003.

Naval Facilities Engineering Command. 2004. *Guidance for Optimizing Remedy Evaluation, Selection, and Design*.

Tables

TABLE 1
Summary of Technologies for SA17

Alternative	Effectiveness	Implementability	Uncertainty	Costs
1. Excavation	• Effective • Will remove defined volume and mass of contamination • Certainty in results • Immediate achievement of RAOs	• Requires significant engineering and planning, and onsite activity • Involves substantial site activity • Permitting will be required	• Integrity of Hawthorne as key medium for shoring • Air quality issues	• Significantly more expensive than other alternatives
2a. ERD with Recirculation	• Effective • Will achieve RAOs in reasonable period of time • Simple process involves minimal disruption at site • Effective delivery system that provides for additional assurance that substrate has been effectively applied to TTZ • May require additional applications	• Permitting will be required • Ability of process to effectively reduce contaminant concentrations in interstitial pore space of source area	• Time to achieve effective contaminant reduction and migration control • Substrate demand over time • Period of DCE and VC accumulation before DHC ramp up	• Costs for future reapplication of substrate, if necessary, not included in cost estimate
2b. ERD with Direct Injection	• Effective • Will achieve RAOs in reasonable period of time • Simple process involves minimal disruption at site • May require additional applications	• Permitting will be required • Ability of process to effectively reduce contaminant concentrations in interstitial pore space of source area	• Time to achieve effective contaminant reduction and migration control • Substrate demand over time • Period of DCE and VC accumulation before DHC ramp up	• Costs for future reapplication of substrate, if necessary, not included in cost estimate.

TABLE 2.
Comparison of Costs for Source Reduction Alternatives at SA17

COST ESTIMATE OF CORRECTIVE ACTION OPTIONS

SA17 Source Reduction Alternatives

Site:	Former Naval Training Center, Orlando - Study Area 17	**Base Year:**	2005
Location:	Orlando, Florida	**Date:**	February 2005
Phase:	SA17 Remediation		

	Alternative 1 **Soil Excavation In the Treatment Zone**	Alternative 2A **Enhanced Bioremediation with EOS using Recirculation**	Alternative 2B **Enhanced Bioremediation with EOS using Inject and Chase Method**	
Total Project Duration (Years)	1	1	1	
Total Capital Cost	$1,193,000	$446,000	$394,000	
Total Present Valve of Alternative	**$1,193,000**	**$446,000**	**$394,000**	
		One Injection Event	One Injection Event	
		Baseline Monitoring only	Baseline Monitoring only	

Disclaimer: The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. Changes in the cost eleme are likely to occur as a result of new information and data collected and potential revisions in the design assumptions

Figures

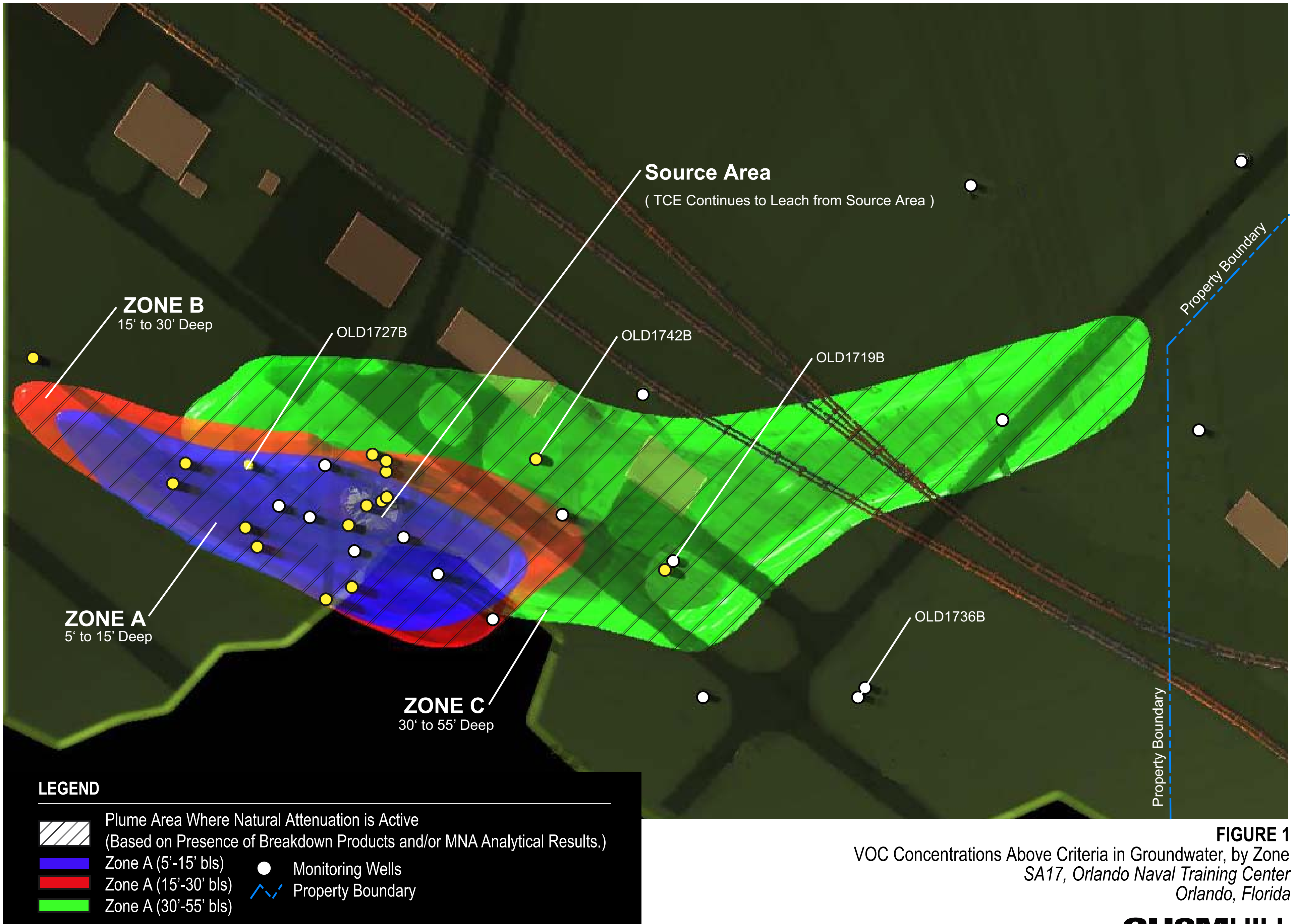

FIGURE 1
VOC Concentrations Above Criteria in Groundwater, by Zone
SA17, Orlando Naval Training Center
Orlando, Florida

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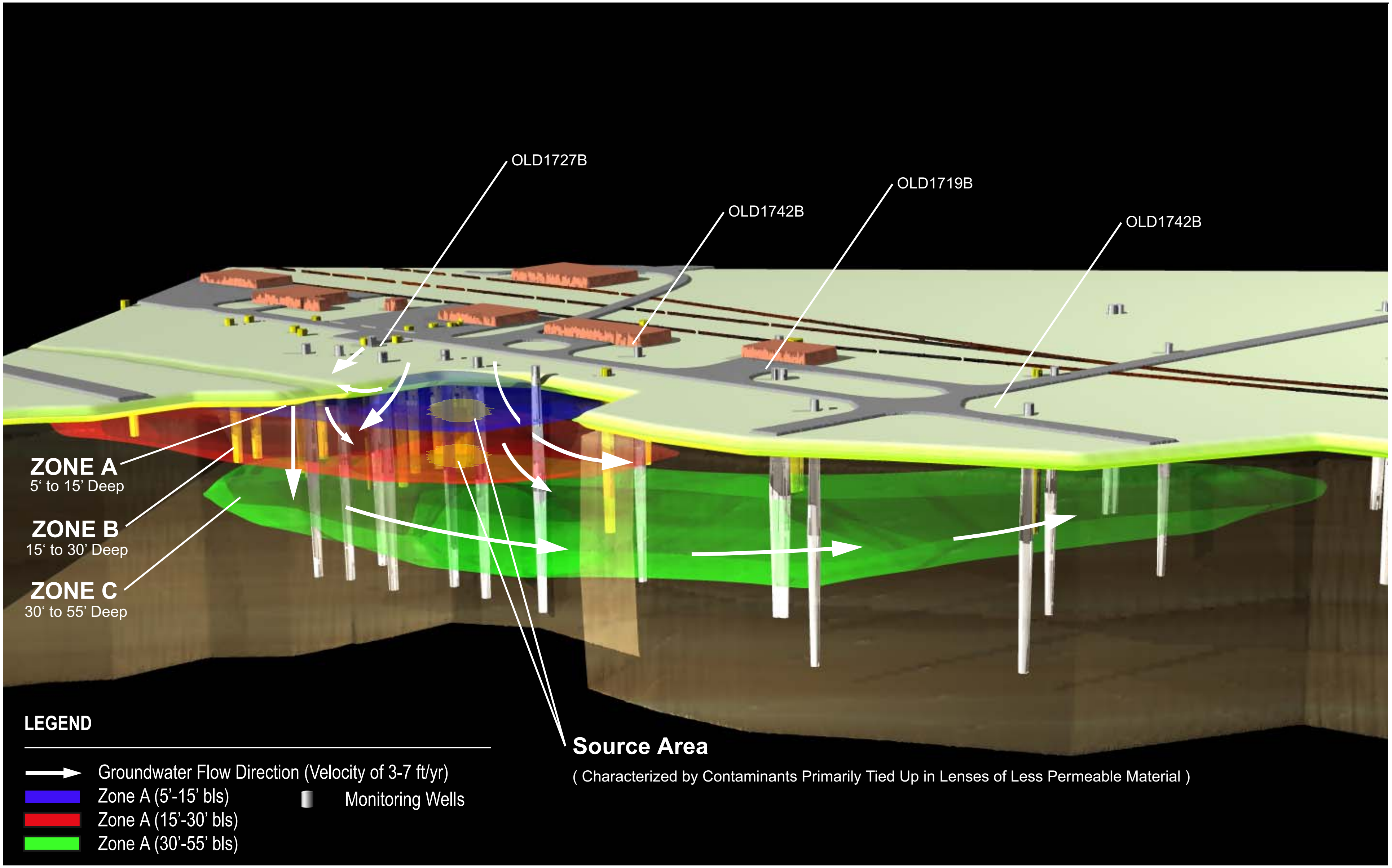
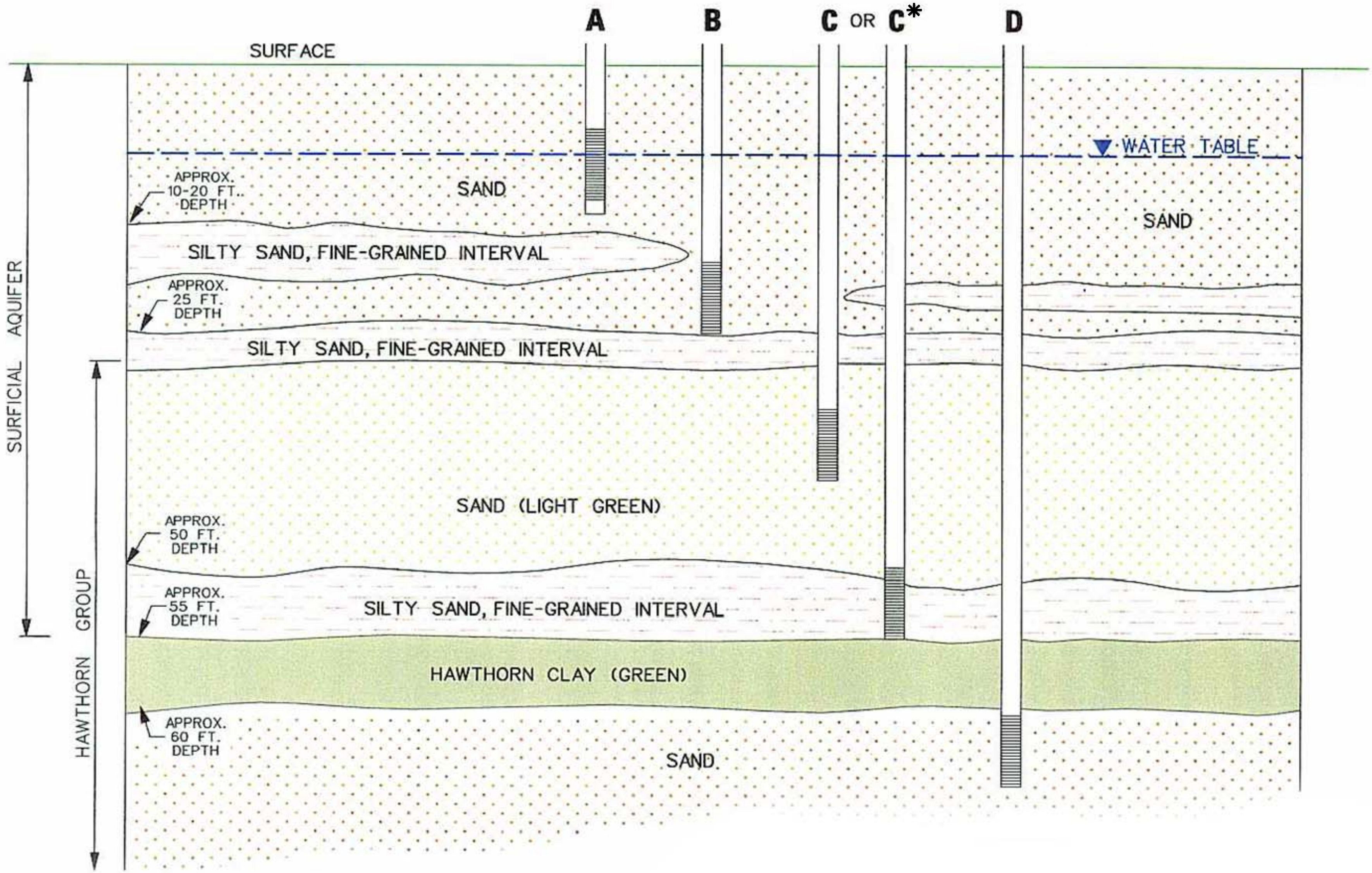


FIGURE 2
VOC Concentrations Above Criteria in Groundwater
SA17, Orlando Naval Training Center
Orlando, Florida

CH2MHILL



Notes:

1) "C" and "D" Wells May or May Not Be Double Cased Depending on Location.

