DECISION DOCUMENT

FOR THE

DERP-FUDS PROJECT NO. I04NC080301
FORMER CHARLOTTE NAVAL AMMUNITION DEPOT
MECKLENBURG COUNTY,
CHARLOTTE, NORTH CAROLINA

Prepared for

U. S. ARMY CORPS OF ENGINEERS
SAVANNAH DISTRICT

CONTRACT NO. W912HN-07-D-0029
DELIVERY ORDER 0001

March 2010

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LIST OF ACRONYMS

ARAR	applicable or relevant and appropriate requirements
ASIP	Arrowood Southern Industrial Park
BRA	baseline risk assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CNAD	Charlotte Naval Ammunition Depot
COC	constituent of concern
COPC	constituent of potential concern
CSM	conceptual site model
DD	Decision Document
FFS	focused feasibility study
ft	feet
HI	hazard index
in/hr	inches per hour
MCL	maximum contaminant level
μg/L	microgram per liter
MNA	monitored natural attenuation
NCAC	North Carolina Administrative Code
NCDENR	North Carolina Department of Environment and Natural Resources
NCP	National Oil and Hazardous Substances Pollution Contingency Plan (referred to as “National Contingency Plan”)
O&M	operation and maintenance
RAO	remedial action objective
RBC	risk-based concentration
RG	remediation goal
RI	Remedial Investigation
SARA	Superfund Amendments and Reauthorization Act
TCE	trichloroethylene
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

1.0 PART 1 – DECLARATION

1.1 Site Name and Location

Former Charlotte Naval Ammunition Depot (CNAD)
DERP-FUDS Project No. I04NC080301
Mecklenburg County
Charlotte, North Carolina 28273

1.2 Statement of Basis and Purpose

This Decision Document (DD) presents the Selected Remedy for the former CNAD in Charlotte, North Carolina. The selected remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), 42 USC § 9601 *et seq.*, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) Part 300 *et seq.*, as amended. The regulatory program performed under the context of these combined laws and regulations is commonly referred to as "Superfund." This decision is based on the administrative record file for this site.

The North Carolina Department of Environment and Natural Resources (NCDENR) concurs with the selected remedy.

1.3 Assessment of Site

Previous investigations conducted by USACE have identified trichloroethylene (TCE) concentrations in groundwater underlying the site, that exceed the North Carolina (NC) groundwater quality standard of 2.8 micrograms per liter (μg/L). The response action selected in this DD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances to the environment.

1.4 Description of the Selected Remedy

The selected remedy for the CNAD site is groundwater treatment using enhanced bioremediation with sodium lactate injection. The major components of the remedy include:

- Installation of 85 injection wells and nine monitoring wells.
- Sodium lactate solution injection events into transition zone wells every two months over a six-month period.
- Sodium lactate solution injection events into bedrock zone wells every two months over a 12-month period.
- Groundwater monitoring activities for the duration of project.

1.5 Statutory Determinations

The Selected Remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial action, and is cost-effective. This alternative also satisfies the statutory preference for treatment as a principal element of the remedy. Through treatment; the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants are reduced. Although this remedy will result in hazardous substances, pollutants, or contaminants in groundwater being reduced to levels that allow for unlimited use and unrestricted exposure; the program will take more than five years to attain the remedial action objectives and cleanup levels. Therefore, remedial program reviews will be conducted every five years after the start of the Remedial Action IAW CERCLA and ER 200-3-1, page 4-15, paragraph 4-4.8.1, to ensure the remedy is, or will be, protective of human health and the environment.

1.6 DD Data Certification Checklist

The following information is included in the Decision Summary section of this DD (Part 2). Additional information can be found in the Administrative Record file for this Site.

- Current and reasonably anticipated future land use assumptions, and current and potential future beneficial uses of groundwater as utilized in the baseline risk assessment calculations;
- Contaminants of concern (COCs) and their respective concentrations;
- Baseline risk represented by the COCs;
- Remaining source (TCE hot spots identified in the groundwater) which constitute the principal threats are addressed;
- Key factors that led to remedy selection (i.e., a description of how the Selected Remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision);
- Cleanup levels established for COCs and the basis for these levels;
- Estimated capital costs, annual operation and maintenance (O&M) costs, and total present-worth costs; discount rate, and the number of years over which the remedy costs are projected; and
- Potential land and groundwater use that will be available at the site as a result of the Selected Remedy.

1.7 AUTHORIZING SIGNATURE

This Decision Document presents the selected response action at the former Charlotte Naval Ammunition Depot, Mecklenburg County, Charlotte, North Carolina. The U.S. Army Corps of Engineers is the lead agency under the Defense Environmental Restoration Program (DERP) at the former Charlotte Naval Ammunition Depot, Formerly Used Defense Site, and has developed this Decision Document consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision document will be incorporated into the larger Administrative Record file for the former Charlotte Naval Ammunition Depot, which is available for public view. This document, presenting a selected remedy with a present worth cost estimate of $7,124,076, is approved by the undersigned, pursuant to Memorandum, DAIM-ZA, September 9, 2003, subject: Policies for Staffing and Approving Decision Documents (DDs), and to Engineer Regulation 200-3-1, Formerly Used Defense Sites (FUDS) Program Policy.

APPROVED:

Christine Godfrey

CHRISTINE A. GODFREY
Acting Chief, Environmental Community of Practice
Directorate of Military Programs

4-18-11

Date

2.0 DECISION SUMMARY

The majority of the information presented in this DD has been taken from the Focused Feasibility Study (FFS) for the Former Naval Ammunition Depot (TPMC, 2009). Additional information on the site is available in the FFS, Remedial Investigation (RI) Reports [Metcalf and Eddy, Inc. (M&E), 1995 and (M&E, 2000)], and other project documents contained in the Administrative Record.

2.1 Site Name, Location, and Brief Description

2.1.1 Site Name and Location

Former Charlotte Naval Ammunition Depot (CNAD)
Mecklenburg County
Charlotte, North Carolina 28273

2.1.2 Lead and Support Agency

The lead agency for the former CNAD is the USACE. The regulatory agency is the NCDENR.

2.1.3 Brief Description of Site

At the time of operation, the entire CNAD complex occupied approximately 2,266 acres of land southwest of Charlotte, Mecklenburg County, North Carolina. The portion of the former property that is the focus of this DD is roughly bounded by Brookford Street, Wilmar Boulevard, Nevada Boulevard, and Westinghouse Boulevard in Mecklenburg County, Charlotte, North Carolina (Figure 1). The area is currently occupied by the Arrowood Southern Industrial Park (ASIP) that houses light industrial and commercial businesses, as well as some residential developments. Several buildings, including ASIP Buildings II, III, and IV, are located within the study area.

The majority of Former CNAD Areas 1 and 2, where the majority of the contamination is present, are located on property owned by Arrowood Southern Company and Norfolk Southern Railway Company. The remaining portions of the site are owned by Alliance IV LLC, Box USA Group Inc., Textron Incorporated, Cabot Industrial Properties, Prologis North Carolina LP, and Frito-Lay Incorporated. The site also has several areas that remain undeveloped and are covered with trees and brush.

2.2 Site History and Enforcement Activities

2.2.1 Site History

On June 1, 1942, the Bureau of Ordnance, Department of Navy signed a contract with the United States Rubber Company for the construction of a 40-mm anti-aircraft ammunition shell loading and assembly plant. Operations began in December 1942. In 1945, plant production was cut and the operation of the facility was transferred to the U. S. Navy. In 1956, the Naval Depot status was changed from Maintenance Status to Inactive Status, and in 1959, the Former CNAD complex was sold to a local partnership. Figure 2 shows the complex as it existed on

June 30, 1950. The property was sold to commercial developers in 1959 and all buildings related to the former operations were demolished. The facility was, in large part, dormant from 1959 until the early 1980s.

Former CNAD Areas 1 and 2 were used for the production of 40-mm antiaircraft munitions. Area 1 consisted of antiaircraft ammunition loading lines. This area was dedicated to the assembly of final rounds and was composed of 22 buildings. The operations carried out in Area 2 were reportedly identical to those conducted in Area 1. Area 2 was also used to process ammunition "fleet returns" (returned ammunition) after World War II for distribution to other Allied Forces Branches. Only Area 2 was used after 1945 for reconditioning of returned munitions.

A TCE vapor-degreasing operation was located on the southeast corner of Building 2-30 (Figure 2). The unit was used to remove cutting oil and preservatives on the exteriors of returned shells. Additional information on the site history is available in the FFS and RI reports contained in the Administrative Record.

2.2.2 History of Site Investigations

Investigations have been conducted at the Former CNAD site since the late 1980's.

<u>Phase I and II Site Assessments</u>

Initial Phase I and II site assessments were conducted from July 1990 through 1992. Results identified low levels of TCE and toluene in soil, and TCE and 1,2-dichloroethane in groundwater at levels above maximum contaminant levels (MCLs). Further assessment determined that the TCE was centralized in the vicinity of the former degreasing activities. Further investigation was recommended.

<u>Remedial Investigations</u>

An initial RI was conducted in 1994. The results are presented in the Phase I Remedial Investigation Final Report for the Former Naval Ammunition Depot Areas 1 and 2, Mecklenburg County, Charlotte, North Carolina (M&E 1995). The RI concluded that the soil was not impacted; however, groundwater was contaminated with volatile organic compounds (VOCs), specifically TCE with minor breakdown products. The TCE concentrations in groundwater exceeded the North Carolina Administrative Code (NCAC) 2L standard of 2.8 μg/L. TCE was found to be the predominant contaminant by mass with TCE breakdown products also present. No specific source of the TCE was identified and efforts to locate a source have been unsuccessful. However, the significant concentrations of TCE near wells NAD-MW-21 and SAIC-14 indicate that this area is most likely the source, and corresponds to the location of the former vapor degreasing building.

The RI indicated that concentrations of TCE tended to be higher in the bedrock monitoring wells, and within Area 2. A qualitative risk evaluation concluded that groundwater would be the most significant exposure pathway but was believed to be incomplete given city-supplied water is used in the area. The extent of groundwater contamination was not fully defined in the Phase I investigation and a Phase II investigation was recommended.

In 1999, a Phase II RI was conducted to delineate the horizontal and vertical extent of contamination, to determine the geologic and hydrogeologic frameworks of shallow and bedrock aquifers, and to conduct a quantitative risk assessment. The results are presented in the Final Phase II Remedial Investigation Report for the Former Naval Ammunition Depot Areas 1 and 2, Mecklenburg County, Charlotte, North Carolina (M&E 2000).

The Phase II RI determined that there were three groundwater zones underlying the property; TCE was the most widespread constituent and detected at the highest concentrations; and that the majority of TCE was detected in the transition zone (middle aquifer zone). Contamination was found to extend vertically to 70 feet (ft) in the most impacted portion of the area (NAD MW-21). While the Phase II RI defined the vertical extent of TCE, the horizontal extent was not completely delineated.

A human health Baseline Risk Assessment (BRA) was completed on the groundwater data. U.S. Environmental Protection Agency (USEPA) default intake values and published toxicity inputs were used in the calculations. The BRA determined the hypothetical risk for groundwater ingestion was approximately 1×10^{-04}. This value exceeded the most commonly used target of 1×10^{-06} but only marginally exceeded the acceptable range for remediation of Superfund sites (1×10^{-06} to 1×10^{-04}). Furthermore, the BRA concluded that considering the conservative set of assumptions used, the potential risk/hazards calculated were not anticipated to result in adverse human health risks. Additional information on the previous investigations is available in the reports contained in the Administrative Record.

<u>Supplemental Investigation Activities</u>

Supplemental investigation activities were conducted to collect data and information to support the FFS and pilot studies. Evaluation of the data collected during a November 2000 field investigation indicated that the contaminant concentrations had changed since the Phase II RI, and that the extent of contamination in the northern portion of the TCE plume was smaller than presented in the RI.

Based on the results of the supplemental investigation, it was determined that a complete plume delineation may not be achievable. Recommendations were made to perform further investigation activities at the site, specifically in the hot spot areas where the vertical extent of the TCE concentrations is greater than 500 μg/L, prior to beginning the FFS process. NCDENR Superfund Section personnel concurred with the recommendation to limit the focus of the next phase of work at the site to areas where the vertical extent of TCE concentrations was >500 μg/L. Additional investigations conducted from October 2002 to April 2003 were completed to better define the contaminant plume with concentrations >500 μg/L.

A receptor survey was conducted in 2002 for a 1-mile radius surrounding the Former CNAD site focus area to determine potential receptors of the groundwater contamination. The receptor survey indicated the following:

- The area is dominated by commercial and light industrial properties that include warehouses, retail stores, restaurants, hotel/motels, and small private businesses.
- Residential properties are located approximately ¾ miles north of the CNAD site focus area.
- The Charlotte Mecklenburg Utility District provides drinking water to the entire area within the 1-mile radius.