* Wells OLD-17-25C and OLD-17-28C

FIGURE 3
Well Depth Schematic Study Area 17 - McCoy Annex
SA17, Orlando Naval Training Center
Orlando, Florida

CH2MHILL

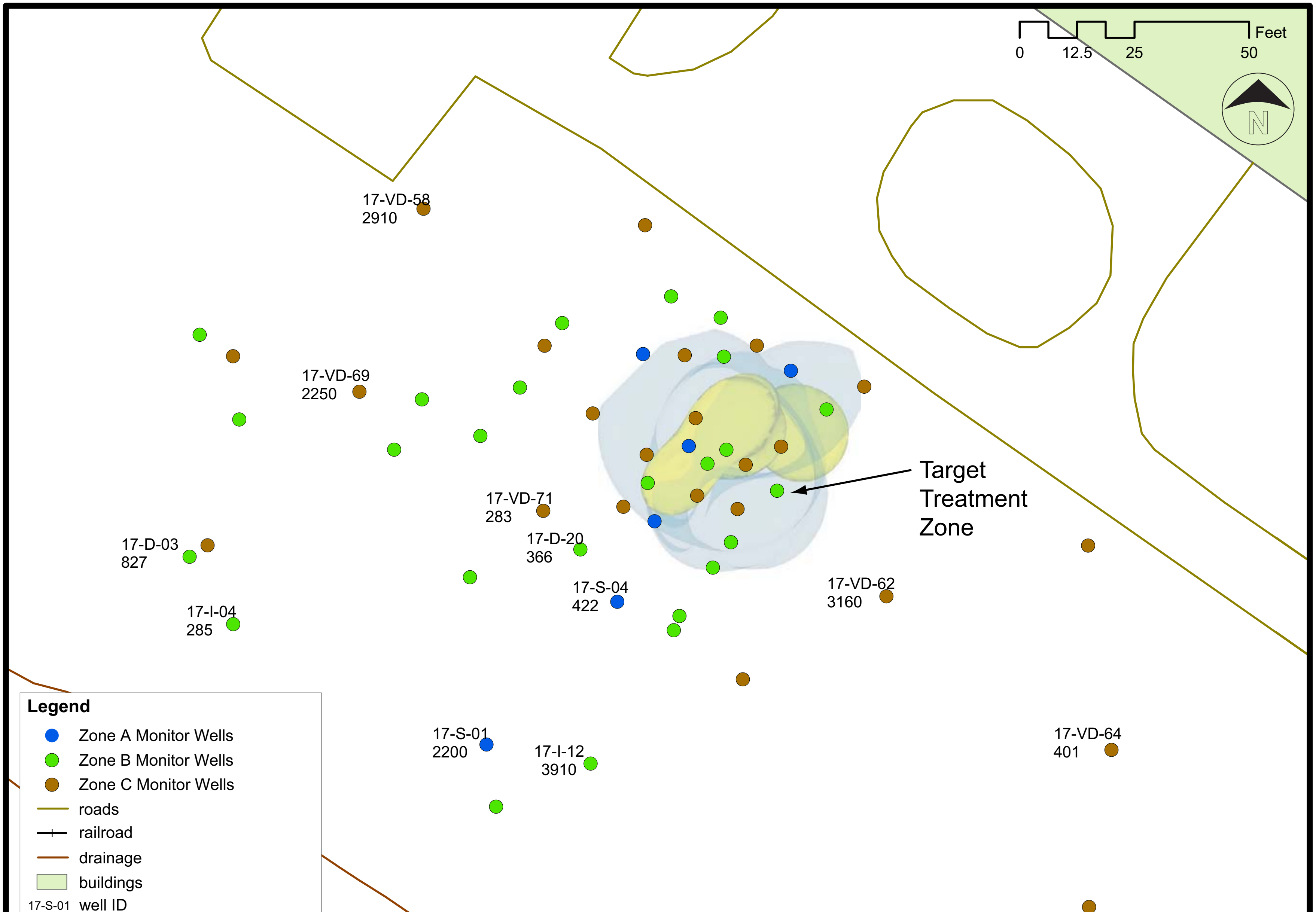


Figure 4
Target Treatment Zone and Select TCE Concentrations
SA-17, Orlando Naval Training Center
Orlando, Florida

Attachments

Attachment A - Determination of Time of Remediation of TCE using Source DK and NAS Software, Naval Training Center, SA-17

Two models were evaluated for the purposes of estimating the Time of Remediation (TOR) of the groundwater plume. The TOR estimates the timeframe required to achieve a pre-determined cleanup level at the source of contamination. One of the two models is also capable of estimating Time of Stabilization (TOS) for the groundwater plume. TOS refers to the time required to achieve a pre-determined compliance or target concentration at a fixed distance downgradient of the source area.

Natural Attenuation Software (NAS) provides routines to calculate both TOS and TOR. Source DK was only used to calculate TOR. The application of each model is discussed in the following section.

Natural Attenuation Software (NAS) (Version 1.2, 2001)

NAS is a Visual Basic interface that was designed to calculate estimates for TOR based on site characterization data for sites contaminated with either fuels or chlorinated solvents. NAS calculates natural attenuation capacity (NAC), TOS, and TOR.

Calculation

Site specific data required to run the model include:

- Hydrogeology (hydraulic conductivity, hydraulic gradient, and porosity)
- Fraction of Organic Carbon (to calculate retardation factors)
- Detected contaminant concentrations in 3 or more consecutive wells along centerline of the plume
- Concentrations for oxygen, iron (II), and sulfate in one or more wells along the centerline of the plume. Other choices are nitrate, manganese (II), sulfide, methane, and hydrogen.
- Source width

Required for TOS window

- Location of downgradient point of compliance (POC)
- Regulatory target concentration (RTC) at the POC

Required for TOR window

- Dimensions of source NAPL
- Mass fraction of each contaminant in the NAPL
- Background concentrations of each electron acceptor
- An estimate of NAPL mass
- Maximum allowable concentration at the contaminant source area

Assumptions: NAS assumes that groundwater flow is uniform and unidirectional. Decay rate can only be calculated given the NAC input values.

Input Parameters:

- NAPL mass = 93 lbs (42 kg), mass of CVOCs calculated using EVS model and June 2003 data. Note, this is the total mass estimate of TCE present at SA17 and represents a conservative basis for modeling.
- Hydraulic conductivity (avg)= 1.5 ft/d
- Hydraulic gradient = 0.002 ft/ft
- Total Porosity = 0.3, Effective porosity = 0.25
- Groundwater Velocity (avg)= 0.012 ft/d
- Contaminated aquifer thickness = 20 ft
- Flow path included wells: VD62, VD64, 43C, 45C, 20C (Zone C) and D25

The above values were selected to represent the site in the model. There is a wide range of data available for many of the above parameters. The values presented above are reasonable for the purposes of model, which were to evaluate the impact of Time of Remediation and Time of Stabilization under different scenarios.

TOS Results

The TOS effort completed with this modeling exercise was designed to determine the distance from a contaminant source that would result in no unacceptable concentrations of contaminants migrating offsite. TOS output includes a range of years given the input contaminant concentration of the project site.

Time of Stabilization was calculated assuming a range of feet to a point of compliance (POC) (100 to 600 feet), a range of source concentrations (2000, 20000, and 40000 μg/L), 30′ source width, and 5 μg/L screening criteria.. The model can be used to compare distances to the POC and their respective TOS. The results of the model runs are presented in the tables below. An example of model output is presented at the end of this appendix.

Time of Stabilization (TOS) Output (2000 µg/L Source Concentration)

POC (ft)	Total NAC, Ferrogenic (1/ft)	Target Concentration (µg/L)	TOS (yrs) - Maximum	TOS (yrs) – Average	TOS (yrs) - Minimum
100	0.0113	25	117.6	47.0	18.6
200	0.0113	122	235.2	94.1	37.1
300	0.0113	503	352.8	141.1	55.7
400	0.0113	NA	No Reduction Required		
500	0.0113	NA	No Reduction Required		
600	0.0113	NA	No Reduction Required		

Time of Stabilization (TOS) Output (20000 µg/L Source Concentration)

POC (ft)	Total NAC, Ferrogenic (1/ft)	Target Concentration (µg/L)	TOS (yrs) - Maximum	TOS (yrs) – Average	TOS (yrs) - Minimum
100	0.035	259	110.0	44.0	17.4
200	0.035	13,394	220.0	88.0	34.7
300	0.035	NA	No Reduction Required		
400	0.035	NA	No Reduction Required		
500	0.035	NA	No Reduction Required		
600	0.035	NA	No Reduction Required		

Time of Stabilization (TOS) Output (40000 μg/L Source Concentration)

POC (ft)	Total NAC, Ferrogenic (1/ft)	Target Concentration (μg/L)	TOS (yrs) - Maximum	TOS (yrs) – Average	TOS (yrs) – Minimum
100	0.0421	524	108.0	43.2	17.1
200	0.0421	NA	No Reduction Required		
300	0.0421	NA	No Reduction Required		
400	0.0421	NA	No Reduction Required		
500	0.0421	NA	No Reduction Required		
600	0.0421	NA	No Reduction Required		

The target concentration is the required source contaminant concentration (C) that NAS calculates. It is used for comparison to the user-provided initial concentration (Co) in the calculation of TOS. A longer POC corresponds to a higher target concentration as can be seen in the first model run above (25 μg/L at 100′ versus 122 μg/L at 200′). Once the user increases the POC to 400′, the target concentration is calculated as not applicable, which means that the plume would reach stabilization by that distance (TOS column corresponds with "No Reduction Required").

It should be noted that the model does not allow for comparison of increasing source concentration by adjustment of that value. By increasing the source concentration, there are other variables that are calculated (NAC and decay constant), and therefore, do not allow a precise comparison of data based on the alternation of varying one input parameter. For instance, comparing the 100 feet POC for 2000 μg/L and 20000 μg/L source concentrations, the TOS actually decreases (47.0 to 44.0 years, respectively). The total NAC (natural attenuation capacity) is included to show that this value also slightly increases. However, as the NAC is calculated by considering the slope concentration as a function of distance, any increase in concentration of the first point (the source) strongly effects the slope and results in artificially decreasing the TOS.

Other tests were performed to verify this observation. For example, the redox conditions at the source well are presently (and for the calculations) ferrogenic. By changing the condition to methanogenic, the TOS did not change. In addition, changing the source concentration from TCE to VC (at the 2000 μg/L concentration) did not change the observation.

The important conclusions from the above model runs are:

- Given the SA17 source area is approximately 600 feet from the property boundary, the model results indicate that the source will not cause an offsite groundwater concentrations to exceed GCTLs at any point in the future; and

- Given the current distribution of contaminants at the site, no location downgradient of the source area at SA17 is anticipated to yield an offsite exceedance of GCTLs at some point in the future.

TOR Output

The TOR portion of the modeling effort was meant to address the time of remediation required to achieve a compliance concentration of 5 μg/L at the source area under assumed mass reductions scenario's.

A total of six scenarios were evaluated to evaluate TOR:

- Plan 1 assumes no initial removal of contaminants prior to allowing MNA to stand alone as a remedial activity
- Plan 2 assumes 25% source reduction prior to allowing MNA to stand alone as a remedial activity
- Plan 3 assumes 50% source reduction prior to allowing MNA to stand alone as a remedial activity
- Plan 4 assumes 75% source reduction prior to allowing MNA to stand alone as a remedial activity
- Plan 5 assumes 85% source reduction prior to allowing MNA to stand alone as a remedial activity
- Plan 6 assumes 95% source reduction prior to allowing MNA to stand alone as a remedial activity

The output also allows for a range of initial contaminant concentrations by inputting the initial source mass value with a ± % deviation. At SA-17, the average source mass concentration , calculated using the EVS Model , was 93 lbs and a 50% deviation was used (46.5, 93.0, and 139.5 lbs). The resulting years to reach the 5 μg/L screening criteria using Plan 1 would be from 61.1 to 63.5 years based on the range of initial contaminant concentrations. Results of the 18 model runs is presented below. As can be seen by review of this data, there is very little change in the TOR estimates by altering the initial source mass or by applying reductions of source mass (e.g., through remediation).

Time of Remediation (TOR) Source Removal Plan Table (yrs)

NAPL Mass (TCE) (lb)	Plan 1 – 0% Removed	Plan 2 – 25% Removed	Plan 3 – 50% Removed	Plan 4 – 75% Removed	Plan 5 – 85% Removed	Plan 6 – 95% Removed
139.5	63.5	62.6	61.7	60.8	60.5	59.9
93.0	62.3	61.7	61.1	60.5	60.2	59.9
46.5	61.1	60.8	60.5	60.2	59.9	59.9

The TOR output for Plan 1 would be best compared to the Source DK output below.