- Two properties were identified as having wells. None of these wells are used to supply drinking water and use of the wells on one of the properties (Frito-Lay) has been discontinued.

Pilot Study and Site-Wide Sampling Event

At the conclusion of the 2002 supplemental investigation effort, it was agreed that it was technically impractical to actively reduce the TCE groundwater plume in both the transition and bedrock zones to below the North Carolina drinking water standard. Therefore, a decision was made to focus the remedial action on areas that exhibit concentrations greater than 500 μg/L.

Recommendations were made to conduct a pilot study to evaluate the use of an electron donor for promoting reductive dechlorination as a remedial approach for the site, and to better understand the hydraulics near well NAD MW-21, which has historically contained the highest concentrations of TCE. Injection of a combination bromide tracer and sodium lactate (electron donor) food source was completed in October 2003 with subsequent monitoring for eight months through June 2004. A site-wide sampling event was then conducted in August and September 2006.

The results of the pilot study indicated that reducing conditions were present in most wells of the study area and that the sodium lactate solution injection assisted in producing reductive conditions in the aquifer that would enhance microbial activity of the *Dehalococcoides* population. The pilot study and site sampling showed that the treatment is an effective technology in promoting biodegradation and reduction of the contaminated groundwater. The details and results of the 2006 sampling event are provided in the Site-Wide Ground Water Sampling Report for the Future Remedial Design at the Former Naval Ammunition Depot (NAD), Mecklenburg County, Charlotte, North Carolina (SAIC 2008). Additional information on the previous site activities is available in the reports contained in the Administrative Record.

2.2.3 Enforcement Activities

No enforcement activities have been recorded at the CNAD site.

2.3 Community Participation

The RI Report and FFS have been available for review in the administrative record. The Proposed Plan for the CNAD site was made available to the public on September 1, 2009. These project documents and historical site information can be found in the administrative record file in the Carolina Room (third floor) of the Public Library of Charlotte and Mecklenburg County located at 310 North Tryon Street in Charlotte, North Carolina, 28202 and at the USACE, Wilmington or Savannah District offices. The notice of availability of the Proposed Plan was published in the Charlotte Observer on 2 September 2009. A public comment period was held from 1 – 30 September 2009. A public meeting was held at the Steele Creek Library in Charlotte, North Carolina on September 9, 2009 to present the Proposed Plan. At this meeting, representatives from USACE and NCDENR presented a short summary of the investigation and proposed actions for the CNAD Site, and answered questions about the site and the remedial alternatives. USACE's response to the comments received during this period is included in the Responsiveness Summary, located in Part 3 of this DD.

2.4 Scope and Role of Response Action

The selected remedy will be designed and implemented to meet State and Federal requirements. Characterization activities have identified the extent of contamination present at the site. These studies aided in the formulation of the Conceptual Site Model (CSM) and implementation of the pilot study. Implementation of the selected remedy, groundwater treatment through enhanced bioremediation via sodium lactate injection, will address potential risks from TCE contamination in the groundwater.

2.5 Site Characteristics

Geologic, hydrogeologic, and groundwater geochemical information and data for the Former CNAD site were obtained from the RIs and supplemental investigation reports developed for the site. Each of these characteristics is described in the following sections to provide a brief yet comprehensive overview of the site.

2.5.1 Physiography and Topography

The landscape is characterized by broad flats and gentle side slopes. Relief at the site is approximately 25 ft with maximum elevation along a low-lying northwest trending ridge in the center of the study area. A major portion of the area slopes away from this ridge to the southwest. Drainage around structures in the area has been diverted to the southwest.

Historical and current building activities have impacted the topography of the Former CNAD complex including the investigation focus area. Graded building pads, foundation structures, drainage features, rail lines, and roads are evident across the area. Within the study area, buildings and associated structures, both historical and current, are generally oriented northeast to southwest. The site also has several areas that remain undeveloped and are covered with trees and brush.

2.5.2 Geology

The Former CNAD site lies within the central Piedmont of North Carolina, which extends from the northwestern edge of the Kings Mountain and Loundsville belts eastward and southward to the Raleigh and Kiokee metamorphic belts. Regional geologic features include the Carolina Slate, and the Charlotte, Kings Mountain, and Loundsville shear zones. The eastern edge of the region is defined by a sequence of faults (Jonesborough and Nutbush Creek) and linear features, which include the Raleigh and Eastern Slate belts.

The Former CNAD site is located within the Charlotte belt. The Charlotte belt occurs near the northern reaches of the central Piedmont. The belt is typically characterized as “dominantly plutonic” with mineralogical compositions ranging from granite to gabbro.

2.5.2.1 Soil

The unconsolidated subsurface soils encountered at the Former CNAD site are primarily residuum and saprolite material. The general soil zone is classified as Iredell-Mecklenburg. Former CNAD Areas 1 and 2 are typically underlain by Iredell fine, sandy loam. The average slope ranges from 0 to 8% over the study area. The hydraulic conductivity of these soils ranges from 2.0 to 6.0 inches per hour (in/hr) in the 0 to 0.5-ft depth range, and 0.06 to 0.6 in/hr at depth greater than 0.5 ft (M&E 2000).

The residuum encountered at the site is characterized as brown, moist, plastic, sandy clays. The clay contains traces of organic construction materials in areas of fill or disturbance. In undisturbed residual soils, the clay is generally lighter in color, with an increase in mica content.

The saprolite encountered below the residuum was found to range in thickness across the site from 1 to 15 ft. Cross sections of the subsurface geology are provided in the FFS (Figures 2-3 and 2-4). It is characterized by medium-grained interbedded reddish to brown silty sand, clay-rich silts, and silty clays that occur over the bedrock and within fractures in the bedrock. In this zone, the material has weathered to sands, silts, and clays, and contains the structure and composition of the parent material with the sands being derived from quartz-rich layers in the bedrock and the silts and clays from biotite, feldspars, hornblende, and plagioclase. The saprolite was found to occur over the bedrock and within the fractures of the bedrock.

Near the top of the bedrock, the saprolite may become coarser grained with the grains becoming sub-angular. Larger fragments of rock may also be encountered. This zone of partially weathered rock in a matrix of saprolite, along with the upper zone of the fractured bedrock, is referred to as the transition zone.

2.5.2.2 Bedrock

Regionally, the rocks of the Charlotte Belt consist of massive to weakly foliated granite to granodiorite and earlier formed gneiss. The gneiss unit consists of amphibolites or hornblende gneisses, quartz-biotite, and quartz-microcline gneisses and various types of migmatite marginal to the major plutons. Both the granite and the gneisses are intruded by very late orogenic gabbros consisting of fibrous amphiboles, biotite, and plagioclase. Pegmatites crosscut these gabbros. In addition to the folding and magmatic activity within the belt, a pronounced N 20 W fracture direction is prominent. Gabbro and metagabbro rock of the Mecklenburg-Weddington complex, a member of the Concord Plutonic suite, underlie the Former CNAD area. Geophysical data suggest the complex forms a body extending for more than 15 miles east-west and ranging in thickness from 2.2 to 2.8 miles (Wilson 1981).

Based on the environmental investigations conducted at the site, the majority of the bedrock directly underlying the saprolite consists of a fractured, partially weathered rock that ranges in thickness from 0 to 5 ft. This zone of partially weathered bedrock, along with the overlying saprolite, is referred to as the transition zone.

Depth to competent bedrock within the Former CNAD site ranges from 4.5 to 31.0 ft below land surface. In the vicinity of the pilot study focus area, approximately 6 to 8 ft of overburden was removed during site grading and construction activities performed by Norfolk Southern in 1996 and 1997. The average depth to bedrock in this area is approximately 6 ft.

2.5.3 Hydrogeology

2.5.3.1 Groundwater

During the Phase II RI, aquifer testing demonstrated that the hydrogeology in the Former CNAD area represents a complex system of interconnected aquifers, corresponding to the hydrogeologic zones: shallow zone, transition zone, and bedrock zone. The shallow zone is characterized by the unconsolidated residuum and the saprolitic soils. The transition zone is identified as the zone of transition along the overburden/bedrock interface. This zone consists of partially weathered parent material and the upper fractured bedrock. The bedrock zone is characterized by the presence of water-bearing fractures within the competent granodiorite. The testing revealed interconnectivity between the zones and anisotropy with the transition zone and the bedrock zone. Testing also indicated that the shallow zone and the transition zone were hydraulically interconnected.

The groundwater hydraulics at the Former CNAD site are complex and have been altered during the performance of the RI/FS process by both on-site alteration of drainage patterns and off-site pumping. Data collected during the RI and supplemental investigations, as well as the pilot study, demonstrate the anisotropic nature of the formation. The groundwater flow direction is predominantly west but there is also a flow component to the south that appears to be associated with the fracture trace lineament.

The former Charlotte Naval Ammunition Depot is located above the groundwaters of the Catawba River Basin. Pursuant to North Carolina Administrative Code, 15 NCAC 02L.0302, the groundwaters of the Catawba River Basin would be determined to be Class GA (as defined in 15 NCAC 02L.0201) if the groundwater naturally contains 250 mg/l or less of chloride. Correspondence from the North Carolina Department of Environment and Natural Resources on September 22, 2010 verifies the classification and has been included as Appendix A of this document. There is no natural background level of TCE at this site and the practical quantitation limit for TCE is less than the standard set in 15 NCAC 02L.0202(g).

2.5.3.2 Surface Water

The Former CNAD site is bisected by a low-lying topographic ridge oriented northwest-southeast. The ridge is probably a result of a subsurface bedrock ridgeform of similar orientation. The apex of both the bedrock and surface ridges forms a line that separates ASIP Buildings II and III from ASIP Building IV. Stormwater runoff on the east side of the ridge flows to a marsh located northeast of Westinghouse Boulevard across from Box USA. The marsh occupies a low-lying area of limited areal extent and drains to the east toward Sugar Creek. Surface water drainage on the west side of the ridge collects in perennial tributaries of Steele Creek. The creek runs parallel to the west side of the area (Nevada Road) and drains towards the south.

2.5.4 Contaminant Nature and Extent

Based upon the analytical, chemical, and physical findings from the investigations conducted to date, the distribution of TCE in the groundwater can be separated into two distinct plumes based on the hydrogeologic zone (i.e., transition zone and bedrock zone).

Within the transition zone at the Former CNAD site, concentrations of TCE ranged from non-detect to 6,200 μg/L with the plume extending to a depth of ~42 ft bgs. Within the bedrock zone, concentrations of TCE ranged from 2.0 μg/L to 40,000 μg/L with the plume extending to a depth of 305 ft bgs.

At the conclusion of the 2002 supplemental investigation effort, a decision was made to focus the remedial action on areas that exhibit TCE concentrations greater than 500 μg/L. Groundwater modeling identified five separate plumes (hot spot areas) with TCE concentrations exceeding 500 μg/L within the transition zone (Figure 3). The following is a list of the individual hot spots along with their associated source (monitoring well with the maximum concentration).

- Hot Spot 1 – NAD MW-58,
- Hot Spot 2 – VERSAR 17,
- Hot Spot 3 – NAD MW-49,
- Hot Spot 4 – NAD MW-42, and
- Hot Spot 5 – NAD MW-25.

Unlike the transition zone, a single large TCE plume centered around SAIC-14 was observed for the bedrock zone (Figure 4).

At the Former CNAD site, the TCE was probably released slowly into the environment until processing activities at the facility were discontinued in the 1950s. Initially, TCE likely diffused downward through the porous matrix of the unsaturated zone of the shallow aquifer. Product-phase TCE would then have diffused into the fracture system displacing groundwater as it moved and increased in size as it interacted with the groundwater in the bedrock.

The results of the Phase I and II RIs and the supplemental investigations support this scenario and indicated that from its point source, the migration of TCE was initially influenced by the hydraulic gradient and top of bedrock topography, with the TCE plume initially moving southwesterly and then moving northeasterly following the bedrock topography and anisotropy. However, the results of the supplemental investigations seem to indicate that the vertical migration of TCE through the bedrock was enhanced by an increase in the hydraulic gradient that was artificially induced by the three production wells located at Plant #1.

2.5.5 Conceptual Site Model

The purpose of the CSM is to provide a basic understanding of potential sources, pathways, and possible receptors based upon available site information.

2.5.5.1 Potential Sources

During the investigation process employed at the Former CNAD site, no remaining source of the TCE was identified. However, the significant concentrations of TCE in the groundwater near wells NAD MW-21 and SAIC-14 indicate this area was most likely the initial entry location.