Source DK (Version 1.0, April 2004)

Source DK is a remediation timeframe decision support system. It utilizes three approaches to estimate time of remediation and the uncertainty in the timeframe estimate. The first approach (Tier 1) estimates time of remediation based on extrapolation, a record of concentration versus time. The second and more complex approach (Tier 2) uses a box model from a source mass estimate, mass flux constituents leaving the source zone, and biodegradation in the source zone. Tier 2 follows first order decay pattern, and calculates the time in years to achieve the dissolved constituent concentration value. The final approach (Tier 3) employs a process model to predict a remediation timeframe based on the amount of naturally flowing groundwater required to flush out dissolved-phase and NAPL constituents from a source zone. While Source DK is primarily used for natural attenuation processes, it can also be used to estimate source lifetimes for groundwater pump-and-treat technologies.

For this report Tier 2 and Tier 3 models were investigated. Tier 1 was not used due to the lack of adequate spatially distributed analytical data for the remediation model and the simplicity of the output (the model extrapolates a trend of concentration versus time to reach a TOR). The Tier 2 model becomes more complex by utilizing a first order decay calculation, which is then used to determine a TOR. This model would be more accurately compared to the NAS output described above, due to similar input value requirements of both models. The Tier 3 Model was included in this discussion for comparison purposes. This model determines a remediation timeframe given a contaminated groundwater zone without any NAPL or matrix diffusion (SA-17 presently contains NAPL). In short, the model assumes all contamination are in the dissolved phase.

Calculation

Data entry for the box model (Tier 2) approach includes:

- Hydrogeology (darcy velocity, hydraulic conductivity, hydraulic gradient)
- Source Characteristics (Average source groundwater concentration, source length, source width, source thickness)
- Source Decay Constant (can be entered directly or calculated using the following:
    1. Source Mass
    2. Source Zone Biodegradation (Choose either no biodegradation, biodegradation rate constant, or biodegradation rate derived from electron acceptor by-product data)
- Time for output (# years to plot the data)
- Field data for comparison (concentration versus time analytical data can be added to compare predicted to actual output)
- See example at end of appendix for input parameters

Source DK Tier 2 Model

Source DK output for 4 scenarios using the box model is presented below. The scenarios are:

Matrix 1 assumes no source decay constant and no biodegradation

Matrix 2a assumes a source decay constant (recommended by Source DK, average for TCE) and no biodegradation

Matrix 2b assumes a source decay constant (calculated) and no biodegradation

Matrix 3 assumes a source decay constant (calculated) and biodegradation (recommended by Source DK)

These matrices were created to compare different times of remediation based on various degradation constants (source decay rate and biodegradation). The source decay rate describes how quickly the dissolved concentrations in the source zone decline over time. This does not represent the attenuation of constituents that have left the source zone or the biodegradation. The biodegradation rate constant is the rate coefficient describing the biodegradation of dissolved constituents (a calculated relationship between microbial populations and a substrate). Both constants contribute to the transformation or removal of contaminants in a source zone.

Matrix 2 is described by two scenarios. Source DK allows for several scenarios in calculating the source decay constant. The user has the option to enter the source decay constant directly, or by calculation using the source mass (Methods 1-4). Matrix 2a utilized Source DK's recommended value for TCE (0.11 yr^{-1}). Matrix 2b used the source mass estimated by backcalculating to maintain the same source decay constant.

Matrix 3 involves the contribution of both constants, and since SA-17 does not have a calculated site specific biodegradation rate constant, the average rate recommended by Source DK for TCE was used. It should also be noted that once the biodegradation constant is entered the source decay constant will recalculate (compare Matrix 2b to 3, 0.022 to 0.18)

Matrix 1: No Decay Constant/No Biodegradation

	Input				Output		
			Calculated Constant Input Parameters		Estimated Time to Reach 5 µg/L		
Output	Source Conc. (µg/L)	Decay Constant (1/yr)	Source Mass (kg)	Biodegradation (lambda, 1/yr)	Low End (yrs)	Mid Range (yrs)	High End (yrs)
1	2000	0	NA	NA	>500	>500	>500
2	20000	0	NA	NA	>500	>500	>500
3	40000	0	NA	NA	>500	>500	>500

Matrix 2a: Source Decay Constant/No Biodegradation

	Input				Output		
			Calculated Constant Input Parameters		Estimated Time to Reach 5 µg/L		
Output	Source Conc. (µg/L)	Decay Constant (1/yr)	Source Mass (kg)	Biodegradation (lambda, 1/yr)	Low End (yrs)	Mid Range (yrs)	High End (yrs)
4	2000	0.11	NA	NA	5	54	>500
5	20000	0.11	NA	NA	8	75	>500
6	40000	0.11	NA	NA	8	82	>500

Matrix 2b: Source Decay Constant (calculated)/No Biodegradation

	Input				Output		
			Calculated Constant Input Parameters		Estimated Time to Reach 5 µg/L		
Output	Source Conc. (µg/L)	Decay Constant (1/yr)	Source Mass (kg)	Biodegradation (lambda, 1/yr)	Low End (yrs)	Mid Range (yrs)	High End (yrs)
7	2000	0.022	4.26	NA	27	274	>500
8	20000	0.022	43	NA	38	380	>500
9	40000	0.022	85	NA	41	410	>500

Matrix 3: Source Decay Constant/Biodegradation

	Input				Output		
			Calculated Constant Input Parameters		Estimated Time to Reach 5 µg/L		
Output	Source Conc. (µg/L)	Decay Constant (1/yr)	Source Mass (kg)	Biodegradation (lambda, 1/yr)	Low End (yrs)	Mid Range (yrs)	High End (yrs)
10	2000	0.18	4.26	0.45	3	33	335
11	20000	0.18	43	0.45	5	46	464
12	40000	0.18	85	0.45	5	50	>500

In conclusion, the output timeframe for Source DK varied based on input parameters. With no decay constant or biodegradation constant the time of remediation would essentially never occur (Matrix 1). Reducing the source concentration by an order of magnitude also did not substantially reduce the time of remediation (compare outputs 4-6). The decay constant appeared to be the most sensitive to the output timeframe (compare Matrices 2a and 2b, the average number of years increased by an order of magnitude). The final matrix scenario, which utilized decay and biodegradation constants, resulted in the shortest timeframe of remediation with a mid range of 33 to 50 years.

Limitations to the model for Tier 2 were shown in Matrix 2b and 3 outputs. By increasing the source groundwater concentration, the source mass would most be assumed to increase for a given site. The source mass concentration contains 3 constituents 1) free-phase or residual NAPL 2) constituent mass sorbed to aquifer 3) dissolved mass in groundwater in the source zone. These matrices' source decay constants were dependent on the source mass concentration for their calculation. Therefore, the source mass was adjusted in Matrix 2b and 3 to maintain a constant source decay constant. For instance, the 2000 μg/L source groundwater concentration would equate to an estimated 4.26 kg source mass concentration. As described above the source mass is calculated as the sum of 3 constituents, and with only one constituent in consideration, estimations of the site source mass were made. .

Source DK Tier 3 Model

The Tier 3 Model employs a process model to predict a remediation timeframe based on the amount of naturally flowing groundwater required to flush out dissolved-phase and NAPL constituents from a source zone.

Data entry for the Tier 3 Process Model includes:

- Original constituent concentration = 2, 20, and 40 mg/L (3 trials)
- Cleanup level = 0.005 mg/L
- Length of source zone parallel to groundwater flow = 50 ft
- Groundwater seepage velocity = 4.38 ft/yr (taken from SA-17, 2003 SI Report)
- Retardation factor = 2.59 (calculated)

This model was employed in order to determine a remediation timeframe given a groundwater zone without any NAPL or matrix diffusion. It is a simple flushing model, based on one-dimensional advection-dispersion, and used to predict the change in dissolved phase constituents over time. The number of pore volumes required to reach the desired cleanup level is also calculated. A pore volume is the volume of water required to replace water in a unit volume of saturated porous media. The output for this model is shown below.

Source DK Tier 3 Output

Source Conc. (μg/L)	Time to Flush Out Constituents and Reach Desired Cleanup Level (yrs)	# Pore Volumes Required to Reach Desired Cleanup Level
2000	93.7	8.21
20000	121	10.6
40000	129	11.3

Modeling Conclusions

Based on the above described results of the modeling effort, the following conclusions were developed:

- Further source reduction results in limited reduction in long term monitoring requirements of site and no measurable increased protection of human health and the environment.
- Given the SA17 source area is approximately 600 feet from the property boundary, the model results indicate that the source will not cause an offsite groundwater concentrations to exceed GCTLs at any point in the future; and
- Given the current distribution of contaminants at the site (i.e., knowing contaminant concentrations downgradient), no location downgradient of the source area at SA17 is anticipated to yield an offsite exceedance of GCTLs at some point in the future.

SourceDK — TIER 2 Box Model

Remediation Timeframe Decision Support System

Air Force Center for Environmental Excellence — *Version 1.0*

Data Input Instructions:

- 115 → 1. *Enter value directly ... or*
- 115 → 2. *Calculate by filling in blue cells. Press Enter, then hit "Calculate" button.*
- 115 → 3. *Value calculated by model. (Do not enter any data.)*

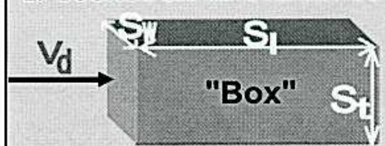
Site Location and I.D.: Orlando NTC, SA-17
Constituent of Interest: Average Zone B, TCE

1. HYDROGEOLOGY

Darcy Velocity	V_d	1.10E+00	(ft/yr)
		↑ or	
Hydraulic Conductivity	K	1.5E+00	ft/d
Hydraulic Gradient	i	0.002	(ft/ft)

Calculate Vd

2. SOURCE CHARACTERISTICS



Key Assumption: ***Source Represented as Box Model***

Average Source Groundwater Concentration at Time = 0	C_{gwo}	40000	ug/L
Source Length	S_l	50	(ft)
Source Width	S_w	50	(ft)
Source Thickness	S_t	30	(ft)
Enter Value for Specific Discharge or Press "Calculate Q" Button	Q	1.6E+03	(ft^3/yr)

Calculate Q

3. SOURCE DECAY CONSTANT

○ Enter Directly — k_s — [ ] (1/yr)

↓ or

◉ Calculate Source Decay Constant Using Sections 3A and 3B — k_s — 1.8E-01 (1/yr)

3A. SOURCE MASS

Source Mass at Time = 0 — M_o — 8.5E+01 (kg)

Select Method for Calculating Source Mass

○ **Method 1:** Enter Source Mass Directly

or

◉ **Method 2:** Simple Volume X Concentration Calculation (Print Method 2)

or

○ **Method 3:** Detailed Volume X Concentration Calculation

or

○ **Method 4:** Estimated From NAPL Relationships

3B. SOURCE ZONE BIODEGRADATION

○ **No Biodegradation**

↓ **or**

Assume Biodegradation Occurs in "Box" in Dissolved Phase Only

◉ **Select Method 1:**
Biodegradation Rate Constant — *lambda* — 0.45 (per yr)

↓ **or**

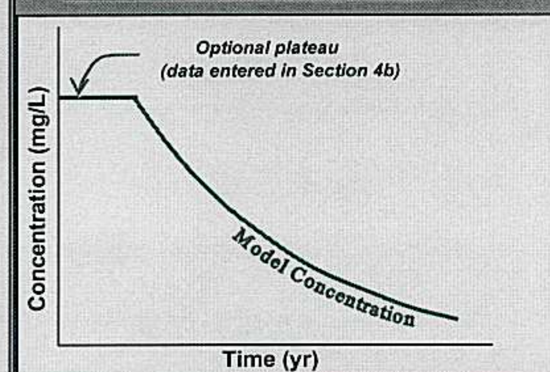
○ **Select Method 2:**
Biodegradation Rate Derived From Electron Acceptor By-Product Data.
(Applies Only to Petroleum Hydrocarbon Sites)

a) Biodegradation Capacity	BC		(mg/L)
or			
Delta Oxygen	DO		(mg/L)
Delta Nitrate	NO_3		(mg/L)
Observed Ferrous Iron	Fe^{2+}		(mg/L)
Delta Sulfate	SO_4		(mg/L)
Observed Methane	CH_4		(mg/L)

and

b) Percentage of Biodegradation Capacity Applied to This Constituent — [ ] (%)

SourceDK OUTPUT SHOWS THIS:



4. TIME FOR OUTPUT

a) Number of Years Over Which to Plot Data — 10 (yr) (Required)

b) Time in Years at Which Decay Starts — [ ] (yr) (Optional)