2.5.5.2 Potential Exposure Pathways

Potential exposure pathways were evaluated as part of the human health BRA for soil and sediment, groundwater, and surface water. Since the entire site vicinity is zoned industrial and no residences are located within 0.5 miles, an industrial scenario was considered for all current and future exposure pathways. It should be noted that land use designations do not apply to the site as groundwater has been identified as the only media of concern. The chemical-specific ARAR for the site is the North Carolina Groundwater Quality Standards (NCGQS) and the remedy implemented will ultimately lead to unrestricted use of the property. This issue is discussed further in section 2.7.5.

Soil and Sediment

Soil and sediment contact could occur through direct exposure, plant uptake, and animal exposure. No agricultural use or animal subsistence was identified at the site. Direct contact could occur although it is unlikely. In the absence of contamination, exposure pathways for soil and sediment were not quantified.

Groundwater

As noted previously, no residential water supply wells were identified within 1 mile of the site and no potable water wells were identified on-site. Given public water supply in the area, current exposure to groundwater via potable use (i.e., drinking water and other domestic use) is not currently considered a complete pathway. However, it is possible that an undocumented well could exist outside the Former CNAD site (as was the case for the Plant #1 wells). Therefore, to be conservative, future exposure to groundwater (i.e., industrial/commercial use) is considered to be a complete pathway.

An inspection of buildings within CNAD Areas 1 and 2 conducted during the Phase II RI revealed slab construction. In the absence of basements, subsurface vapor accumulation due to groundwater migration was considered not to be a complete pathway.

Surface Water

Surface water in the site area consists of small man-made drainage ditches. These features are non-navigable and unsuitable for recreational purposes. Surface water is similarly not used for potable purposes. No agricultural irrigation is conducted and animal subsistence is not known to exist at the site. Surface water pathways under current and future site uses are considered to be incomplete.

2.5.6 Contaminant Fate and Transport

Based on the site characteristics described above and the results of the pilot study, fate and transport modeling was undertaken to assess whether monitored natural attenuation (MNA) is an appropriate remedy for the dissolved-phase groundwater plume at the site and to support the development of additional, viable remedial alternatives for the site. The fate and transport model used for this effort was AT123D. The fate and transport modeling was conducted for two discrete scenarios which include no action and MNA. As with all models, assumptions used create uncertainty. Uncertainties associated with the fate and transport modeling included the use of literature values for K_d, projected organic concentrations, and assumption of uniform flow conditions and homogenous geology.

For the no action/MNA scenarios, the results of the fate and transport modeling indicated that the concentrations of TCE would decrease to the NCAC 2L standard of 2.8 μg/L through natural attenuation in 47 years for the transition zone and in 63 years for the bedrock zone. The modeling results also indicated that the maximum migration distance for the TCE plume boundary exceeding the NCAL 2L standard would be limited to 400 m (~1,312 ft) from the point of maximum concentration(s) for both the transition and bedrock zones.

Fate and transport modeling was also performed based on residual contamination that would be left in the aquifers after implementation of an active treatment (e.g., sodium lactate injection to the core of the plume bounded by 500 μg/L). Results of the modeling indicated that the concentrations of TCE would decrease to the NCAC 2L standard of 2.8 μg/L through natural attenuation in 14 years for the transition zone and in 12 years for the bedrock zone after completion of the sodium lactate injection to the core of the plume. Modeling results also indicated that the TCE concentration in the groundwater is not expected to exceed its NCAC 2L standard (2.8 μg/L) beyond 400 m (~1,312 ft) downgradient from the existing source(s) in each of the five transition zone plumes or the bedrock plume.

Modeling predicted the time required to reduce the maximum TCE plume concentrations to below 500 μg/L in both the transition and bedrock zones to be approximately six and 12 months, respectively.

2.6 Current and Potential Future Land and Resource Use

The current on-site and adjacent land use is industrial. No change in industrial use is anticipated given the operating history for the last 50 years.

Currently, there is no known use of groundwater on-site or in the vicinity. City-supplied water exists throughout the area which is provided by the Charlotte Mecklenburg Utility District. Therefore, current exposure to groundwater via potable use is not considered a complete pathway. Potential beneficial use of the groundwater for industrial purposes was assumed for future exposure. Surface water is not currently used and was not assumed to be used for future scenarios.

2.7 Summary of Site Risks

The human health BRA compared surface soil, groundwater, surface water, and sediment data against screening criteria including risk-based concentrations (RBCs) developed by USEPA Region III for soil and sediment; Federal drinking water standards and North Carolina groundwater quality standards for groundwater; and North Carolina Surface Water Standards (15A NAC B.0200) and federal standards for surface water to identify chemicals of potential concern (COPCs). Constituents below screening values were eliminated from further consideration. Those constituents that were above the screening values were determined to represent a risk to human health based on the pathway analysis were retained as COCs.

2.7.1 Sediment

No COPCs were identified in sediment using conservative, risk-based screening values; therefore, no complete exposure pathway exists. Since no COPCs were identified, no COCs were determined and no risk assessment for sediment was completed. Consequently, sediment was not evaluated in the FFS.

2.7.2 Surface Soil

No COPCs were identified in surface soil using conservative, risk-based screening values; therefore, no complete exposure pathway exists. Since no COPCs were identified, no COCs were determined and no risk assessment for surface soil was completed. Consequently, surface soil was not evaluated in the FFS.

2.7.3 Subsurface Soil

No COPCs were identified in the subsurface soil using conservative, risk-based screening values; therefore, no complete exposure pathway exists. Since no COPCs were identified, no COCs were determined and no risk assessment for subsurface soil was completed. Consequently, subsurface soil was not evaluated in the FFS.

2.7.4 Surface Water

Surface water in the site area consists of small man-made drainage ditches. These features are non-navigable and unsuitable for recreational purposes. Like groundwater, surface water is not used for potable purposes. No agricultural irrigation is conducted and animal subsistence is not known. Surface water pathways under current and future site use are considered to be incomplete. Therefore, no COCs were determined and no risk assessment for surface water was completed. Consequently, surface water was not evaluated in the FFS.

2.7.5 Groundwater

Several COPCs were identified from the Phase I, Phase II, and supplemental sampling results. Although groundwater is not used currently as a source of potable water in this area, based on their prevalence in the groundwater at high concentrations, the following COPCs were considered COCs in groundwater for potential future exposure:

cis-1,2-dichloroethylene	1,1,2-trichloroethane;2-butanone
1,1-dichloroethylene	tetrachloroethylene
1,2-dichloroethane	TCE
1,2 dichloropropane	vinyl chloride

Since COCs were identified, a human health BRA was completed for the site. The BRA calculated carcinogenic risks and non-carcinogenic hazard indexes (HI) based on a reasonable maximum potential exposure.

Hypothetical future groundwater ingestion by an industrial worker was considered the only completed pathway. The BRA determined the risk for groundwater ingestion was approximately 4.2×10^{-4}, and exceeded the acceptable range for remediation of Superfund sites (1×10^{-6} to 1×10^{-4}). The BRA also concluded the HI exceeded a target of 1 (at 2.6).

The BRA established that an unacceptable risk to human health existed at the site due to ingestion of TCE in the groundwater. During the remedial investigation, the State of North Carolina proposed 15 NCAC 02L.0202 as an ARAR for the remedial action. The USACE concurred that the acceptable contaminant levels promulgated in that environmental statute are applicable to this cleanup. This ARAR sets the remedial goal for cleaning up the groundwater at this site.

2.7.6 Ecological Risk Assessment

An ecological risk assessment conducted during the Phase I of the RI indicated no COPCs were identified for the sediment, surface soil, or surface water and concluded no unacceptable risks were present for ecological receptors.

2.8 Remedial Action Objectives (RAOs)

The RAOs established in the FFS for the CNAD Site include:

- Actively remediate the groundwater where the TCE concentrations exceed 500 μg/L.
- After active remediation, monitor residual groundwater contamination to track contaminant levels as they naturally attenuate to achieve the NCAC 2L groundwater quality standard of 2.8 μg/L. The monitoring program will verify that TCE levels are declining.
- Restoring the aquifer to North Carolina groundwater quality standards within a reasonable time frame.

2.9 Description of Alternatives

The remedial action alternatives developed in the FFS were based on the data available from the Phase I and II RIs, the supplemental investigations, the sodium lactate injection pilot study results, and the results of fate and transport modeling. The remedial action alternatives developed for the Former CNAD site are shown below and presented in the following sections.

- Alternative 1 – No Action
- Alternative 2 – Monitored Natural Attenuation
- Alternative 3 – Enhanced Bioremediation Using Sodium Lactate Injection

2.9.1 Alternative 1 – No Action

The no action alternative is considered in accordance with CERCLA and NCP requirements for comparison with other alternatives. Under this alternative, no remedial action would be implemented at the Former CNAD site to reduce contaminant concentrations in the contaminant plume to return the impaired groundwater to beneficial use. Access to contaminated groundwater would be unrestricted, allowing exposure to contaminated media, and no monitoring of groundwater would be performed.

The no action alternative does not protect human health or the environment, or maintain or monitor site conditions. The no action alternative would not meet the RAO to achieve the NCAC 2L criteria for TCE in groundwater. Although the no action alternative would be the lowest cost and the easiest to implement, unacceptable risk from exposure to contaminated groundwater may be realized if the site were available for uncontrolled use. However, consideration of the no action alternative is required by NCP as a baseline for comparison.

2.9.2 Alternative 2 – Monitored Natural Attenuation

Alternative 2 would include MNA and the implementation of institutional controls, such as property owner notification. Groundwater monitoring would be included as an institutional action to evaluate whether MNA was decreasing the TCE contamination as predicted.

Modeling has indicated that TCE in the transition zone groundwater would naturally attenuate to the NCAC 2L standards within 47 years; whereas, in the bedrock zone groundwater, it would take approximately 63 years. Therefore, the transition zone groundwater would be monitored for 47 years and the bedrock zone groundwater would be monitored for 63 years or until such time as the transition zone and bedrock zone groundwater at the site meets the NCAC 2L standards. Groundwater would be analyzed for COCs (VOCs) and natural attenuation parameters [anions (chloride, fluoride, bromide, sulfate, nitrite, and nitrate), alkalinity, sulfide, methane, phosphates, carbon dioxide, total organic carbon, and iron].

MNA can be effective in achieving the remedial goals, particularly if naturally occurring biodegradation is already taking place. At the Former CNAD site, conditions in the aquifer are anaerobic and therefore, favorable for intrinsic reductive dechlorination of the TCE. Conditions are also favorable for the intrinsic remediation of TCE daughter products.

2.9.3 Alternative 3 – Enhanced Bioremediation Using Sodium Lactate Injection

Alternative 3 would use a combination of enhanced bioremediation and MNA to achieve the remedial goals in groundwater at the Former CNAD site. The plume area with contamination greater than 500 μg/L will be treated using sodium lactate injection. The residual contamination within the treatment areas and the contamination located outside of the radius of influence of the horizontal injection wells will attenuate naturally following the treatment period. Contamination levels would be monitored to ensure natural attenuation of contamination to below remedial levels. Modeling predicted that natural attenuation would degrade contaminants in approximately 14 years in the transition zone and 12 years in the bedrock zone following the completion of the sodium lactate injection program.

Based on the results from the pilot study, this alternative would include four injection events in the transition zone using a network of 54 injection wells to reduce the TCE concentrations to below 500 μg/L. Seven injection events were estimated for the bedrock zone using a network of 31 wells to reduce the TCE concentrations to below 500 μg/L. The enhanced bioremediation systems will be monitored through a network of monitoring and injection wells to evaluate the operating conditions of the system (Figures 5 and 6, respectively). In addition, groundwater monitoring is included as an institutional control to maintain protectiveness.

The monitoring program would include a baseline sampling event at the start of the implementation of the alternative and sampling event before each injection event. Groundwater samples would be collected from all 85 injection wells, 11 existing and 4 new transition zone monitoring wells, and 10 existing and 5 new bedrock monitoring wells every 2 months for a 6-month period for 4 events. Following active treatment, the groundwater monitoring program would include groundwater sampling from the aforementioned 30 monitoring wells quarterly for the first 12 quarters (3 years), semi-annual for four events (2 years), and annual sampling beyond the first 5 years. The groundwater samples would be analyzed for COCs (VOCs) and natural attenuation parameters [anions (chloride, fluoride, bromide, sulfate, nitrite, and nitrate), alkalinity, sulfide, methane, phosphates, carbon dioxide, total organic carbon, and iron].

2.10 Comparative Analysis of Alternatives

This section provides a brief comparative analysis of the alternatives with respect to the nine CERCLA assessment criteria. The preferred alternative is identified from this evaluation. The comparative analysis identifies the advantages and disadvantages of the alternatives relative to each other. Each of the nine criteria is discussed below.

2.10.1 Overall Protection of Human Health and the Environment

Each alternative's ability to protect human health and the environment is assessed along with its ability to comply with the project-specific RAOs.

The action alternatives evaluated would provide adequate protection of human health and the environment by eliminating, reducing, or controlling risk through treatment, engineering controls, and/or institutional controls.

The action alternatives would achieve the RAO to reduce TCE contamination below the NCAC 2L standard. The inclusion of Alternative 2 assumes that MNA is occurring and that it will be demonstrated through monitoring that TCE is being degraded naturally in the groundwater. The primary distinction between the alternatives with respect to attainment of this RAO is the time required; Alternative 3 would achieve this RAO in 14 years whereas Alternative 2 would achieve this RAO in 63 years. All action alternatives would reduce both the mass and volume of contamination, while also largely preventing the migration of the contamination exceeding the NCAC 2L (2.8 μg/L) groundwater standards outside the property boundary.

Under the No Action alternative, no restoration of the aquifer would be attempted, no institutional controls would be put in place, and no monitoring would be performed. Therefore, the No Action alternative would not be protective of human health and the environment.

2.10.2 Compliance with Applicable or Relevant and Appropriate Requirements

Each alternative is assessed to address compliance with Federal and state environmental requirements that are legally applicable or relevant and appropriate.

Alternatives 2 and 3 are aimed at reducing the high concentrations of TCE until ARAR standards, criteria and limitations are met. Alternative 3 is an active remediation approach expected to be in compliance within 14 years for the transition zone and 12 years for the bedrock zone. Alternative 2 is a passive treatment approach expected to be in compliance with the primary chemical-specific ARARs for the target area within approximately 47 years in the transition zone and 63 years in the bedrock zone. The primary differences in achieving ARARs among Alternatives 2 and 3 are based on the type of the action and the time that each alternative would take to achieve the remedial levels. Again, this evaluation assumes that MNA can be demonstrated under Alternative 2.

The No Action alternative will not address contaminants that exceed the NCAC 2L standards. Since no action is taken, there is no way to determine if compliance is demonstrated. Therefore, the No Action alternative does not comply with the primary chemical-specific ARAR for the site.

2.10.3 Long-Term Effectiveness and Permanence

Each alternative is assessed to determine its ability to achieve overall reduction in risk to human health and the environment and to provide sufficient long-term controls and reliability.

Long-term effectiveness and permanence would be increased in Alternatives 2 and 3 through the establishment of institutional controls both on- and off-site and a measured reduction in risk with time. Alternative 3 would use both active and passive treatment of contaminants in groundwater to achieve RAOs within 14 years in the transition zone and 12 years in the bedrock zone after injection. Alternative 2 would use passive technologies and institutional controls to reduce the risk over a period of approximately 63 years.

Alternative 1, no action, would have no definable long-term effectiveness or permanence because reduction of the risk to human health and the environment could not be demonstrated. Contaminants would remain in the groundwater, and no institutional controls would be implemented to control exposure from the potential use of groundwater for drinking water or irrigation.

2.10.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Each alternative is assessed to determine the extent to which it can effectively and permanently fix, transform, or reduce the volume of waste material and contaminated media.

Alternative 3 would reduce the toxicity and volume of contaminants through an active treatment program. Alternative 1, No Action, and Alternative 2, MNA, would provide the lowest degree of reduction of toxicity and volume because no treatment would be implemented. Alternatives 1 and 2 would have essentially the same reduction in toxicity and volume; however, Alternative 2 would utilize groundwater monitoring to confirm the reduction of toxicity and volume over the long treatment period. Alternative 1 would provide no testing, and therefore could not demonstrate any reduction.

None of the alternatives would reduce the mobility of the contaminants in groundwater.

2.10.5 Short-Term Effectiveness

Each alternative is assessed to determine the extent to which it effects human health and the environment during construction and implementation of the remedial action.

Alternative 1 requires no time to implement. Alternative 2 requires minimal time to implement (approximately 1 month) to install additional monitoring wells and sample. As a result, alternative 1 (No Action) and alternative 2 (MNA) would have a high level of short-term effectiveness because no action would be implemented. There would be no possibility of exposure of workers, the community, or the environment under Alternative 1 and minimal potential exposure to workers during well installation and sampling under Alternative 2.

Alternative 3 includes the installation of injection and monitoring wells and bi-monthly injections for six months in the transition zone and 12 months in the bedrock zone. As a result, Alternative 3 requires approximately 12 months to implement and would have the highest potential short-term exposure during the installation of additional monitoring and injection wells; as well as the injection process and sampling activities.

2.10.6 Implementability

Each alternative is assessed to evaluate the technical and administrative factors affecting implementation of the remedial action.

All the alternatives are implementable, with Alternative 1 having the highest implementability because no action would be taken. Materials, equipment, and labor are available for implementing the remaining alternatives. Alternatives 2 and 3 are proven technologies for the treatment of VOCs in groundwater; therefore, site-specific conditions and the implementation of institutional controls required would have the most impact on the implementability of these two alternatives.

The implementation of Alternatives 2 and 3 would require standard construction technology; therefore, their construction implementability, presented in decreasing order, varies based on the level of construction. Alternative 2 is considered more easily implementable than Alternative 3 because it would only require the installation of monitoring wells and establishment of a groundwater sampling and reporting program; whereas, Alternative 3 would require installation of 85 injection and nine monitoring wells, and bi-monthly injections for six months (for a total of four injections) in the transition zone and 12 months (for a total of seven injections) in the bedrock zone.

2.10.7 Cost

A comparison is made of the cost estimates developed to support the detailed analysis based on feasibility-level scoping. Alternative 1 would have no costs because no action would be taken. Alternative 2, MNA with institutional controls, would have a cost of $6,563,242 while Alternative 3, enhanced bioremediation using sodium lactate injection with MNA, would have the highest costs at $7,124,076.

2.10.8 State Acceptance

The criterion addresses the state’s acceptance of the selected alternative.

The NCDENR agrees with the selected remedy.

2.10.9 Community Acceptance

The criterion addresses the state’s acceptance of the selected alternative.

Comments and questions received from the community regarding the selected remedy is presented in the Responsiveness Summary section of this DD.

2.11 Principal Threat Waste

TCE can be considered a principal threat waste. The reasons for this classification is the highly toxic nature of the compound, a high potential for migration within the groundwater system, and the health risks associated with exposure. Though the health risks currently are considered low, the potential for contaminant migration to areas on or off site cannot be eliminated.

2.12 Selected Remedy

2.12.1 Summary of Rationale for the Selected Remedy

The preferred alternative for achieving the RAO at the CNAD site is Alternative 3, Enhanced Bioremediation using Sodium Lactate Injection. This alternative was selected for several reasons. In particular:

- This alternative was selected because it will achieve the RAO in a reasonable amount of time.
- This remedial technology was proven to be successful in reducing the TCE concentration effectively, as demonstrated during the pilot study.
- This alternative provides the highest overall protection of human health and the environment by reducing the TCE concentrations in groundwater to below the NCAC 2L groundwater quality standard of 2.8 μg/L (for TCE) in the shortest amount of time.

2.12.2 Description of the Selected Remedy

The major components of the remedy include:

- Installation of 85 injection wells (54 transition and 31 bedrock) and nine monitoring wells.
- Sodium lactate solution injection events (four) into transition zone wells every two months over a six-month period.
- Sodium lactate solution injection events (seven) into bedrock zone wells every two months over a 12-month.
- Groundwater monitoring activities for the duration of project.

The plume area with contamination greater than 500 μg/L will be treated using sodium lactate injection. The residual contamination within the treatment areas and the contamination located outside of the radius of influence of the horizontal injection wells will attenuate naturally following the treatment period. Contamination levels would be monitored to ensure natural attenuation of contamination to below remedial levels. Modeling predicted that natural attenuation would degrade contaminants in approximately 14 years in the transition zone and 12 years in the bedrock zone following the completion of the sodium lactate injection program. Throughout implementation of the remedial action, monitoring would be conducted through a network of monitoring and injection wells to evaluate the operating conditions of the system (Figures 5 and 6).

2.12.3 Summary of the Estimated Remedy Costs

A quick summary of estimated remedy costs are provided below. A detailed cost estimate (from the FFS) is provided in Appendix A. The data in the cost estimate is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. Major changes may be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Difference, or a DD amendment. This order of magnitude engineering cost estimate is expected to be within +50 to -30 percent of the actual project cost.

Estimated Capital Cost: $4,555,321
Estimated O&M Cost: $2,568,755
Estimated Present Worth Cost: $7,124,076
Estimated Time to Achieve RAOs: 10 years

2.12.4 Expected Outcomes of the Selected Remedy

Available use of the groundwater upon achieving cleanup levels is anticipated to be unrestricted use. The estimated time to achieve unrestricted use is approximately 14 years after implementation of the remedial action.

Although several chlorinated VOCs were identified as COCs, TCE was detected at higher concentrations than the other constituents and has been selected as the model compound for the remedial action. The remediation goal (RG) for groundwater is 2.8 ug/L for TCE. The basis for the RG is compliance with the chemical-specific ARAR for groundwater, the North Carolina groundwater quality standards (15A NCAC 02L.0202). The RG is protective at the 10^{-6} excess cancer risk level for TCE.

2.13 Statutory Determinations

2.13.1 Overall Protection of Human Health and the Environment

Alternative 3 would be protective of human health and the environment. Potential exposure to contaminated groundwater would be addressed by reducing TCE concentrations to below the NC groundwater quality standards through bioremediation and monitored natural attenuation. It is anticipated that administrative controls could be instituted to control potential exposure while the remedial program is implemented.

The selected remedy will not pose unacceptable short term risks during installation of the injection wells, as procedures and precautions would be implemented to minimize worker exposure to contaminants. In addition, workers would be trained in hazardous waste operations as mandated by 29 *CFR* 1910.120.

2.13.2 Compliance with Applicable Relevant and Appropriate Requirements (ARARs)

Evaluation against the threshold criteria for the chemical-, action-, and location-specific ARARs is provided in this section.

The chemical-specific ARAR for the site is the North Carolina groundwater quality standards (15A NCAC 02L.0202). The selected remedy implements bioremediation with injection of sodium lactate to treat the elevated levels of chlorinated VOCs in the groundwater. MNA will be implemented to address the residual plume following shutdown of the treatment operations. Therefore, the selected remedy will ultimately attain the chemical-specific ARAR.

There are no action-specific or location-specific ARARs for the selected remedy. Although an ARAR doesn't exist for underground injection, the State of North Carolina regulates the injection of materials through the Underground Injection Control Program. Sodium lactate is an approved injectant in the program for the purposes of in-situ remediation.

2.13.3 Cost Effectiveness

The cost effectiveness of a remedial alternative is determined by evaluating the following three of the five balancing NCP criteria used in the detailed analysis of alternatives: 1. Long-term effectiveness and permanence; 2. Reduction in toxicity, mobility, and volume through treatment; and 3. Short-term effectiveness.

The selected remedy, Alternative 3 (Enhanced Bioremediation Using Sodium Lactate Injection), provides long-term effectiveness and permanence through treatment and the establishment of institutional controls. This alternative implements both active and passive treatment of contaminants in groundwater to achieve RAOs within 14 years in the transition zone and 12 years in the bedrock zone after injection. Contaminant toxicity and volume are reduced through an active treatment program.

Implementation has some potential short-term exposure during the installation of additional monitoring and injection wells and during the injection process and sampling activities. However, these risks would be addressed by limiting exposure through access controls and the implementation of health and safety procedures/controls for workers on site as stipulated by Occupational Safety and Health Administration.

The cost for the selected remedy is $7,124,076 and is considered cost effective since it provides protection of human health and environment in a short time and is only slightly more expensive than the other treatment alternative considered.

2.13.4 Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the site. In comparison to the other alternatives evaluated, the selected remedy provides the best balance with respect to the NCP criteria. The selected remedy provides the greatest long-term effectiveness and satisfies the preference for treatment. The selected remedy is protective of human health and environment, attains ARARs, and is the most cost-effective of the alternatives considered.

2.13.5 Preference for Treatment as a Principal Element

The selected remedy implements enhanced bioremediation with sodium lactate injection to treat TCE contamination in the groundwater and satisfy the statutory preference for treatment.

2.13.6 Five-Year Review Requirements

The selected remedy will not result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, but it will take more than five years to attain remedial action objectives and cleanup levels. Therefore, five-year reviews will be conducted in five-year intervals after remedy construction completion to ensure the remedy is, or will be, protective of human health and the environment.