5. UNCERTAINTY RANGE FOR MASS ESTIMATE

± Factor of 10

6. FIELD DATA FOR COMPARISON

Year From Time = 0 (yr)	0										
Concentration (ug/L)	40000										

7. CHOOSE OUTPUT TO VIEW

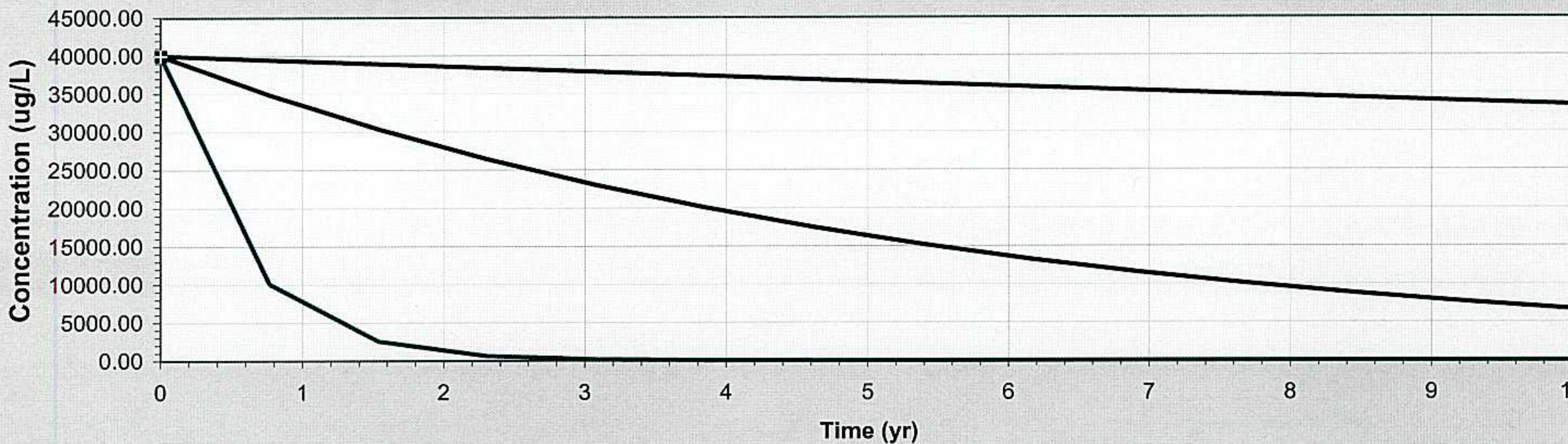
Show Graph | Return to Main Screen | New Site/Clear Screen | Paste Example Data Set | HELP

Site Location and I.D.: Orlando NTC, SA-17
Constituent of Interest: Average Zone B, TCE

SourceDK TIER 2 OUTPUT

TYPE OF MODEL	0.00	0.77	1.54	2.31	3.08	3.85	4.62	5.38	6.15	6.92	7.69	8.46	9.23	10.00
Model Conc. (ug/L)	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	8749.351	7620.232	6636.828
Actual Conc. (ug/L)	#######													
Mass Discharge (kg/yr)	1.9E+00	1.6E+00	1.4E+00	1.2E+00	1.1E+00	9.3E-01	8.1E-01	7.1E-01	6.2E-01	5.4E-01	4.7E-01	4.1E-01	3.5E-01	3.1E-01

Time (yr)



1. ◉ **Display Concentration Vs. Time Chart**
   or
   ○ Display Source Mass Vs. Time Chart

2. Number of Years Over Which to Plot Graph 10 *(yr)*
   (Press "Calculate Current Sheet" button after changing value.)

Log ⟷ Linear

Concentration/Time Mini-Calculator

Time *(yr)* → High End Conc Estimate *(ug/L)*; Mid Range Conc Estimate *(ug/L)*; Low End Conc Estimate *(ug/L)*

Concentration 5.000 *(ug/L)* → High End Time Estimate >500 *(yr)*; Mid Range Time Estimate 50 *(yr)*; Low End Time Estimate 5 *(yr)*

Return To Input

Calculate Current Sheet

HELP

SourceDK

Remediation Timeframe Decision Support System

Air Force Center for Environmental Excellence — *Version 1.0*

TIER 3 Process Models

Data Input Instructions:

- 115 → *1. Enter value directly....or*
- 115 → *2. Calculate by filling in blue cells. Press Enter, then hit "Calculate"*
- 115 → *3. Value calculated by model. (Don't enter any data.)*

◉ METHOD 1: DISSOLVED PHASE CONSTITUENTS

Parameter	Symbol	Value	Units
Original Constituent Concentration	C_o	40	(mg/L)
Desired Cleanup Level	C_t	0.005	(mg/L)
Length of Source Zone Parallel to Groundwater Flow	L	50	(ft)
Groundwater Seepage Velocity	V_x	4.38	(ft/yr)
Retardation Factor	R	2.59	(-)
		↑ or	
Soil Bulk Density	Rho	1.7	(kg/L)
Partition Coefficient	K_{oc}	130	(L/kg)
Fraction Organic Carbon	f_{oc}	0.0017	(-)
Effective Porosity	n_e	0.25	(-)

Calculate R

Create Graph | HELP

○ METHOD 2: NAPL ZONE CONSTITUENTS

Parameter	Symbol	Value	Units
Type of Media			
Initial Aqueous-Phase Concentration in Source Zone Under Natural Flow Conditions	C_s		(mg/L)
Desired Cleanup Concentration	C_t		(mg/L)
Density of NAPL Fluid	Rho		(g/mL)
Initial NAPL Saturation in Porous Media	S_o		(%)
Uncertainty in NAPL Saturation	± *Factor of*		
Natural Groundwater Seepage Velocity	V_s		(ft/yr)
Length of Source Zone Parallel to Groundwater Flow	L		(ft)

Is This a Pumping Scenario?

Site Location:

Constituent:

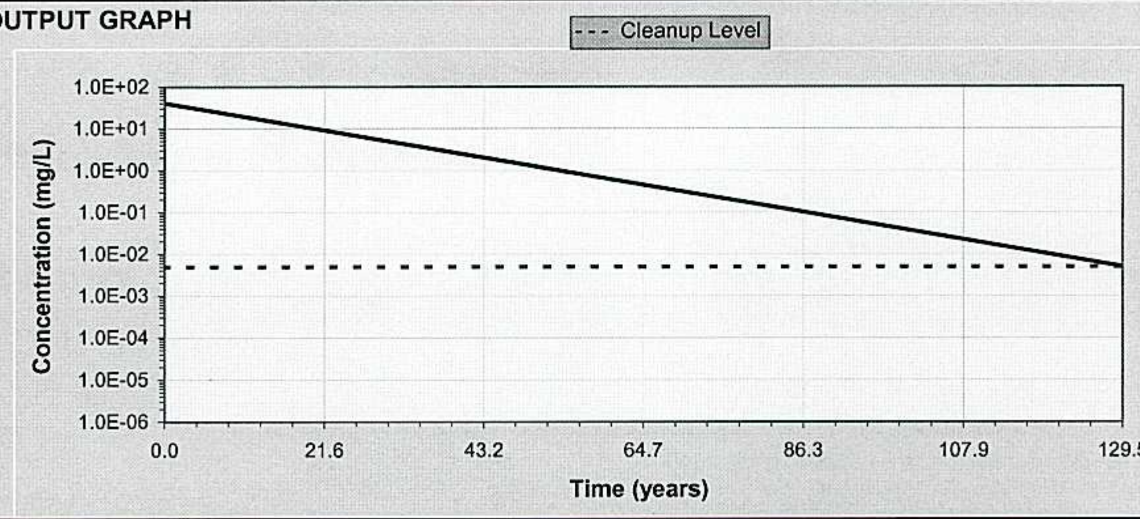
METHOD 2: Continued

What is the Typical Groundwater Seepage Velocity While Pumping? (ft/yr)

Concentration in Produced Groundwater as a Result of Mass Transfer Effects is (mg/L)

Create Graph | HELP

OUTPUT GRAPH



RESULTS

1) The Number of Pore Volumes Required to Reach Desired Cleanup Level — **1.13E+01** (-)

2) Time to Flush Out Constituents and Achieve Desired Cleanup Level — **1.29E+02** (yrs)

Return to Main Screen | New Site/Clear Screen | Paste Example Data Set

Facility Name: NTC Orlando
Site Name: SA-17
Additional Description: TOS Output - 100' POC and 2,000 ug/L source cor

Length: feet
Time: days
Mass: pounds

Hydrogeologic Data and Contaminant Transport Calculations

	Maximum	*Average*	*Minimum*		*Value*
Hydr. Conductivity [ft/d]	3.8	1.5	0.6	*Estimated Plume Length [ft]*	1721.5
Hydraulic Gradient [ft/ft]	0.002	0.002	0.002	*Longitudinal Dispersivity [ft]*	30.48
Total Porosity [-]		0.3		*Dispersivity Ratio [-]*	20.0
Effective Porosity [-]		0.25		*Contaminated Aquifer*	
Groundwater Vel. [ft/d]	0.03	0.012	0.005	*Thickness [ft]*	20.0

Contaminant Data (August 2004)

Well Name	*Distance [ft]*	*TCE [µg/L]*	*cis-DCE [µg/L]*	*Vinyl Chl. [µg/L]*	*Total Chl. Eth. [µg/L]*
D-25	0.0	2000	BD	BD	2000
VD-62	55.0	1000	395	6.9	1401.9
VD-64	100.0	401	233	0.93	634.93
43C	150.0	BD	222	30.9	252.9
20C	275.0	BD	476	820	1296
45C	550.0	BD	114	BD	114

Redox Data (August 2004)

Well Name	*Distance [ft]*	*Oxygen [mg/L]*	*Nitrate [mg/L]*	*Mn(II) [mg/L]*	*Iron(II) [mg/L]*	*Sulfate [mg/L]*	*Sulfide [mg/L]*	*Methane [mg/L]*	*Hydrogen [mg/L]*	*Redox Condition*
D-25	0.0	0.41	NS	0.115	30	128	BD	0.061	NS	Ferrogenic
VD-62	55.0	0.63	BD	0.887	140	737	BD	0.13	NS	Ferrogenic
VD-64	110.0	0.52	BD	1.14	160	158	BD	0.55	BD	Ferrogenic
43C	113.0	0.92	BD	0.0286	5.36	6480	BD	2	BD	SO4/CO2-red.
20C	265.0	0.24	BD	0.0194	2.12	4.51	BD	2.3	2	SO4/CO2-red.
45-C	550.0	6.22	0.03	0.03	2.15	29.4	BD	2.7	2.5	Methanogenic

Sorption Parameters

Fraction Org. Carbon [-]	
Maximum	0.0017
Average	0.0017
Minimum	0.0017

	TCE	*cis-DCE*	*Vinyl Chl.*
Koc [L/kg]	126	24	57
Retardation Factor [-]			
Maximum	2.59	1.3	1.72
Average	2.59	1.3	1.72
Minimum	2.59	1.3	1.72

Attenuation Rates

	Total Chl. Eth.	*TCE*	*cis-DCE*	*Vinyl Chl.*
NAC (Single Zone) [1/ft]	0.0042	0.0159	0.0052	Insuff. Data
Decay Rate [1/d]				
Maximum	0.0001	0.0006	0.0002	
Average	0.0001	0.0002	0.0001	
Minimum	0.000	0.0001	0.000	
NAC (Zone 1) [1/ft]	0.0113	0.0159	.0052 (Est.)	
Decay Rate [1/d]				
Maximum	0.0005	0.0006	0.0002	
Average	0.0002	0.0002	0.0001	
Minimum	0.0001	0.0001	0.000	
NAC (Zone 2) [1/ft]	0.0113 (Est.)	.0159 (Est.	.0052 (Est.)	
Decay Rate [1/d]				
Maximum	0.0005	0.0006	0.0002	
Average	0.0002	0.0002	0.0001	
Minimum	0.0001	0.0001	0.000	
NAC (Zone 3) [1/ft]	0.0042 (Est.)	.0159 (Est.	.0052 (Est.)	
Decay Rate [1/d]				
Maximum	0.0001	0.0006	0.0002	
Average	0.0001	0.0002	0.0001	
Minimum	0.000	0.0001	0.000	

Time of Stabilization(TOS) and Max Source Conc. Calculations

Distance to POC [1 100.0
Estimated Source Wi 30.0

		Source Concentration [µg/L]			TOS [years]		
	RCC [µg/L]	*Well*	*Current*	*Target*	*Maximum*	*Average*	*Minimum*
Total Chl. Eth.	5.0	1	2000	25	117.6	47.0	18.6

Time of Remediation(TOR) Calculations

NAPL Source Widtl 50.0
NAPL Source Lengt 50.0
Contaminated Aquifer Thi 30.0

NAPL Component	*% of NAPL*
TCE	1.00
cis-DCE	0.00

	Oxygen [mg/L]	*Nitrate [mg/L]*	*Mn(IV) [mg/kg]*	*Iron(III) [mg/kg]*	*Sulfate [mg/L]*
Background EA Conc.	0.7	0.0	NS	100.0	96.7

	Average	*+/- %*
NAPL Mass [lb]	93.0	50

	Plan 1	*Plan 2*	*Plan 3*
% NAPL Removed	0	25	50

Maximum Time of Analysis [yr] 100

	SCC [µg/L]
Total Chl. Eth.	5.0

	NAPL Mass (TCE) [lb]	*Source Removal Plan* *Plan 1* *0% Rem'o*	*Plan 2* *25% Rem'*	*Plan 3* *50% Rem'd*
	139.5	61.1	60.5	59.9
TCE	93.0	60.5	60.2	59.9
	46.5	59.6	59.6	59.6

Attachment B

This Attachment contains the following information:

Attachment B-1: Basis and Level of Accuracy of Estimate
Attachment B-2: Costs for Alternatives 1, 2A, and 2B
Attachment B-3: Technical Input Received from Solutions IES
Attachment B-4: Sketches of Well Configurations for Alternatives 2A and 2B

Attachment B-1 Basis and Level of Accuracy of Estimate

All cost estimates were based on our understanding of the site and current market conditions, as of February 2005. The basis of estimate for each alternative is presented in the discussion below.

Basis of estimate for Alternative 1

The basis of this estimate was the JV-II cost estimate submitted March 22, 2004 to EFD South for implementing the excavation alternative. The estimate was revisited to check key components of the estimate (e.g., excavation quantities, sheet piling costs, soils treatment). This estimate has a level of accuracy of +15/-10% for costs presented as capital.

The main component of this estimate considered to be price - sensitive is the cost of steel for sheet-piling. There is an ample supply of equipment and labor to construct and operate the system and with the exception of price fluctuations of steel, none of the other system components consist of materials that are typically considered volatile with respect to costs. This estimate is classified as a definitive estimate.