2.14 Documentation of Significant Changes

The Proposed plan for the CNAD site was released for public comment in September 2009. The Proposed plan identified Alternative 3, enhanced bioremediation with sodium lactate solution injection, as the preferred alternative. USACE reviewed all written and verbal comments submitted during the public comment period. It was determined that no significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

3.0 PART 3 – RESPONSIVENESS SUMMARY

Response to CNAD Proposed Plan Questions at the Public Meeting

1. When will the sodium lactate injections start?

Response: No set date is defined in the document.

2. Will construction associated with the remedial alternative inhibit customers driving around or operations at the site? (Pg. 20, Paragraph 6)

Response: Our proposal, as it is now, we don’t propose to close any roads or anything like that.

3. How many injection events are planned as part of the remedial action? (Pg. 25, Paragraph 3)

Response: For the transition zone, we’re looking at four injections over a six-month period, and the bedrock wells, we’re looking at seven injections over a 12-month period.

4. What quantity of sodium lactate will be injected? (Pg. 26, Paragraph 6)

Response: From what I recall in the pilot studies that were conducted for the site, really, you’re talking minor, minor injections, as far as volume-wise. I’d have to look at the feasibility study to tell you exactly what, but that information is in there, as far as the pilot study and talks about extrapolating from the pilot study.

5. Will there be any injection/treatment in the area of the production wells on Frito-Lay property? (Pg. 28, Paragraph 3)

Response: There will not be any injection that takes place in those wells that are on Frito-Lay’s property, but the remedy or the remedial action will address the contaminants in the groundwater throughout the site.

6. Would the groundwater be useable after the remedial action? (Pg. 28, Paragraph 6)

Response: One the remedy is conducted, the goal is to clean the groundwater to North Carolina Groundwater Quality Standards. It would probably be this 14-year time frame before you even see something on the periphery.

7. Can the process water from Frito-Lay be used to recharge the groundwater to aid in the remediation? (Pg. 33, Paragraph 5)

Response: Probably discharging to a surface water would be a better option. I mean, I understand. I think the idea of trying to get beneficial reuse or something of the water is good, but discharging to a surface water would prevent it from impacting the contaminated groundwater plume. I don’t think that you really want to try doing that.

8. Will there be any posting of signs to inform people of the remediation project underway? (Pg. 41, Paragraph 5)

Response: We're not going to put any signs up.

Response to CNAD Proposed Plan Questions Received Following the Public Meeting

Comments from EASTGROUP Properties

General Comment: As an owner of a parcel in the area, we are concerned regarding the Proposed Plan's lack of identification of where the proposed 85 different injection wells will be located.

Response: The final location of the 85 injection wells will be determined during the remedial design phase of the project. The US Army Corps of Engineers (USACE) will be working with property owners to keep them informed as the remedial process moves forward, and especially during the definition of design parameters in order to minimize impacts to site operations and use.

1 We would need adequate notice prior to entry on the grounds by the USACE or its contractors so as not to disturb our tenants' businesses. A mutually agreeable access agreement could discuss controls to prevent nuisance and interference for work conducted pursuant to the Proposed Plan.

Response: The USACE concurs that an access agreement that addresses property owner needs will be a key element of the remedial design and implementation package. As mentioned in the response to Comment 1, the USACE plans to work with property owners as this project moves forward. Prior to conducting any work on private property, the USACE acquires an access agreement termed "Right of Entry". This document will be required to be signed by the property owner and the USACE. The right of entry form stipulates the terms and conditions of the agreement.

2 As part of any access agreement, we would require adequate proof of liability insurance prior to any entry on the property.

Response: Insurance requirements are standard for all USACE contracts, and especially for remedial action projects. The USACE will provide proof of insurance for our contractors.

3 As previously mentioned, we would like to know precisely where the proposed 85 injections wells (as specified in Alternative 3, which was recommended) are planning to be located. Also, should the enhanced bioremediation using sodium lactate injections as proposed under Alternative 3 not produce the intended results, what will be done to the wells, and how will other remedial alternatives be explored at that point?

Response: As noted in the response to Comment 1, the actual location of remedial action components will be defined during the remedial design stage of the project and will be shared with property owners to limit potential impacts. Should the proposed remedial action not produce the intended results, the USACE will re-evaluate the remedial action and determine if a change is required. If a change is required, other remedial alternatives will be considered and a revised proposed plan and public comment period may be required. In addition, an amendment to the record of decision may be required, which would necessitate additional coordination with USACE Headquarters. It should be noted that the USACE will again work with property owners to minimize impacts from any changes in the remedial approach.

4 We would also ask to see copies of the results that the USACE receives or produces regarding the ongoing testing if possible.

Response: As mentioned, the USACE will be working with property owners to keep them informed as the program moves forward. This will include providing updates on test results as appropriate.

5 We would like to review a schedule of anticipated on-site work dates to evaluate the impact on our tenants, and plan for any intrusions which could disrupt their businesses.

Response: As mentioned, the USACE will be working with property owners to keep them informed as the program moves forward. This will include schedules and field activities to allow for proper planning to minimal impacts on the property owners.

4.0 PART 4 – REFERENCES

M&E (Metcalf and Eddy, Inc.) 1995. *Phase I Remedial Investigation Final Report for the Former Naval Ammunition Depot Areas 1 and 2, Mecklenburg County, Charlotte, North Carolina*, April.

M&E 2000. *Final Phase II Remedial Investigation Report for the Former Naval Ammunition Depot Areas 1 and 2, Mecklenburg County, Charlotte, North Carolina*, October.

SAIC 2008. *Site-Wide Ground water Sampling Report for the Future Remedial Design at the Former Naval Ammunition Depot (NAD), Mecklenburg County, Charlotte, North Carolina*, April.

TPMC 2009. *Focused Feasibility Study for the Former Charlotte Naval Ammunition Depot, Mecklenburg County, Charlotte, North Carolina, February 2009.*

FIGURES

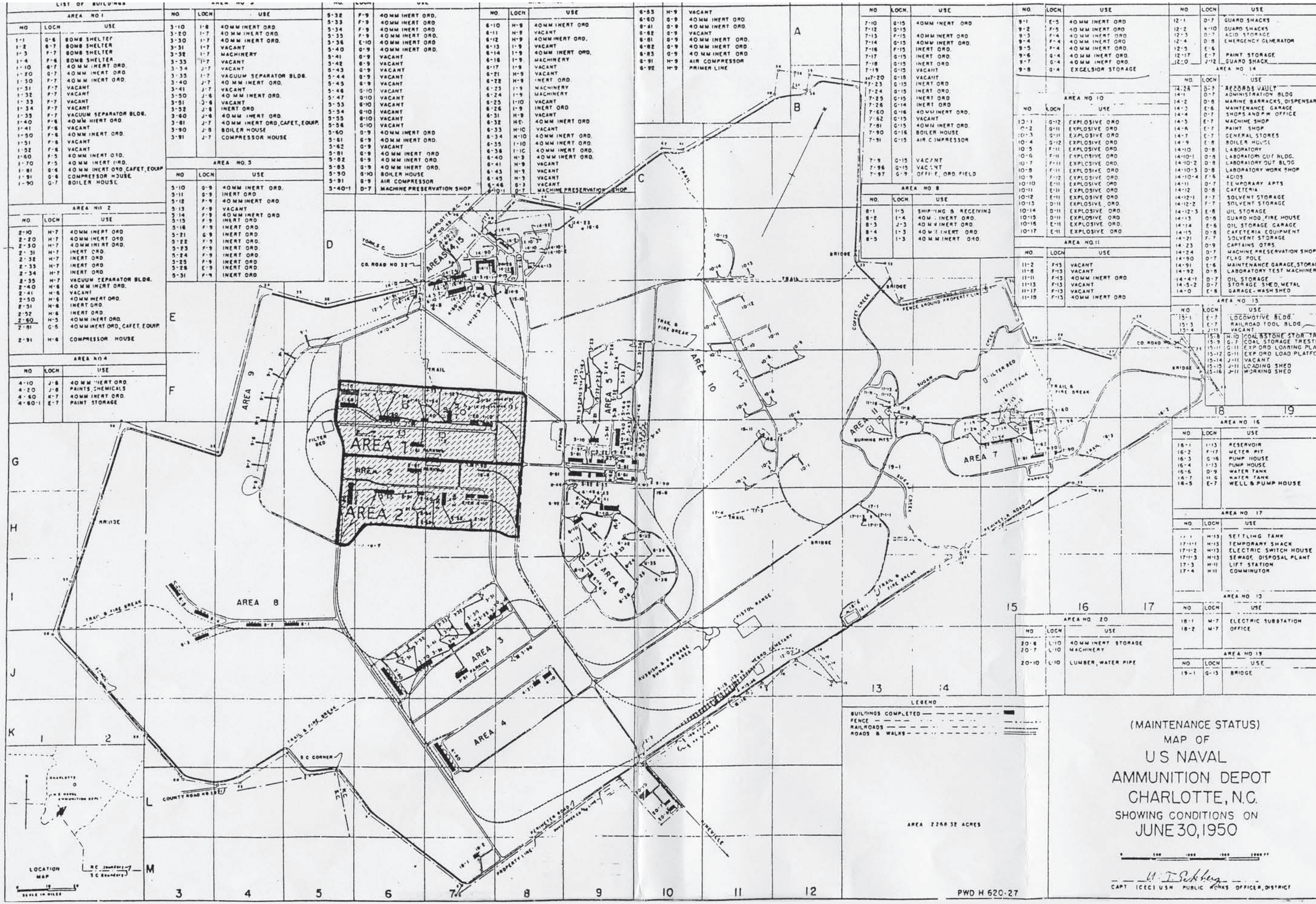

Figure 1. U.S. Naval Ammunition Depot Complex, June 30, 1950

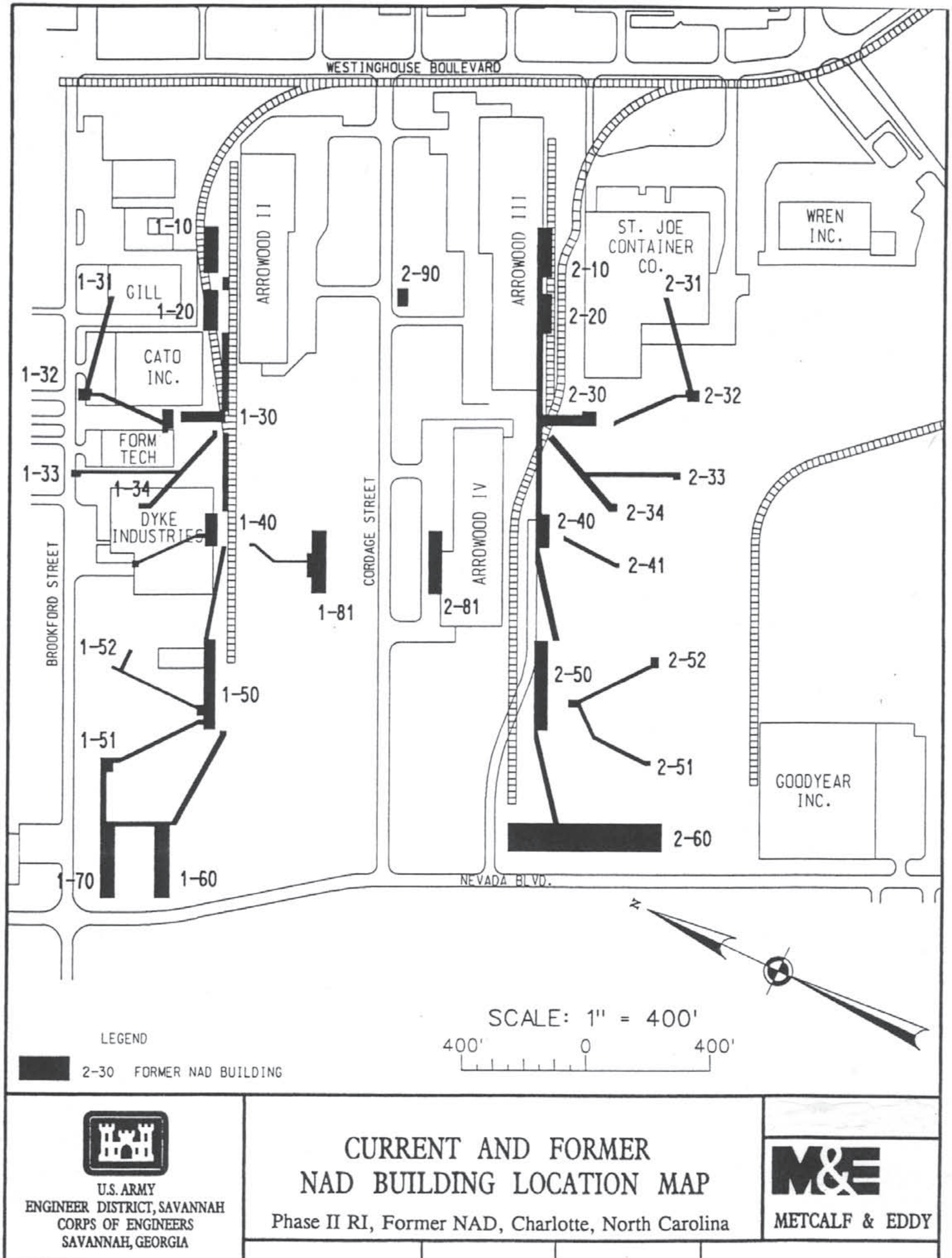

Figure 2. Current and Former NAD Buildings Location Map
(Source: Phase II RI, M&E 2000)

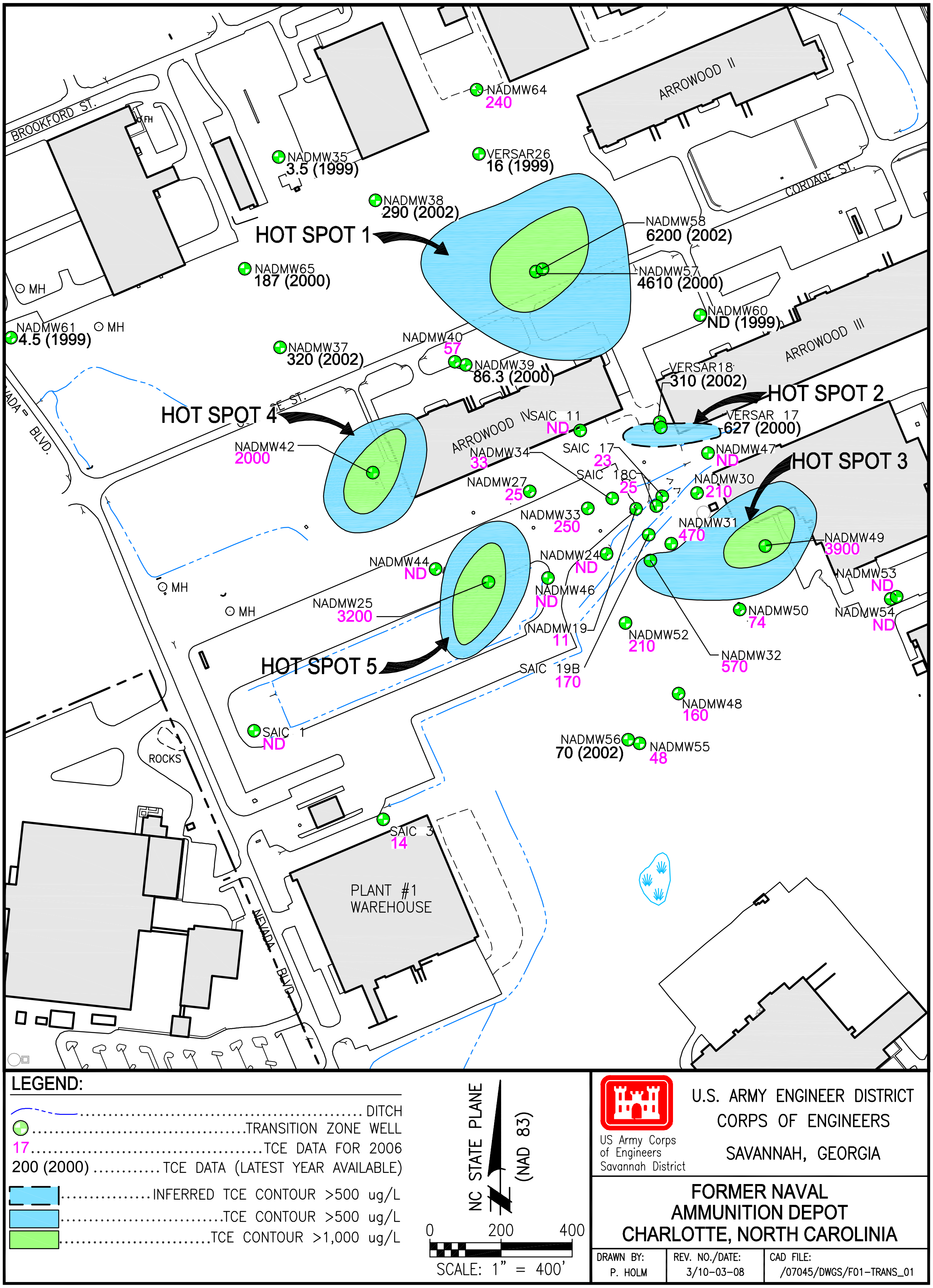

Figure 3. TCE Concentrations in the Transition Zone

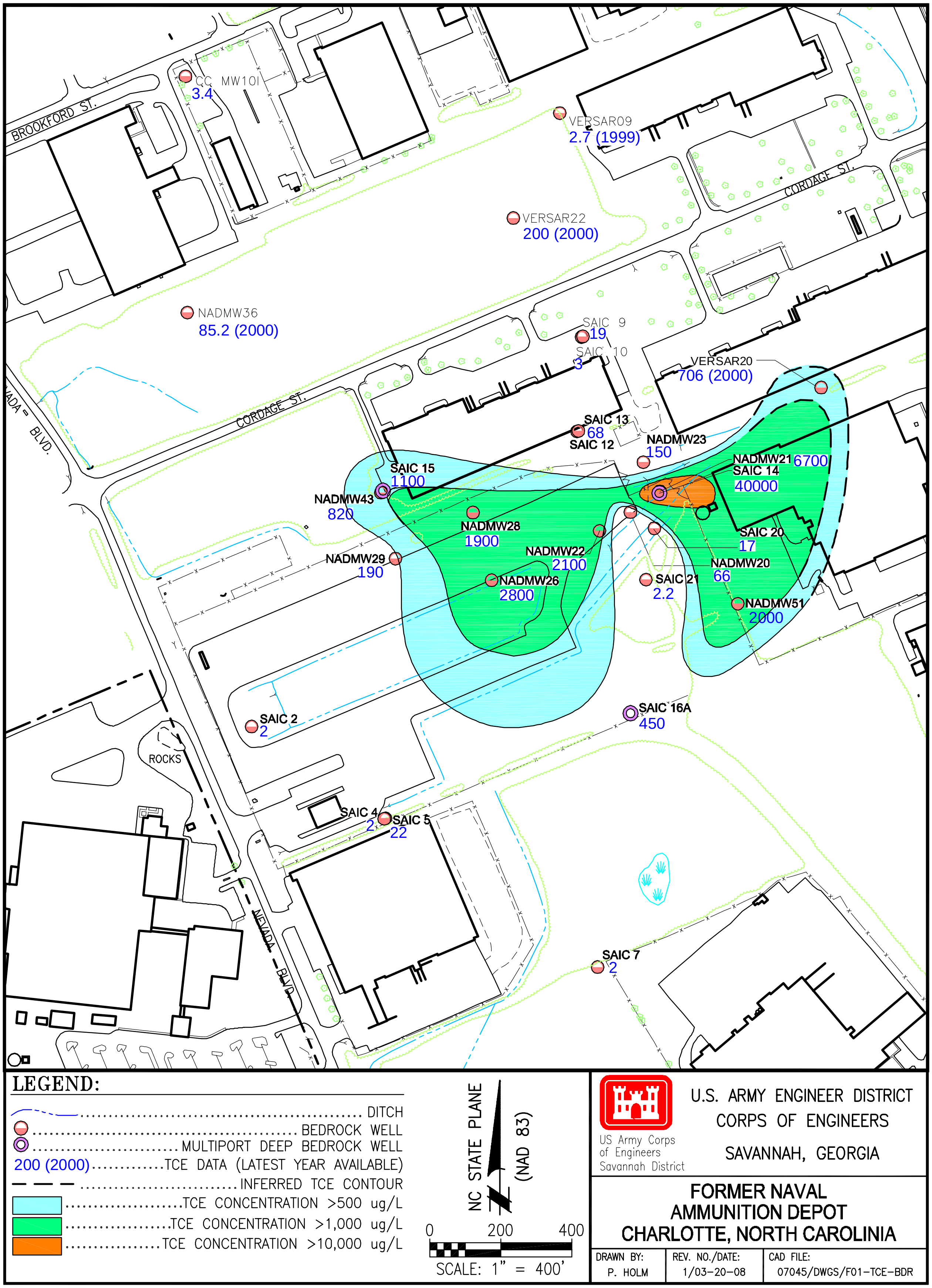

Figure 4. TCE Concentrations in the Bedrock Zone

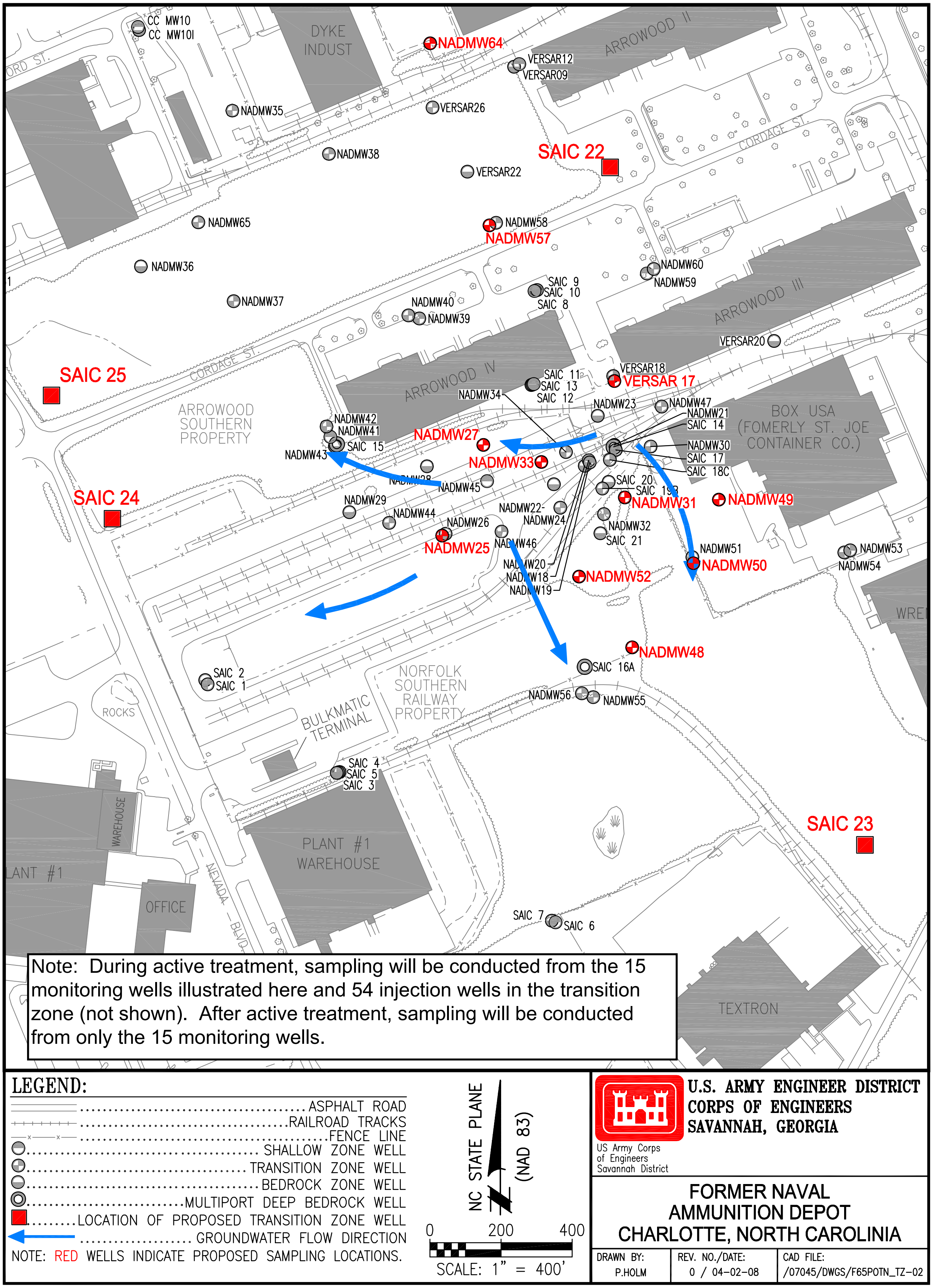

Figure 5. Location of Proposed Monitoring Wells and Sampling Locations for the Transition Zone