Bases of Estimates for Alternatives 2A and 2B

The general basis of the cost estimate for Alternatives 2A and 2B has been established by incorporating the various elements of engineering and construction involved in implementing similar systems, and CH2MHill's experience operating several similar systems. The major elements involved in the implementation of these alternatives is well installation, injection of EOS, injection and recirculation of water, equipment and materials, and the associated labor for engineering, oversight and field implementation.

The major components of the cost estimate for these alternatives include the calculation of the amount of EOS required to treat the estimated mass of contamination within the TTZ, well installation, EOS injection and groundwater recirculation costs. Based on the aquifer characteristics and the quantity of EOS required, the number of injection wells was determined and the associated costs of well installation were arrived at from price quotations from drillers. The cost of injection of the EOS into the subsurface was based on a price quotation from Solutions-IES, Inc, of Raleigh, NC, who is the primary vendor in the market for the implementation of EOS injections. This price quotation is attached to this cost estimate as Attachment B. Additionally, the costs of equipment required for recirculation (pumps and piping), rental of storage tanks for temporary storage of extracted groundwater, mixing with EOS and reinjection into the subsurface are also included in the price quotation from Solutions-IES, Inc.

The main difference between the cost estimates for Alternatives 2A and 2B is that in the cost estimate for Alternative 2B, the costs of recirculation of groundwater are not included. If necessary, the use of DPT push-points, in lieu of injection wells, could be evaluated in the remedial design phase of Alternative 2B.

The estimates for Alternatives 2A and 2B have a level of accuracy of +50/-30% for costs presented as capital cost. No O&M costs are included in these alternatives, since the post-treatment monitoring will be performed outside the injection effort. This estimate is classified as a conceptual design estimate.

The most market sensitive component of these estimates is the cost of emulsified edible oil substrate (EOS) . However, this material is relatively inexpensive on a per pound basis compared to other injectates, and barring any significant changes in costs, price fluctuations of this material would not significantly impact the cost estimate. Aside from this factor, all other cost factors associated with this alternative are relatively stable and easily available.

A detailed draft quote for EOS injection implementation from Solutions-IES, Inc., the leading subcontractor implementing the EOS injection, has been included in Attachment B-3 for reference. Relevant elements of this quote have been incorporated into the cost estimates for Alternatives 2A and 2B

Attachment B-2: Costs for Alternatives 1, 2A, and 2B

COST ESTIMATE OF CORRECTIVE ACTION OPTIONS
SA17 Source Reduction Alternatives

Site: Former Naval Training Center, Orlando - Study Area 17
Location: Orlando, Florida
Phase: SA17 Remediation

Base Year: 2005
Date: February 2005

	Alternative 1 **Soil Excavation In the Treatment Zone**	Alternative 2 **Enhanced Bioremediation with EOS using Recirculation**	Alternative 3 **Enhanced Bioremediation with EOS using Inject and Chase Method**	
Total Project Duration (Years)	1	1	1	
Total Capital Cost	$1,193,000	$446,000	$394,000	
Total Present Valve of Alternative	**$1,193,000**	**$446,000**	**$394,000**	
		One Injection Event	One Injection Event	
		Baseline Monitoring only	Baseline Monitoring only	

Disclaimer: The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. Changes in the cost elementsof upto +/-50% are likely to occur as a result of new information and data collected and potential revisions in the design assumptions

Alternative 1
SA17 Excavation

COST ESTIMATE SUMMARY

Site:	Orlando Naval Training Center - SA17	**Description:**	Excavation of the Target Treatment Zone to a depth of 50 ft bgs with a footprint of 50 ft width x 50 ft length Backfill for final grade and restore site vegetation
Location:	Orlando, Florida		
Phase:	SA17 Remediation		
Base Year:	2005		

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
STARTUP					
Mobilization/Demobillization	1	EA	$30,855	$30,855	JVII- Cost Estimate Mar'04
Surface Grading	1.0	LS	$500	$500	350 ft Disturbed Rectangle
SUBTOTAL				**$31,355**	
SHEETING AND SHORING					
Drive Sheeting for Retaining Cell	11,435	sq ft	$49.83	$569,845	Source: Hayward Baker 56 foot diameter cell with 65 foot deep sheeting
Pull Sheeting from Retaining Cell	11,435	sq ft	($1.67)	($19,053)	Cost of pulling plus credit for return of sheet pile
Waler	1	sq ft	$75,286	$75,286	Ring beam
SUBTOTAL				**$626,100**	
EARTHWORK					
Excavate to 50 foot depth	4,561	cy	$13.58	$61,921	JVII- Cost Estimate Mar'04
Backfill	$ 7,000	ls	$7,000.00	$7,000	JVII- Cost Estimate Mar'04
Grass for Erosion Control	62,500	sf	$0.15	$9,375	JVII- Cost Estimate Mar'04
SUBTOTAL				**$78,296**	
TREATMENT					
Treat Excavated Soil	5,108	ton	$36	$182,825	JVII- Cost Estimate Mar'04
Residual Waste Management	250	cy	$68.50	$17,125	JVII- Cost Estimate Mar'04
Add Chemical to Open Excavation	$12,500	LS	$1.23	$15,428	JVII- Cost Estimate Mar'04
Treatment confirmation sampling	$20	ea	$154.28	$3,086	JVII- Cost Estimate Mar'04
SUBTOTAL				**$218,462**	

Alternative 1
SA17 Excavation

COST ESTIMATE SUMMARY

Site:	Orlando Naval Training Center - SA17	**Description:**	Excavation of the Target Treatment Zone to a depth of 50 ft bgs with a footprint of 50 ft width x 50 ft length Backfill for final grade and restore site vegetation
Location:	Orlando, Florida		
Phase:	SA17 Remediation		
Base Year:	2005		

IMPLEMENTATION COSTS					
Engineering and Permitting	8	%	$918,832	$73,507	JVII- Cost Estimate Mar'04
Project Management and Work Plan Preparation	8	%	$918,832	$73,507	JVII- Cost Estimate Mar'04
Field Labor and Field Office Support During Construction	10	%	$918,832	$91,883	JVII- Cost Estimate Mar'04
Travel Costs	5	%	$918,832	$45,942	
SUBTOTAL				**$238,896**	
TOTAL CAPITAL COST				**$1,193,000**	

ANNUAL OPERATING COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES

PRESENT VALUE ANALYSIS - 0 YEARS

Discount Rate = 7%

End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	PRESENT VALUE	NOTES
0	CAPITAL COST	$1,193,000	$1,193,000	1.000	$1,193,000	
0	ANNUAL O&M COST	$0	$0	0.000	$0	
		$1,193,000			$1,193,000	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$1,193,000**	

SOURCE INFORMATION

JVII-Cost Estimate March 2004, which includes subcontractor costs based on bids.
Subcontractor prices subject to change due to market variations since March 2004.

EOS Remediation, Inc.

Emulsified Edible Oil Source Design Software
Beta Version 1.0
www.eosremediation.com

Site Name:	SA 17, Former Naval Training Center, Orlando.
Location:	Orlando, FL
Project No.:	

Section A: Treatment Area Dimensions

Width of source area perpendicular to groundwater flow	50	ft	15.2	m
Length of source area parallel to groundwater flow	50	ft	15.2	m
Minimum depth to contamination	35	ft	10.7	m
Maximum depth of contamination	55	ft	16.8	m
Treatment thickness	20	ft	6.1	m
Treatment zone cross-sectional area	1,000	ft^2	93	m^2
Treatment zone volume	50,000	ft^3	1,416	m^2
Treatment zone groundwater volume (volume x effective porosity)	63,580	gallons	240,693	L

Groundwater Flow Rate/ Site Data

Soil Characteristics				
Nominal Soil Type (enter clay, silt, silty sand, sand, or gravel)	silty sand			
Hydraulic Characteristics				
Total Porosity (accept default or enter *n*)	0.28	(decimal)		
Effective Porosity (accept default or n_e)	0.17	(decimal)		
Hydraulic Conductivity (accept default or enter *K*)	15	ft/day	5.3E-03	cm/sec
Hydraulic Gradient (accept default or enter *i*)	0.005	ft/ft		
Seepage velocity (V_x)	0.441	ft/day	0.1345	m/day
Groundwater flowrate through treatment zone (Q)	561	gallons/day	2124	L/day

Design Lifespan For One Application	5	year(s)	typical values 5 to 10 years	
Total groundwater volume treated over design life	1,087,405	gallons	4,116,562	L

Electron Acceptors

Inputs		Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2 (wt/wt H_2)*	Hydrogen Demand *(g H_2)*
Dissolved Oxygen (DO)	from MNA04.xls	0 to 8	0.3	32.0	4	7.94	155.5964252
Nitrate Nitrogen (NO_3^- - N)	from MNA04.xls	1 to 10	0.06	62.0	5	12.30	20.07461867
Sulfate (SO_4^{2-})	from MNA04.xls	10 to 500	89	96.1	8	11.91	30753.90886
Tetrachloroethene (PCE), C_2Cl_4				165.8	8	20.57	
Trichloroethene (TCE), C_2HCl_3			20	131.4	6	21.73	3789.436468
cis-1,2-dichloroethene (c-DCE), $C_2H_2Cl_2$			1	96.9	4	24.05	171.1953693
Vinyl Chloride (VC), C_2H_3Cl			0.3	62.5	2	31.00	39.83201964
Carbon tetrachloride, CCl_4				153.8	8	19.08	
Chloroform, $CHCl_3$				119.4	6	19.74	
sym- tetrachloroethane, $C_2H_2Cl_4$				167.8	8	20.82	
1,1,1-Trichloroethane (TCA), CH_3CCl_3				133.4	6	22.06	
1,1-Dichloroethane (DCA), CH_2CHCl_2				99.0	4	24.55	
Chloroethane, C_2H_5Cl				64.9	2	32.18	
Perchlorate, ClO_4^-				99.4	8	12.33	
Hexavalent Chromium, Cr[VI]				52.0	3	17.20	
User added							
User added							
User added							

Additional Hydrogen Demand and Carbon Losses

Generation (Potential Amount Formed)	Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2 (wt/wt H_2)*	Hydrogen Demand *(g H_2)*	DOC Released *(moles)*
Estimated Amount of $Fe2^+$ Formed	10 to 100	50	55.8	1	55.41	3714.819957	
Estimated Amount of Manganese (Mn^{2+}) Formed		5	54.9	2	27.25	755.2299701	
Estimated Amount of CH_4 Formed	5 to 20	10	16.0	8	1.99	20690.32406	
Target Amount of DOC to Release	60 to 100	100	12.0				34273.26

Note:
Calculations assume:
1.) all reactions go to completion during passage through emulsified edible oil treated zone; and,
2.) perfect reaction stoichiometry.

EOS® Requirement Calculations Based on Hydrogen Demand and Carbon Losses

Stoichiometric Hydrogen Demand	132	pounds
DOC Released	1,177	pounds

EOS® Requirement Based on Hydrogen Demand and Carbon Loss

6 drums

Substrate Requirement Calculations Based on Adsorptive Capacity of Soil

Soil Characteristics

Nominal soil type (enter silt, silty sand, or sand)	silty sand	
Density of soil (accept default or enter site specific value)	125	lbs / ft3
Effective Thickness (typically less than 40%)	0.25	
Weight of sediment to be treated	1,562,500	lbs
Adsorptive Capacity of Soil (accept default or enter site specific value)	0.002	lbs EOS® / lbs soil

Aquifer "Sorption" Capacity[1]
- Fine sand with some clay 0.001 to 0.002 lbs EOS® / lbs soil
- Sand with higher silt/clay content 0..002 to 0.004 lbs EOS® / lbs soil

[1]Default values provided based on laboratory studies completed by NCSU

EOS® Requirement Based on Adsorptive Capacity of Soil

8 drums

Suggested Quantity of EOS® for Your Project

8 drums

EOS Remediation, Inc.