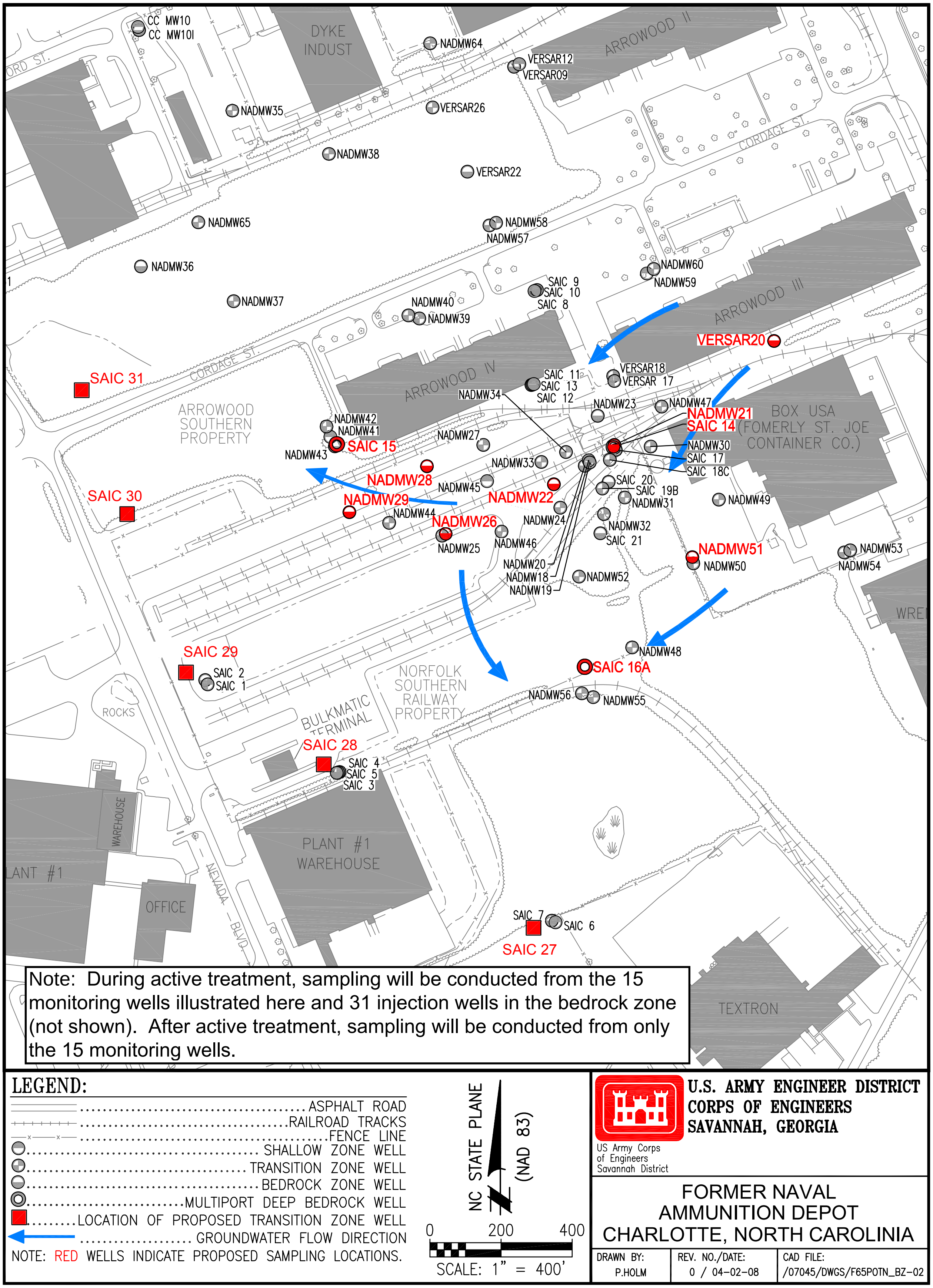

Figure 6. Location of Proposed Monitoring Wells and Sampling Locations for the Bedrock Zone

Appendix A

NCDENR
North Carolina Department of Environment and Natural Resources
Division of Waste Management

Beverly Eaves Perdue
Governor

Dexter R. Matthews
Director

Dee Freeman
Secretary

September 22, 2010

US Army Corps of Engineers
Attention: Mr. Ray Livermore
69 Darlington Avenue
Wilmington, North Carolina 28402

Subject: Groundwater Classification
Former Charlotte Naval Ammunition Depot (FUDS)
North Carolina

Dear Mr. Livermore:

The State of North Carolina classifies the groundwater in the vicinity of the Charlotte Naval Ammunition Depot as Class GA. Groundwaters which are ranked as Class GSA are found in areas subject to saltwater intrusion in the coastal areas of the State. Note that the Ground Water Quality Standards listed in 15A NCAC 02L .0202 apply to both Class GA and GSA with the exception of chloride and total dissolved solids for the Class GSA designation (see paragraph (h) of 2L .0202).

Please contact me if you have any questions. I may be reached at (919) 508-8447.

Sincerely,

Marti Morgan

Marti Morgan
Environmental Engineer
Superfund Section/Federal Remediation Branch
NC DENR

Cc: Dave Lown
Art Shacter

Appendix B

Focused Feasibility Study at the Former Naval Ammunition Depot (NAD), Charlotte, North Carolina
Alternative 3 - Enhanced Bioremediation using Sodium Lactate with Monitored Natural Attenuation
Key Parameters and Assumptions

Key Parameters and Assumptions:

Item	Unit	Value	Notes
Capital Cost			
Institutional Controls			
Groundwater Use Restrictions	hrs	120	Assume 120 hrs to implement restrictions.
Legal/Technical Labor	$/hr	90	
Monitoring Wells			
Mob/Site Preparation	$/lot	5,000	Based on historical drilling cost. Inc mob/demob, and decon pad.
Transition Wells	ea	4	Assume TD 25' (2-inch casing) - Screened 15'-25'. Inc drill, install MW, surface completion, driller perdiem.
Transition Wells	$/ea	2,801	
SAIC Geologist	$/well	662	Based on historical cost. Inc travel, perdiem, install, develop, document.
Bedrock Wells	ea	5	Assume TD 250' (2-inch casing) - Screened 230'-250' - Inc drill, install MW, surface completion, driller perdiem.
Bedrock Wells	$/ea	25,328	
SAIC Geologist	$/well	3,238	Based on historical cost. Inc travel, perdiem, install, develop, document.
IDW - Soil/water	drums	115	Assume 4 drums in transition zone and 19 drums in bedrock zone each well. Includes nonhazardous soil ($62/ea) & hazardous water ($375/ea) .
IDW - Disposal	$/drum	219	
Transportation	ea	3	
Transportation	$/event	1,415	Based on historical IDW mob, forklift, and transportation.
IDW Sampling	ea	9	Samples for TCLP, VOCs, SVOCs, and Metals. Assumes composite sample every well.
IDW Sampling	$/ea	600	
Development Equip, H&S Equip	weeks	5	Includes PID, Horiba, gloves, eyewash, safety glasses, hard hats, etc.
Development Equip, H&S Equip	$/week	525	Based on historical equipment rental and disposable cost.
Well Installation Report	$/hours	3,200	Assume 40 hours @ $80/hr average.
In Situ Biodegredation			
Injection Well Installation			
Injection Permit	ea	3200	Assume 40 hours @ $80/hr average.
Mob/Site Preparation	$/lot	5,000	Based on historical drilling cost. Inc mob/demob, and decon pad.
Transition Wells	ea	54	Assume TD 25' (2-inch casing) - Screened 8'-25'. Inc drill, install MW, surface completion, driller perdiem.
Transition Wells	$/ea	2,801	
SAIC Geologist	$/well	395	Based on historical cost. Inc travel, perdiem, install, develop, document.
Bedrock Wells	ea	31	Assume TD 100' (2-inch casing) - Screened 25'-100' - Inc drill, install MW, surface completion, driller perdiem.
Bedrock Wells	$/ea	10,626	
SAIC Geologist	$/well	1,336	Based on historical cost. Inc travel, perdiem, install, develop, document.
IDW - Soil/water	drums	526	Assume 4 drums in transition zone and 10 drums in bedrock zone each well. Includes nonhazardous soil ($62/ea) & hazardous water ($375/ea) .
IDW - Disposal	$/drum	219	
Transportation	ea	1	
Transportation	$/event	19,810	Based on historical IDW mob, forklift, and transportation.
IDW Sampling	ea	9	Samples for TCLP, VOCs, SVOCs, and Metals. Assumes composite sample every 10 wells.
IDW Sampling	$/ea	600	
Development Equip, H&S Equip	weeks	17	Includes PID, Horiba, gloves, eyewash, safety glasses, hard hats, etc.
Development Equip, H&S Equip	$/week	525	Based on historical equipment rental and disposable cost.
Well Installation Report	$/hours	32,000	Assume 400 hours @ $80/hr average.

Focused Feasibility Study at the Former Naval Ammunition Depot (NAD), Charlotte, North Carolina
Alternative 3 - Enhanced Bioremediation using Sodium Lactate with Monitored Natural Attenuation
Key Parameters and Assumptions

Key Parameters and Assumptions:

Item	Unit	Value	Notes
Injection System Setup			
Injector Installation Labor	days	43	Duration based on installing 2 injector setups/day.
Injector Installation Labor	$/days	700	1 FTE at $70/hr and 10 hour days.
Injector Installation Matls	wells	85	
Injector Installation Matls	$/well	300	Engineer Estimate
Injection Program - Fixed Cost			Includes fixed equipment cost.
Metering Pump	$/lot	9,000	3 each @ $3,000, up to 50 gpm, Engineer Estimate
Header System	$/lot	42,000	10 each @ $3,500, Engineer Estimate
Storage Sheds	$/lot	20,000	1 each @ 20,000, Heated, Engineer Estimate
Pressure Pipe	$/lot	375,000	Includes 15,000 lf of 2" HDPE pipe with direct bury installation. $25/lf.
Injection Setup	hours	400	One time setup. Assume 2 field techs for 20 days @ 10 hour/day to setup prior to injection.
Injection Setup	$/hour	60	
Per Diem	$/event	4,960	(2 people x 20 days x $124/day)
Cargo Van Rental / Gas	$/event	4,000	(2 trucks x 20 days x $100/day).
Installation Report	$/report	15,000	Estimate Includes 200 hrs @ $75/hour.
Injection System Operations - Transition Zone	events	4	
Injection Labor	hrs/event	160	Includes 4 injection events. Assume all wells are injected in 8 days. Includes travel. Total effort = 2 FTE x 8 days x 10 hrs/day.
Injection Labor	$/hr	70	
Per Diem	$/lot	1,360	(2 people x 8 days x $85/day)
Cargo Van Rental / Gas	$/lot	1,760	(2 trucks x 8 days x $110/day) Includes gas.
Fork Lift Rental	$/lot	600	Includes mob and rental.
Sodium Lactate Materials - Transition Zone	event	4	Pumping duration 2 days @ 24 hrs/day = 48 hours. 54 injection wells @ 1.5 gpm = approx 81 gpm Total gallons = 48 hours x 60 minutes/hr x 81 gallons/minute = 233,280 gal Assume 1% Lactate by volume = 2,332 gals of 60% lactate (as delivered) = 2,332/0.6 = 3,900 @ $0.77/lb x (600lb/55gal)= $33,000/event
Sodium Lactate Materials	$/event	33,000	
Water	$/event	1,000	
Injection System Operations - Bedrock Zone	events	7	
Injection Labor	hrs	160	Includes 7 injection events. Assume all wells are injected in 8 days. Includes travel. Total effort = 2 FTE x 8 days x 10 hrs/day.
Injection Labor	$/hr	70	
Per Diem	$/lot	1,360	(2 people x 8 days x $85/day)
Cargo Van Rental / Gas	$/lot	1,760	(2 trucks x 8 days x $110/day) Includes gas.
Fork Lift Rental	$/lot	5,000	Includes mob and rental.
Sodium Lactate Materials - Bedrock Zone	event	4	Pumping duration 2 days @ 24hrs/day = 48 hours. 31 injection wells @ 6 gpm = approx 186 gpm Total gallons = 48 hours x 60 minutes/hr x 186 gallons/minute = 535,680 gal Assume 1% Lactate by volume = 5,360 gals of 60% lactate (as delivered) = 5,360/0.6 = 8,950 @ $0.77/lb x (600lb/55gal)= $76,000/event
Sodium Lactate Materials	$/event	76,000	
Water	$/event	1,500	

Focused Feasibility Study at the Former Naval Ammunition Depot (NAD), Charlotte, North Carolina
Alternative 3 - Enhanced Bioremediation using Sodium Lactate with Monitored Natural Attenuation
Key Parameters and Assumptions