Emulsified Edible Oil Source Design Software
Beta Version 1.0
www.eosremediation.com

Site Name:	SA 17, Former Naval Training Center, Orlando.
Location:	Orlando, FL
Project No.:	

Section A: Treatment Area Dimensions

Width of source area perpendicular to groundwater flow	50	ft	15.2	m
Length of source area parallel to groundwater flow	50	ft	15.2	m
Minimum depth to contamination	20	ft	6.1	m
Maximum depth of contamination	35	ft	10.7	m
Treatment thickness	15	ft	4.6	m
Treatment zone cross-sectional area	750	ft^2	70	m^2
Treatment zone volume	37,500	ft^3	1,062	m^2
Treatment zone groundwater volume (volume x effective porosity)	47,685	gallons	180,520	L

Groundwater Flow Rate/ Site Data

Soil Characteristics				
Nominal Soil Type (enter clay, silt, silty sand, sand, or gravel)	silty sand			
Hydraulic Characteristics				
Total Porosity (accept default or enter *n*)	0.28	(decimal)		
Effective Porosity (accept default or n_e)	0.17	(decimal)		
Hydraulic Conductivity (accept default or enter *K*)	15	ft/day	5.3E-03	cm/sec
Hydraulic Gradient (accept default or enter *i*)	0.005	ft/ft		
Seepage velocity (V_x)	0.441	ft/day	0.1345	m/day
Groundwater flowrate through treatment zone (Q)	421	gallons/day	1593	L/day

Design Lifespan For One Application	5	year(s)	typical values 5 to 10 years	
Total groundwater volume treated over design life	815,554	gallons	3,087,421	L

Electron Acceptors

Inputs		Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2* *(wt/wt H_2)*	Hydrogen Demand *(g H_2)*
Dissolved Oxygen (DO)	from MNA04.xls	0 to 8	0.3	32.0	4	7.94	116.6973189
Nitrate Nitrogen (NO_3^- - N)	from MNA04.xls	1 to 10	0.06	62.0	5	12.30	15.055964
Sulfate (SO_4^{2-})	from MNA04.xls	10 to 500	89	96.1	8	11.91	23065.43165
Tetrachloroethene (PCE), C_2Cl_4				165.8	8	20.57	
Trichloroethene (TCE), C_2HCl_3			20	131.4	6	21.73	2842.077351
cis-1,2-dichloroethene (c-DCE), $C_2H_2Cl_2$			1	96.9	4	24.05	128.3965269
Vinyl Chloride (VC), C_2H_3Cl			0.3	62.5	2	31.00	29.87401473
Carbon tetrachloride, CCl_4				153.8	8	19.08	
Chloroform, $CHCl_3$				119.4	6	19.74	
sym- tetrachloroethane, $C_2H_2Cl_4$				167.8	8	20.82	
1,1,1-Trichloroethane (TCA), CH_3CCl_3				133.4	6	22.06	
1,1-Dichloroethane (DCA), CH_2CHCl_2				99.0	4	24.55	
Chloroethane, C_2H_5Cl				64.9	2	32.18	
Perchlorate, ClO_4^-				99.4	8	12.33	
Hexavalent Chromium, Cr[VI]				52.0	3	17.20	
User added							
User added							
User added							

Additional Hydrogen Demand and Carbon Losses

Generation (Potential Amount Formed)	Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2* *(wt/wt H_2)*	Hydrogen Demand *(g H_2)*	DOC Released *(moles)*
Estimated Amount of $Fe2^+$ Formed	10 to 100	50	55.8	1	55.41	2786.114968	
Estimated Amount of Manganese (Mn^{2+}) Formed		5	54.9	2	27.25	566.4224776	
Estimated Amount of CH_4 Formed	5 to 20	10	16.0	8	1.99	15517.74305	
Target Amount of DOC to Release	60 to 100	100	12.0				25704.95

Note:
Calculations assume:
1.) all reactions go to completion during passage through emulsified edible oil treated zone; and,
2.) perfect reaction stoichiometry.

EOS® Requirement Calculations Based on Hydrogen Demand and Carbon Losses

Stoichiometric Hydrogen Demand	99	pounds
DOC Released	883	pounds

EOS® Requirement Based on Hydrogen Demand and Carbon Loss

5 drums

Substrate Requirement Calculations Based on Adsorptive Capacity of Soil

Soil Characteristics

Nominal soil type (enter silt, silty sand, or sand)	silty sand	
Density of soil (accept default or enter site specific value)	125	lbs / ft3
Effective Thickness (typically less than 40%)	0.25	
Weight of sediment to be treated	1,171,875	lbs
Adsorptive Capacity of Soil (accept default or enter site specific value)	0.002	lbs EOS® / lbs soil

Aquifer "Sorption" Capacity[1]

- Fine sand with some clay 0.001 to 0.002 lbs EOS® / lbs soil
- Sand with higher silt/clay content 0..002 to 0.004 lbs EOS® / lbs soil

[1]Default values provided based on laboratory studies completed by NCSU

EOS® Requirement Based on Adsorptive Capacity of Soil

6 drums

Suggested Quantity of EOS® for Your Project

6 drums

Emulsified Edible Oil Source Design Software
Beta Version 1.0
www.eosremediation.com

EOS Remediation, Inc.

Site Name:	SA 17, Former Naval Training Center, Orlando.
Location:	Orlando, FL
Project No.:	

Section A: Treatment Area Dimensions

Width of source area perpendicular to groundwater flow	50	ft	15.2	m
Length of source area parallel to groundwater flow	50	ft	15.2	m
Minimum depth to contamination	5	ft	1.5	m
Maximum depth of contamination	20	ft	6.1	m
Treatment thickness	15	ft	4.6	m
Treatment zone cross-sectional area	750	ft^2	70	m^2
Treatment zone volume	37,500	ft^3	1,062	m^2
Treatment zone groundwater volume (volume x effective porosity)	47,685	gallons	180,520	L

Groundwater Flow Rate/ Site Data

Soil Characteristics				
Nominal Soil Type (enter clay, silt, silty sand, sand, or gravel)	silty sand			
Hydraulic Characteristics				
Total Porosity (accept default or enter *n*)	0.28	(decimal)		
Effective Porosity (accept default or n_e)	0.17	(decimal)		
Hydraulic Conductivity (accept default or enter *K*)	15	ft/day	5.3E-03	cm/sec
Hydraulic Gradient (accept default or enter *i*)	0.005	ft/ft		
Seepage velocity (V_x)	0.441	ft/day	0.1345	m/day
Groundwater flowrate through treatment zone (Q)	421	gallons/day	1593	L/day

Design Lifespan For One Application	5	year(s)	typical values 5 to 10 years	
Total groundwater volume treated over design life	815,554	gallons	3,087,421	L

Electron Acceptors

Inputs		Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2 (wt/wt H_2)*	Hydrogen Demand *(g H_2)*
Dissolved Oxygen (DO)	from MNA04.xls	0 to 8	0.3	32.0	4	7.94	116.6973189
Nitrate Nitrogen (NO_3^- - N)	from MNA04.xls	1 to 10	0.06	62.0	5	12.30	15.055964
Sulfate (SO_4^{2-})	from MNA04.xls	10 to 500	89	96.1	8	11.91	23065.43165
Tetrachloroethene (PCE), C_2Cl_4				165.8	8	20.57	
Trichloroethene (TCE), C_2HCl_3			20	131.4	6	21.73	2842.077351
cis-1,2-dichloroethene (c-DCE), $C_2H_2Cl_2$			1	96.9	4	24.05	128.3965269
Vinyl Chloride (VC), C_2H_3Cl			0.3	62.5	2	31.00	29.87401473
Carbon tetrachloride, CCl_4				153.8	8	19.08	
Chloroform, $CHCl_3$				119.4	6	19.74	
sym- tetrachloroethane, $C_2H_2Cl_4$				167.8	8	20.82	
1,1,1-Trichloroethane (TCA), CH_3CCl_3				133.4	6	22.06	
1,1-Dichloroethane (DCA), CH_2CHCl_2				99.0	4	24.55	
Chloroethane, C_2H_5Cl				64.9	2	32.18	
Perchlorate, ClO_4^-				99.4	8	12.33	
Hexavalent Chromium, Cr[VI]				52.0	3	17.20	
User added							
User added							
User added							

Additional Hydrogen Demand and Carbon Losses

Generation (Potential Amount Formed)	Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2 (wt/wt H_2)*	Hydrogen Demand *(g H_2)*	DOC Released *(moles)*
Estimated Amount of Fe^{2+} Formed	10 to 100	50	55.8	1	55.41	2786.114968	
Estimated Amount of Manganese (Mn^{2+}) Formed		5	54.9	2	27.25	566.4224776	
Estimated Amount of CH_4 Formed	5 to 20	10	16.0	8	1.99	15517.74305	
Target Amount of DOC to Release	60 to 100	100	12.0				25704.95

Note:
Calculations assume:
1.) all reactions go to completion during passage through emulsified edible oil treated zone; and,
2.) perfect reaction stoichiometry.

EOS® Requirement Calculations Based on Hydrogen Demand and Carbon Losses

Stoichiometric Hydrogen Demand	99	pounds
DOC Released	883	pounds

EOS® Requirement Based on Hydrogen Demand and Carbon Loss

5 drums

Substrate Requirement Calculations Based on Adsorptive Capacity of Soil

Soil Characteristics

Nominal soil type (enter silt, silty sand, or sand)	silty sand	
Density of soil (accept default or enter site specific value)	125	lbs / ft3
Effective Thickness (typically less than 40%)	0.25	
Weight of sediment to be treated	1,171,875	lbs
Adsorptive Capacity of Soil (accept default or enter site specific value)	0.002	lbs EOS® / lbs soil

Aquifer "Sorption" Capacity[1]
- Fine sand with some clay 0.001 to 0.002 lbs EOS® / lbs soil
- Sand with higher silt/clay content 0..002 to 0.004 lbs EOS® / lbs soil

[1]Default values provided based on laboratory studies completed by NCSU

EOS® Requirement Based on Adsorptive Capacity of Soil

6 drums

Suggested Quantity of EOS® for Your Project

6 drums

Alternative 2 **COST ESTIMATE SUMMARY**

Enhanced In Situ Biodegradation Using Emulsified Edible Oil

SA17- EOS Injection and Recirculation of Treated Groundwater with Treatment Monitoring Downgradient

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

Description: Enhanced in-situ biodegradation using emulsified edible oil in the shallow and deep intervals of the surficial aquifer.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
PRE-INJECTION ACTIVITIES					
Injection and Monitoring Well Installation	1	EA	$104,231	$104,231	See Extraction and Injection Well Installation Cost Detail Sheet; extraction well costs excluded
Survey	1	LS	$1,000	$1,000	
Mobilization and Prep Work					
Security Fencing, Signs, Traffic Control, and Utility Location	1	LS	$3,500	$3,500	
Baseline Groundwater Sample Collection Event	1	EA	$25,300	$25,300	Sample 15 Proposed Monitoring Wells
Procurement of fresh water from utility co.	1	LS	$6,000	$6,000	of trenching, piping, fittings and labor + water bill
Electrical Hookup	1	LS	$61,710	$61,710	CH2M HILL Estimate
Electrcity Usage	1	LS	$3,000	$3,000	CH2M HILL estimate
Transportation and Disposal of Asphalt (non-haz waste)	20	tons	$68.50	$1,370	CH2M HILL Estimate
SUBTOTAL				**$206,110**	
EMULSIFIED EDIBLE OIL (EOS) INJECTION					
Pressurized Injection System					
Plans, Mob / Demob, Reports	1	EA	$11,108	$11,108	
Field Implementation	1	LS	$59,488	$59,488	Solutions-IES Inc.estimate Jan '05
Material Costs - Emulsified Edible Oil (EOS)	20	DRUM	$1,037	$20,735	EOS Remediation Systems telecon January 2005
Shipping - Emulsified Edible Oil	1	LOAD	$800	$800	EOS Remediation Systems telecon January 2005
Equipment and Material	1	LS	$2,468	$2,468	
SUBCONTRACTOR SUBTOTAL				**$94,599**	
LABOR					
Project Managemen,Plans and Reports	8	%	$300,710	$24,057	
Engineering (Design and Permitting)	8	%	$300,710	$24,057	
Field Oversight	10	%	$300,710	$30,071	
Travel Costs	5	%	$300,710	$15,035	
SUBTOTAL				**$93,220**	
TOTAL CAPITAL COST				**$393,930**	

Alternative 2 **COST ESTIMATE SUMMARY**

Enhanced In Situ Biodegradation Using Emulsified Edible Oil

SA17- EOS Injection and Recirculation of Treated Groundwater with Treatment Monitoring Downgradient

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

Description: Enhanced in-situ biodegradation using emulsified edible oil in the shallow and deep intervals of the surficial aquifer.

PRESENT VALUE ANALYSIS - 8 YEARS

Discount Rate = 7%

End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	PRESENT VALUE	NOTES
0	CAPITAL COST - 1st injection event	$393,930	$393,930	1.000	$393,930	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$394,000**	

SOURCE INFORMATION

Alternative 2 **COST ESTIMATE SUMMARY**

Enhanced In Situ Biodegradation Using Emulsified Edible Oil

SA17- EOS Injection and Recirculation of Treated Groundwater with Treatment Monitoring Downgradient

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

Description: Enhanced in-situ biodegradation using emulsified edible oil in the shallow, intermediat and deep intervals of the surficial aquifer.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
PRE-INJECTION ACTIVITIES					
Injection, Extraction and Monitoring Well Installation	1	EA	$132,000	$132,000	See Extraction and Injection Well Installation Cost Detail Sheet
Survey	1	LS	$1,000	$1,000	
Mobilization and Prep Work					
Security Fencing, Signs, Traffic Control, and Utility Location	1	LS	$3,500	$3,500	
Trenching for underground piping	1	LS	$3,000	$3,000	CH2M HILL Estim. approx 350 LF to 2 ft bgs-incl labor & equip
2"- Sched 80 PVC Piping & fittings for conveyance of EOS and extraction water	400	LF	$1.50	$600	USPlastics Corp web quote
Baseline Groundwater Sample Collection Event	1	EA	$25,300	$25,300	Sample 15 Proposed Monitoring Wells
Frac Tank for Temporary Storage of Extracted Water and Fresh Water	1	MO	$2,172	$2,172	CH2MHll historic pricing-17,000 gal capacity/3 month rental @ $2,172/month
Procurement of fresh water from utility co.	1	LS	$6,000	$6,000	CH2M HILL Estim. approx 600 LF of trenching, piping, fittings and labor + water bill
Electrical Hookup	1	LS	$61,710	$61,710	CH2M HILL Estimate
Electrcity Usage	1	LS	$3,000	$3,000	CH2M HILL estimate
Transportation and Disposal of Asphalt (non-haz waste)	20	tons	$68.50	$1,370	CH2M HILL Estimate
SUBTOTAL				**$239,652**	
EMULSIFIED EDIBLE OIL (EOS) INJECTION					
Pressurized Injection System					
Plans, Mob / Demob, Reports	1	EA	$11,108	$11,108	
Field Implementation	1	LS	$65,659	$65,659	Solutions-IES Inc.estimate Jan '05
Material Costs - Emulsified Edible Oil (EOS)	20	DRUM	$1,037	$20,735	EOS Remediation Systems telecon January 2005
Shipping - Emulsified Edible Oil	1	LOAD	$800	$800	EOS Remediation Systems telecon January 2005
Equipment and Material	1	LS	$2,468	$2,468	
SUBCONTRACTOR SUBTOTAL				**$100,770**	
LABOR					
Project Managemen,Plans and Reports	8	%	$340,422	$27,234	
Engineering (Design and Permitting)	8	%	$340,422	$27,234	
Field Oversight	10	%	$340,422	$34,042	
Travel Costs	5	%	$340,422	$17,021	
SUBTOTAL				**$105,531**	
TOTAL CAPITAL COST				**$445,953**	

Alternative 2 **COST ESTIMATE SUMMARY**

Enhanced In Situ Biodegradation Using Emulsified Edible Oil

SA17- EOS Injection and Recirculation of Treated Groundwater with Treatment Monitoring Downgradient

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

Description: Enhanced in-situ biodegradation using emulsified edible oil in the shallow, intermediat and deep intervals of the surficial aquifer.

PRESENT VALUE ANALYSIS - 8 YEARS

Discount Rate = 7%

End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	PRESENT VALUE	NOTES
1	CAPITAL COST	$445,953	$445,953	1.000	$445,953	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$446,000**	

SOURCE INFORMATION

Alternative: **Alternative 2**

Element: **Injection and Extraction Well Installation in the Shallow, Intermediate and Deep Zones**

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

WORK STATEMENT

Installation of EOS injection wells, extraction wells and monitoring wells to evaluate EOS performance.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Monitoring Well Installation - HSA Drilling (incl all drilling sub costs)	300	LF	$72.82	$21,845	Partridge - 2005 Assume combination of existing and 8 new monitoring wells
Injection Well Installation - HSA Drilling (incl. all drilling sub costs)	525	LF	$72.82	$38,229	Partridge - 2005 4 Inj Wells each in the shallow and interm. zones; 4 pairs of inj wells in deep zone total of 16 inj wells with 5 ft screens
Extraction Well Installation - HSA Drilling (incl. all drilling costs)	250	LF	$88.86	$22,216	Partridge - 2005 Two 4-inch extraction wells ea. in the shallow and interm. zones; 2 pairs in deep zone total 8 inj wells with 5 ft screens
Waste Management	1	LS	$18,513	$18,513	CH2M HILL and Driller Estimate-2005
SUBTOTAL				**$100,803**	
Project Management	8%	of	$100,803	$8,064	
Technical Support	8%	of	$100,803	$8,064	
Construction Management	10%	of	$100,803	$10,080	
Travel Costs	5%	of	$100,803	$5,040	
SUBTOTAL				**$31,249**	
TOTAL UNIT COST				**$132,000**	

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
TOTAL ANNUAL O&M COST				**$0**	

Source of Cost Data

1. Sources are as noted in cost table.

Alternative:	**Alternatives 4S**
Element:	**Substrate Injection Duration**

Site:	Orlando Naval Training Center - SA17
Location:	Orlando, Florida
Phase:	SA17 Remediation
Base Year:	2005

WORK STATEMENT

Determination of the number of injection wells required for each injection zone and the amount of time required to inject the EOS substrate and chase volume calculated in the respecitve EOS Calcs sheet.

DIRECT PUSH TECHNOLOGY INJECTION TIME REQUIREMENTS

Shallow Zone

Treatment Area Injection Well Requirements:

Treatement Area:

Length:	50	ft	
Width:	50	ft	
Area:	2,500	sq ft	
Number of Injection Wells Required:			
Assumed ROI:	15	ft	
Coverage per injection well:	707	sq ft	
Number of wells required:	4		

Injection Time Requirements:

Treatment area thickness:	15	ft	
Porosity:	0.17		
Treatment area pore water volume:	6,375	cubic ft	
	47,688	gallons	
EOS injection volume per injection point	578	gallons	From EOS Source Area Calcs-SZ
Total EOS injection volume:	2,310	gallons	
Chase volume:	6,930	gallons	
(percent pore volume contacted:	19.4%)		
Estimated flow rate per well:	3	gpm	
Number of concurrent injection points:	4		
Hours of injection per day:	8	hrs	
Time to complete injection:	2	days	

Alternative:	**Alternatives 4S**
Element:	**Substrate Injection Duration**

Site:	Orlando Naval Training Center - SA17
Location:	Orlando, Florida
Phase:	SA17 Remediation
Base Year:	2005

WORK STATEMENT

Determination of the number of injection wells required for each injection zone and the amount of time required to inject the EOS substrate and chase volume calculated in the respecitve EOS Calcs sheet.

Intermediate Zone

Treatment Area Injection Well Requirements:

Treatement Area:

Length:	50	ft	
Width:	50	ft	
Area:	2,500	sq ft	

Number of Injection Wells Required:

Assumed ROI:	15	ft	
Coverage per injection well:	707	sq ft	
Number of wells required:	4		

Injection Time Requirements:

Treatment area thickness:	15	ft	
Porosity:	0.17		
Treatment area pore water volume:	6,375	cubic ft	
	47,688	gallons	
EOS injection volume per injection point	578	gallons	From EOS Source Area Calcs-IZ
EOS injection volume:	2,310	gallons	
Chase volume:	6,930	gallons	
(percent pore volume contacted:	19.4%)		
Estimated flow rate per well:	3	gpm	
Number of concurrent injection points:	4		
Hours of injection per day:	8	hrs	
Time to complete injection:	2	days	

Alternative:	**Alternatives 4S**
Element:	**Substrate Injection Duration**

Site:	Orlando Naval Training Center - SA17
Location:	Orlando, Florida
Phase:	SA17 Remediation
Base Year:	2005

WORK STATEMENT

Determination of the number of injection wells required for each injection zone and the amount of time required to inject the EOS substrate and chase volume calculated in the respecitve EOS Calcs sheet.

Deep Zone

Treatment Area Injection Well Requirements:

Treatement Area:

Length:	50	ft	
Width:	50	ft	
Area:	2,500	sq ft	

Number of Injection Wells Required:

Assumed ROI:	15	ft	
Coverage per injection well:	707	sq ft	
Number of injection locations required:	4		

Injection Time Requirements:

Treatment area thickness:	20	ft	
Porosity:	0.17		
Treatment area pore water volume:	8,500	cubic ft	
	63,584	gallons	
EOS injection volume per injection point	385	gallons	From EOS Source Area Calcs-DZ
EOS injection volume:	3,080	gallons	
Chase volume:	9,240	gallons	
(percent pore volume contacted:	19.4%)		
Estimated flow rate per well:	3	gpm	
Number of concurrent injection points:	4		
Hours of injection per day:	8	hrs	
Time to complete injection:	3	days	

Alternative: **Alternatives 4S**

Element: **Sample Collection and Laboratory Costs -**
Evaluation of Enhanced In Situ Biodegradation Performance

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

WORK STATEMENT

Costs associated with water sample collection from monitoring wells only for baseline monitoring included. Samples collected to evaluate enhanced bio performance. Unit Costs are per sample per event.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	COST	TOTAL	NOTES
Equipment & Labor per Event					
Sample Analysis					
VOCs - SW8260 - Level III	15	SAMPLE	$95	$1,425	
Carbon Dioxide - RSK-175	0	SAMPLE	$135	$0	
Nitrate/Nitrite - 352.2 or 300	0	SAMPLE	$50	$0	
Sulfide	15	SAMPLE	$20	$300	
Sulfate	15	SAMPLE	$20	$300	15 Monitoring Wells
Manganese - SW6010B	0	SAMPLE	$20	$0	5 Shallow Zone,
Potassium - SW6010B	0	SAMPLE	$20	$0	5 Intermediate Zone and
Bromide	0	SAMPLE	$20	$0	5 Deep Zone
Alkalinity - SM 2320-B	15	SAMPLE	$15	$225	
Chloride - SW9056	15	SAMPLE	$20	$300	Sulfate/Sulfide, Iron,
Iron - SW6010B	15	SAMPLE	$20	$300	Alkalinity, Chloride -
Iron II - SM3500 - Fe	15	SAMPLE	$20	$300	Semi-Annual Only
Iron III (calculated)	15	SAMPLE	$0	$0	
Total Organic Carbon - SW9060	15	SAMPLE	$25	$375	
Total Dissolved Solids E160.1	0	SAMPLE	$20	$0	
Total Suspended Solids E160.2	0	SAMPLE	$20	$0	
Hexavalent Chromium	0	SAMPLE	$25	$0	
Methane/Ethene/Ethane	15	SAMPLE	$150	$2,250	
Trip Blanks- VOCs	1	SAMPLE	$95	$95	
Dehalococcoides etheneogenes	15	SAMPLE	$275	$4,125	Microbial Insights - August
Volatile Fatty Acids	15	SAMPLE	$100	$1,500	2004
Phospholipid Fatty Acids	15	SAMPLE	$265	$3,975	Semi-Annual Only
QA/QC Samples	2	SAMPLE	$95	$190	VOCs Only
Equipment & Labor					
Sampling Supplies	1	EA	$750	$750	
Groundwater Sampling					Includes YSI 6500 and
Equipment Rental	1	WK	$600	$600	Grunfos Pump
Sample Shipment	1	EA	$400	$400	CH2M HILL Estimate
Labor - Technicians	30	HR	$100	$3,000	1 hr/well, 2 people
SUBTOTAL				**$20,410**	
Data Validation	4	HR	$100	$400	
Data Management	4	HR	$100	$400	
Project Management	5%	of	$20,410	$1,021	
Technical Support	5%	of	$20,410	$1,021	
Construction Management	0%	of	$20,410	$0	
Project Delivery	10%	of	$20,410	$2,041	
Subcontractor General Requirements	5%	of	$20,410	$1,021	
SUBTOTAL				**$4,882**	
TOTAL UNIT COST				**$25,300**	

Alternative:	**Alternatives 4S**
Element:	**Sample Collection and Laboratory Costs - Evaluation of Enhanced In Situ Biodegradation Performance**

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

WORK STATEMENT

Costs associated with water sample collection from monitoring wells only for baseline monitoring included. Samples collected to evaluate enhanced bio performance. Unit Costs are per sample per event.

Source of Cost Data

Recent analytical sampling conducted by CH2M HILL on other projects of similar nature.

Attachment B-3: Technical Input Received from Solutions IES

Solutions
Industrial & Environmental Services

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January 7, 2005

Mr. Sam Naik
CH2MHILL
115 Perimeter Center Plaza NE, Suite 7000
Atlanta, GA 30346-1278

**Re.: Proposal for Services
Study Area 17, Naval Training Center
Orlando, Florida
Solutions-IES Proposal No. NC05335P**

Dear Mr. Naik:

Solutions Industrial & Environmental Services, Inc. (Solutions-IES) is pleased to provide this proposal to inject an emulsified oil substrate (EOS®) to treat chlorinated solvents in groundwater within Study Area (SA)-17 at the Naval Training Center (NTC) in Orlando, Florida. This proposal summarizes background information regarding the site, outlines our planned approach, and provides a range of estimated costs.

Background

We received copies of site data via e-mail. The data package consisted of a geologic profile from north to south (Figure 1-2) and six concentration maps: TCE-NAPL, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE and vinyl chloride where the different wells are shaded according to the contaminant concentration range. The existing monitor wells have been screened within four zones: Zone A is from 5 to 15 feet below land surface (bls), Zone B is from 15 to 30 feet bls, Zone C is from 30 to 50 feet bls and Zone D is deeper than 50 feet bls. Wells finished in Zone A have TCE concentrations ranging up to 3,090 μg/L. Wells finished in Zone B have TCE concentrations ranging up to 42,400 μg/L. Wells screened in Zone C have TCE concentrations ranging up to 3,160 μg/L. No data were shown for wells deeper than 50 feet.

Figure 1-2 shows the water table occurs approximately 5 feet bls. The top 30 feet of the section is comprised primarily of tan gray and brown fine-grained sand (Unified Soil Classification SP) with several interlayered beds of gray brown silty sand (SM). The top of the Hawthorn Group occurs at approximately 30 feet bls. The Hawthorn Group is described as light green silty to fine to coarse-grained sand with phosphate nodules and shell fragments (SP). These materials appear to become siltier with depth becoming a silty fine-grained sand (SM) at a depth of 42 to 48 feet bls. The Hawthorn clay occurs at approximately 50 feet bls. The Hawthorn clay is described as brown green clayey silt with layers of dark green clay of low plasticity (SC/CL). It is our understanding the Hawthorn clay is considered to be an aquiclude or barrier minimizing vertical migration of the contaminants.

It is our understanding that you would like to consider treating a 50-foot by 50-foot area using EOS® using a recirculation process where groundwater is withdrawn from one or more wells, blended with EOS® concentrate and re-injected. The treatment thickness is proposed to be 50 feet, which presumably would treat all of the aquifer above the Hawthorn clay.

It is our understanding the CH2MHILL would act as the prime contractor for the project and would have the recovery/injection wells installed by others. Solutions-IES would act as a sub-consultant to CH2MHILL and would have the primary responsibility of providing and injecting the EOS® and performing what other services were requested on an "as-needed basis". Such additional services might include providing preliminary design of the well spacing and substrate quantities and various reporting activities or data interpretation after the injection.

Proposed Approach

Solutions-IES has reviewed the information you provided to us. In designing the test area wells, we offer the following suggestions:

- Install injection wells in pairs rather than attempt to screen the entire 50-foot treatment thickness. In other words, install a well pair with the shallow well screened from 5 feet to 25 feet along with a deeper well screened from 30 feet to 50 feet.

- Use the same strategy for the recovery well(s).