Key Parameters and Assumptions:

Item	Unit	Value	Notes
Verification Sampling & Analysis - Events 1-4	events	4	Includes sampling to monitor effectiveness of sodium lactate injection. Includes monitoring after first four injections. The baseline sampling will be included under O&M. Includes 30 monitoring wells that are sampled in 12 days (2.5 wells/day) plus 2 days travel. Assumes 2 sampling technicians at 10 hours/day. Sample all wells for VOCs, natural attenuation parameters (10 wells), and water quality parameters.
Sampling Labor	days	14	
Sampling Labor	hrs/event	280	
Sampling Labor	$/hr	65	
Per Diem	$/event	3,472	(2 FTE x 14 days x $124/day)
Cargo Van Rental / Gas	$/event	1,540	(1 van x 14 days x $110/day includes gas).
Sample materials	ea/event	51	Reference ECHOS 33 02 0401/0402 for disposable sampling and decon materials.
Sample materials	$/ea	21.00	
Sample equipment	$/event	1,200	Water quality parameter equipment, pumps, misc tools, and sampling equipment rental/purchase. Based on RACER model.
Sample equipment	lot	1,000	Purge water tank (1,000 gal) and trailer.
Analytical Cost	$/event	9,520	Analyze GW samples from 30 wells for VOCs (41 @ $120) and Natural Attenuation Parameters (10 @ $460). Includes 10% duplicate and 5% rinsate, and trip blanks.
Sample Shipment	$/event	300	6 coolers @ $50 ea.
Data Management	hrs	26	Data validation
Data Management	$/hr	70	
IDW Water Disposal	events	4	Assume 100% hazardous water ($0.38/gal @ 800 gal) to dispose. Add $5,000 pickup, transport, & tank cleanout. Add $600 sampling & analysis.
IDW Water Disposal	$/event	5,904	Based on Safety Kleen Quote.
Verification Sampling & Analysis (Events 4-7)	events	3	Includes sampling to monitor effectiveness of sodium lactate injection. Includes monitoring after injections 4-7 in bedrock zone. The baseline sampling will be included under O&M. Includes 15 monitoring wells that are sampled in 6 days (2.5 wells/day) plus 2 days travel. Assumes 2 sampling technicians at 10 hours/day. Sample all wells for VOCs, natural attenuation parameters (10 wells), and water quality parameters.
Sampling Labor	days	8	
Sampling Labor	hrs/event	160	
Sampling Labor	$/hr	65	
Per Diem	$/event	1,984	(2 FTE x 8 days x $124/day)
Cargo Van Rental / Gas	$/event	880	(1 van x 8 days x $110/day includes gas).
Sample materials	ea/event	26	Reference ECHOS 33 02 0401/0402 for disposable sampling and decon materials.
Sample materials	$/ea	21.00	
Sample equipment	$/event	1,200	Water quality parameter equipment, pumps, misc tools, and sampling equipment rental/purchase. Based on RACER model.
Analytical Cost	$/event	4,820	Analyze GW samples from 15 wells for VOCs (21 @ $120) and Natural Attenuation Parameters (5 @ $460). Includes 10% duplicate and 5% rinsate, and trip blanks.
Sample Shipment	$/event	150	3 coolers @ $50 ea.
Data Management	hrs	13	Data validation
Data Management	$/hr	70	
IDW Water Disposal	events	3	Assume 100% hazardous water ($0.38/gal @ 400 gal) to dispose. Add $5,000 pickup, transport, & tank cleanout. Add $600 sampling & analysis.
IDW Water Disposal	$/event	5,752	Based on Safety Kleen Quote.
Reporting			
Injection and Monitoring Report	$/event	16,000	Assume 200 hrs @ $80/hr.

Focused Feasibility Study at the Former Naval Ammunition Depot (NAD), Charlotte, North Carolina
Alternative 3 - Enhanced Bioremediation using Sodium Lactate with Monitored Natural Attenuation
Key Parameters and Assumptions

Key Parameters and Assumptions:

Item	Unit	Value	Notes
O&M			
Groundwater Sampling & Analysis (Years 0 through 15)	events	26	Includes quarterly sampling for Years 0-3, semiannual for Years 4-5, and annual sampling for Years 6-15 in transition and bedrock zone. Includes conformational sampling in the transition and bedrock zone (year 15). There are 8 total events. Includes 21 existing and 9 new wells that are sampled in 12 days (2.5 wells/day) plus 2 days travel. Assumes 2 sampling technicians at 10 hours/day. Sample all wells for VOCs, natural attenuation parameters (5 wells), and water quality parameters.
Sampling Labor	days	14	
Sampling Labor	hrs/event	280	
Sampling Labor	$/hr	65	
Per Diem	$/event	3,472	(2 FTE x 14 days x $124/day)
Cargo Van Rental / Gas	$/event	1,540	(1 van x 14 days x $110/day includes gas).
Sample materials	ea/event	51	Reference ECHOS 33 02 0401/0402 for disposable sampling and decon materials.
Sample materials	$/ea	21.00	
Sample equipment	$/event	1,200	Water quality parameter equipment, pumps, misc tools, and sampling equipment rental/purchase. Based on RACER model.
Sample equipment	lot	1,000	Purge water tank (1,000 gal) and trailer.
Analytical Cost	$/event	9,520	Analyze GW samples from 30 wells for VOCs (41 @ $120) and Natural Attenuation Parameters (10 @ $460). Includes 10% duplicate and 5% rinsate, and trip blanks.
Sample Shipment	$/event	300	6 coolers @ $50 ea.
Data Management	hrs	26	Data validation
Data Management	$/hr	70	
IDW Water Disposal	events	26	Assume 100% hazardous water ($0.38/gal @ 800 gal) to dispose. Add $5,000 pickup, transport, & tank cleanout. Add $600 sampling & analysis.
IDW Water Disposal	$/event	5,904	Based on Safety Kleen Quote.
Reporting			
Annual/Periodic Report	$/event	9,600	Assume 120 hours @ $80/hr average for analytical report and to recalibrate GW model.
5-Year Reviews	event	3	Assume 5-Year reviews for years 5-15.
5-Year Reviews	$/event	6,400	Assume 80 hours @ $80/hr.
Well Abandonment			
Abandon Monitoring Well	lot	1	Assume 70 wells @ 25 ft,41 wells @ 100 ft, and 5 wells @ 250 ft. Assume $1,000 mob, $12/lf to grout, and $500 per well to remove surface casing and restore.
Abandon Monitoring Well	$/lot	120,400	

Focused Feasibility Study at the Former Naval Ammunition Depot (NAD), Charlotte, North Carolina
Alternative 3 - Enhanced Bioremediation using Sodium Lactate with Monitored Natural Attenuation
Cost Estimate

CAPITAL COST **$4,555,321**

Activity (unit)	Quantity	Unit Cost	Total
Institutional Controls			
Groundwater Use Restrictions (hrs)	120	$90	$10,800
Monitoring Wells			
Mob/Site Preparation (ea)	1	$5,000	$5,000
Transition Wells (ea)	4	$3,463	$13,854
Bedrock Wells (ea)	5	$28,566	$142,832
IDW Disposal (drums)	115	$219	$25,128
Transportation (ls)	1	$1,415	$1,415
IDW Sampling (ea)	9	$600	$5,400
Development Equip, H&S Equip (wk)	5	$525	$2,625
Well Installation Report (ea)	1	$3,200	$3,200
In Situ Biodegredation			
Injection Well Installation			
Injection Permit (ea)	1	$3,200	$3,200
Mob/Site Preparation (lot)	1	$5,000	$5,000
Transition Wells (ea)	54	$3,196	$172,598
Bedrock Wells (ea)	31	$11,962	$370,825
IDW Disposal (drums)	526	$219	$114,931
Transportation (ls)	1	$19,810	$19,810
IDW Sampling (ea)	9	$600	$5,100
Development Equip, H&S Equip (wk)	17	$525	$8,925
Installation Report (ea)	1	$32,000	$32,000
Injection System Setup			
Injector Installation Labor (days)	43	$700	$30,100
Injector Installation Matls (wells)	85	$300	$25,500
Injection Program - Fixed Cost			
Metering Pump (lot)	1	$9,000	$9,000
Header System (lot)	1	$42,000	$42,000
Storage Sheds (lot)	1	$20,000	$20,000
Pressure Pipe (lot)	1	$375,000	$375,000
Injection Setup	400	$60	$24,000
Per Diem (lot)	1	$4,960	$4,960
Cargo Van Rental / Gas (lot)	1	$4,000	$4,000
Installation Report (ea)	1	$15,000	$15,000
Injection System Operations - Transition Zone			
Injection Labor (events)	4	$11,200	$44,800
Injection Program - Per Diem (events)	4	$1,360	$5,440
Injection Program - Rental Vehicle (events)	4	$1,760	$7,040
Fork Lift Rental	4	$600	$2,400
Sodium Permanganate Materials (events)	4	$33,000	$132,000
Water (events)	4	$1,000	$4,000

Focused Feasibility Study at the Former Naval Ammunition Depot (NAD), Charlotte, North Carolina
Alternative 3 - Enhanced Bioremediation using Sodium Lactate with Monitored Natural Attenuation
Cost Estimate

Activity (unit)	Quantity	Unit Cost	Total
Injection System Operations - Bedrock Zone			
Injection Labor (events)	7	$11,200	$78,400
Injection Program - Per Diem (events)	7	$1,360	$9,520
Injection Program - Rental Vehicle (events)	7	$1,760	$12,320
Fork Lift Rental	7	$5,000	$35,000
Sodium Permanganate Materials (events)	7	$76,000	$532,000
Water (events)	7	$1,500	$10,500
Verification Sampling & Analysis - Events 1-4			
Sampling Labor (event)	4	$18,200	$72,800
Per Diem (event)	4	$3,472	$13,888
Cargo Van Rental / Gas (event)	4	$1,540	$6,160
Sample materials (event)	4	$1,071	$4,284
Sample equipment (event)	4	$1,200	$4,800
Sample equipment (event)	1	$1,000	$1,000
Analytical Cost (event)	4	$9,520	$38,080
Sample Shipment (event)	4	$300	$1,200
Data Management (event)	4	$1,820	$7,280
IDW Disposal (event)	4	$5,904	$23,616
Verification Sampling & Analysis - Events 5-7			
Sampling Labor (event)	3	$10,400	$31,200
Per Diem (event)	3	$1,984	$5,952
Cargo Van Rental / Gas (event)	3	$880	$2,640
Sample materials (event)	3	$546	$1,638
Sample equipment (event)	3	$1,200	$3,600
Analytical Cost (event)	3	$4,820	$14,460
Sample Shipment (event)	3	$150	$450
Data Management (event)	3	$910	$2,730
IDW Disposal (event)	3	$5,752	$17,256
Reporting			
Injection and Monitoring Report (lot)	1	$16,000	$16,000
Subtotal			$2,634,656
Design		10%	$263,466
Office Overhead		5%	$131,733
Field Overhead		15%	$395,198
Subtotal			$3,425,053
Profit		8%	$274,004
Contingency		25%	$856,263
Total			$4,555,321

Focused Feasibility Study at the Former Naval Ammunition Depot (NAD), Charlotte, North Carolina
Alternative 3 - Enhanced Bioremediation using Sodium Lactate with Monitored Natural Attenuation
Cost Estimate

OPERATION AND MAINTENANCE	**$2,568,755**

Activity (unit)	Quantity	Unit Cost	Total Cost
O&M Sampling & Analysis (Years 0 through 15)			
Sampling Labor (event)	26	$18,200	$473,200
Per Diem (event)	26	$3,472	$90,272
Cargo Van Rental / Gas (event)	26	$1,540	$40,040
Sample materials (event)	26	$1,071	$27,846
Sample equipment (event)	26	$1,200	$31,200
Purge Water Tank and Trailer (lot)	1	$1,000	$1,000
Analytical Cost (event)	26	$9,520	$247,520
Sample Shipment (event)	26	$300	$7,800
Data Management (event)	26	$1,820	$47,320
IDW Disposal (event)	26	$5,904	$153,504
Reporting			
Annual/Periodic Report (ea)	26	$9,600	$249,600
5-Year Review (ea)	3	$6,400	$19,200
Monitoring Well Abandonment			
Abandon Monitoring Well (lot)	1	$120,400	$120,400
Subtotal O&M			$1,508,902
Design		8%	$120,712
Office Overhead		5%	$75,445
Field Overhead		15%	$226,335
Subtotal			$1,931,395
Profit		8%	$154,512
Contingency		25%	$482,849
Total			$2,568,755

TOTAL ALTERNATIVE CAPITAL AND O&M COST (Non Discounted Cost)	**$7,124,076**