Contaminant concentrations appear to range up to 42,400 μg/L in zones A and B but are shown as being much lower within the Hawthorn Group materials deeper than 30 feet bls. The high concentrations suggest the possibility that free-phase TCE (DNAPL) may be present in the shallow zone. Because concentrations decrease below the 30-foot depth, this suggests that the silty sand shown between 25 and 30 feet may function as some sort of barrier restricting downward contaminant migration. Installing injection/recovery wells with long screens through the silty sand may allow downward migration of DNAPL. From the perspective of the pumping well, you would not want to recover water from the shallow zone and inject it into the deep zone for the same reason.

Based on the information provided to us, it appears that four injection well pairs located near the corners of the 50-foot by 50-foot grid would be sufficient. One pair of pumping wells would be located in the center of the test area. Water would be recovered from the center shallow well and used to inject the four corner shallow wells. Then the process would be repeated for the deeper zone wells.

You indicated that CH2MHILL would have the wells installed. Two-inch wells will be used for injection and four-inch wells will be used for recovery. Installing all wells as 4-inch wells would provide greater flexibility in pumping should it be desirable to pump from additional wells. The incremental cost may not be that great.

Solutions-IES would provide the EOS® concentrate and perform the injection. In the costing section below, we have added some upfront engineering or consulting time to assist you with the final design and UIC permit application as well as the Work Plan and Health and Safety Plan if requested. The time would be used to fine-tune the design and to provide you with any data, wording or drawings describing the injection process.

Prior to the start of injection, Solutions-IES personnel will set up a process equipment trailer containing pumps, tanks, and hoses. Solutions-IES will require access to utilities [e.g., water and electricity (single and/or three phase power)] in the vicinity of the process trailer. The EOS® concentrate will be delivered to the site and will need to be stored near the equipment trailer. Prior to injection, Solutions-IES will dilute the EOS® concentrate by mixing 1 part EOS® with 4 to 9 parts water depending on the final design. The diluted EOS will be pumped at low pressure or gravity-drained into each injection well to distribute the EOS® throughout the subsurface. Additional groundwater will be pumped behind the EOS to move it into the formation and increase the hydraulic head toward the center of the test area.

Solutions-IES' personnel will be on site during the injection. If CH2MHILL desires to continue recirculation for an extended period of two to four weeks, CH2MHILL will assume operation and maintenance of the pump and injection system and Solutions-IES will leave the site. Following completion of the EOS® injection, CH2MHILL would ship the pumps back to Solutions-IES. Costs for Solutions-IES to prepare a brief report documenting the injection activities are included in the cost estimate. The report will discuss the injection, summarize the amount of EOS® and chase water injected and any observations made.

Estimated Cost

At the present, many of the final details have to be finalized. As such, the cost of the injection is shown as a range in costs as detailed below. Please note that it is Solutions-IES' practice to process invoice every four weeks. Applicable federal, state and local taxes and permit fees are added to our invoices. All invoices are due upon receipt. Balances outstanding more than 30 days after the invoice date are subject to a monthly finance charge of 1½ percent per month from the invoice date.

Task 1 –Engineering Services (on as-needed basis)	$2,500 to $4,500
Task 2 – EOS® Injection (substrate, labor and equipment)	$55,000 to $70,000
Task 3 – Equipment Rental (continued recirculation)	$500 to $2,000
Task 4 –Reporting/Consulting Services (on as-needed basis)	$3,000 to $5,000
Estimated Range of Costs	$61,000 to $ 81,500

The cost estimate is based on the following:

- 20 drums of EOS concentrate will be provided by Solutions-IES and injected. The final volume is subject to design confirmation.
- The minimum injection costs reflect approximately 1 week of time on site. The high range cost reflects approximately two weeks on site. Obviously recovery and injection rates will control the length of the project.
- The wells will be installed by others. Recovery wells will be 4-inch diameter. Injection wells will be 2-inch diameter. Solutions-IES will provide all pumps hose and mixing equipment to perform the injection.
- Solutions-IES will take reasonable precautions while on-site to minimize property damage to the rights-of-way to the work area and the site. CH2MHILL/US NAVY recognizes that, during completion of services by Solutions-IES under this Agreement, alteration or damage may occur at the site. Client/Property Owner recognizes and accepts that this is inherent in the services provided by Solutions-IES.
- CH2MHILL/US NAVY warrants that any right-of-way provided by property owner to/from the property owner's premises to/from the most convenient way is sufficient to bear the weight of all Solutions-IES and/or our subcontractor's equipment and vehicles required to perform the services.
- Solutions-IES shall not be responsible for damages caused to any private pavement or accompanying subsurface of any route reasonably necessary to perform the services.
- CH2MHILL/US NAVY will provide complete openings, access, and rights-of-way to the work area at all times during the project. The work area will be large enough to accommodate the equipment and materials necessary for the project, and CH2MHILL/US NAVY will provide security.

- Single phase and/or three-phase power drops are available within 100 ft of the work area.
- Water is available from a hydrant or other water supply source within 1,000 ft of the injection area, and secure connections can be maintained between the water source and the work area.
- Subsurface conditions within the injection area are generally as represented in Figure 1-2. The presence of massive foundations and/or buried debris may involve additional costs.
- Weather delays are minimal.
- In preparing our cost proposal, we have assumed that all debris, wastes, washwaters, rinseates, wastewaters, soils, subsoils, and residues generated as a result of the field activities will be disposed of by CH2MHILL/US NAVY. Waste characterization and disposal services are not included in our cost estimate. A separate proposal can be provided for these services, if requested.

Project Team

Solutions-IES is a woman-owned, environmental engineering firm with extensive environmental engineering experience, particularly related to the assessment and remediation of industrial, governmental or other properties where releases of hazardous substances have occurred. We work with and on behalf of our clients to find cost-effective, practical solutions to their environmental problems. All key technical personnel have the necessary experience and expertise, as highlighted in the brief biographical sketches provided below.

Christie Zawtocki P.E. – Project Manager: Christie has a M.S. in Environmental Engineering, and most of her work has focused on soil and groundwater assessment and remediation projects. She has worked at a variety of government, industrial, and commercial sites located in NC, SC, TX, CA, MD, and OK. Her work has included soil and groundwater sampling, aquifer testing, natural attenuation screening assessments, soil stabilization studies, remedial alternative evaluations, risk-based cleanup level evaluations, and remedial system design, implementation and performance evaluation. Christie is the lead engineer and/or project manager on many of Solutions-IES' emulsified oil projects. This includes development of monitoring and demonstration plans, design of the injection system, groundwater flow and transport modeling, and reporting. Christie's expertise with design, implementation, monitoring, and reporting will be utilized in managing all project activities at your site. Christie will be responsible for maintaining communication with CH2MHILL and assuring that requirements for scope, schedule and cost are met.

Walter J. Beckwith, P.G. – Director of Technical Services: Walt Beckwith has a B.S. degree in Geology and is a licensed geologist in six states. He has over 30 years of field sampling, testing, and assessment experience and is well recognized in the environmental consulting industry. In 2000/2001, Walt served as the President of the Groundwater Professionals of North Carolina. His unique ability to implement and oversee field services, solve field problems, and interpret site conditions, provides an invaluable benefit to his clients. Walt has personally performed and overseen assessment and remediation of fuel related and chlorinated solvent sites using excavation, soil vapor extraction, air sparging, enhanced bioremediation, monitored natural attenuation, and pump-and-treat technologies. His expertise was used extensively in evaluating the contaminant fate and transport at statewide NCDOT asphalt-testing sites that were contaminated with TCE. Walt has served as field team leader on numerous Solutions-IES' remediation sites including participating in and overseeing the design and implementation of EOS® barriers of at three Air Force Bases and three industrial sites to date. Walt's extensive field experience will be used to assist with the design and implementation of the EOS® injection activities at your site.

Brian Rebar – Field Services Manager: Brian is a licensed Well Drilling Contractor in North Carolina. He has installed air sparging, soil vapor extraction, bio-sparging, pump-and-treat, free product recovery, bioslurping, and infiltration gallery systems for the remediation of soil and/or groundwater. Brian is

Solutions-IES' technical lead for remediation system operation and maintenance (O&M). Brian has also taken the lead in conducting the injection and monitoring activities for multiple Solutions-IES EOS® sites. Brian's experience will be used to head site-specific field team efforts.

Authorization

If you elect to accept our proposal by issuing a purchase order, then please reference this proposal number (Solutions-IES Proposal No. NC05335P) and date. Your purchase order will be an acceptance of our Agreement for Services and an authorization to proceed with the performance of our services. Unless otherwise agreed in writing signed by Solutions-IES, any and all services provided to CH2MHILL pursuant to the acceptance of a proposal by Solutions-IES, a written contract, a purchase order, or other evidence of an agreement between Solutions-IES and CH2MHILL where a copy of our Agreement for Services has been provided in advance to CH2MHILL, shall be deemed to be controlled by our Agreement for Services and incorporated into any other among the parties, whether or not contrary terms are included in a purchase order or other document provided by CH2MHILL.

Closing

Solutions-IES appreciates the opportunity to provide this proposal to you. We look forward to your favorable reply and an authorization to proceed. If you have any questions regarding information contained in this proposal, please feel free to contact us at 919-873-1060.

Yours truly,
Solutions-IES

Walter J. Beckwith, P.G.
Director of Technical Services

M. Tony Lieberman
Bioremediation Program Director

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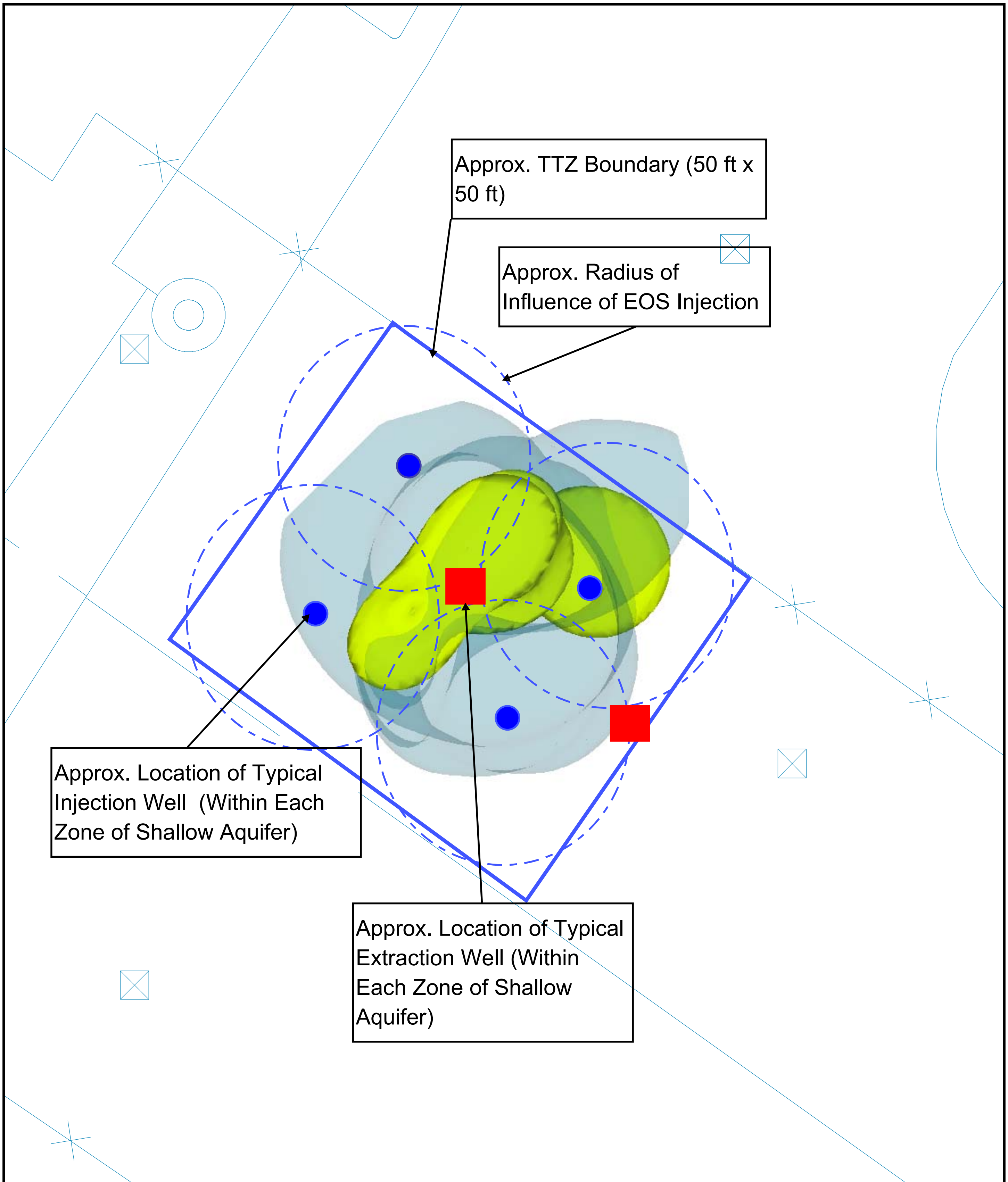
Attachment B-4: Sketches of Well Configurations for Alternatives 2A and 2B

NOTE: Original figure created in color



Blue - 10,000 ppb TCE in Groundwater
Green - 10,000 ppb TCE in Soil

N

0 10 20 Feet

1 inch = 18.6544 feet

Figure B-4

Proposed Injection and Extraction Well Scheme EOS Injection Approach
SA 17, NTC Orlando

CH2MHILL

File Path: c:\ntc gis\ntc-sa17.apr, Date: 27 Feb 2004 9:17, User: PFAVARA, Figure 4-1 10,000 ppb in Soil and Groundwater