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FINAL NON TIME CRITICAL REMOVAL ACTION WORK PLAN FOR SITE 89 OPERABLE UNIT 16 (OU 16) MCB CAMP LEJEUNE NC

04/01/2008

AGVIQ/CH2M HILL

FINAL

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Non-Time Critical Removal Action Work Plan
Site 89, Operable Unit 16

Marine Corps Base
Camp Lejeune, North Carolina

Prepared for

NAVFAC
Naval Facilities Engineering Command

Department of the Navy
Mid-Atlantic Division
Naval Facilities Engineering Command
Norfolk, Virginia

Contract No. N62470-03-D-4401
Task Order-0080

April 2008

Prepared by

AGVIQ ENVIRONMENTAL SERVICES
CH2M HILL
JOINT VENTURE

Final

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Acronyms and Abbreviations

AHA	activity hazard analysis
Base	Marine Corps Base Camp Lejeune
bgs	below ground surface
CIH	Certified Industrial Hygienist
CSP	Certified Safety Professional
CSU	Colorado State University
1,2-DCE	1,2-dichloroethene
DLA	Defense Logistics Agency
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DPT	direct push technology
DRMO	Defense Reutilization and Marketing Office
EE/CA	Engineering Evaluation and Cost Analysis
EPA	Environmental Protection Agency
ft/day	feet per day
ft/ft	feet per foot
ft/year	feet per year
FID	flame ionization detector
FTL	field team leader
GPS	Global Positioning System
HEPA	high efficiency particulate air
HSP	Health and Safety Plan
IDW	investigation derived waste
JV I	AGVIQ-CH2M HILL Joint Venture I
MCB	Marine Corps Base
MEK	methyl-ethyl-ketone
mg/kg	milligrams per kilogram
mL	milliliters
MIP	membrane interface probe
msl	mean sea level
NAD	North American Datum

NAVD	North American Vertical Datum
NAVFAC	Naval Facilities Engineering Command
NCDENR	North Carolina Department of Environment and Natural Resources
NTCRA	Non-Time Critical Removal Action
ORP	oxidation reduction potential
OU	Operable Unit
PCA	1,1,2,2-tetrachloroethane
PCE	tetrachloroethene
P.E.	Professional Engineer
P.G.	Professional Geologist
PHSM	Project Health and Safety Manager
PPE	personal protective equipment
psi	pounds per square inch
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance and quality control
RI	Remedial Investigation
rpm	revolutions per minute
SAP	Field Sampling and Analysis Plan
SOP	Standard Operating Procedure
SPCS	State Plane Coordinate System
SSC	Site Safety Coordinator
TCE	trichloroethene
TLV	threshold limit value
TO	Task Order
U.S.	United States
UST	underground storage tank
VOC	volatile organic compound
WP	Work Plan
ZVI	zero valent iron

1. Introduction

1.1 Project Overview

This plan describes the objectives and activities for a Non-Time Critical Removal Action (NTCRA) source area treatment that will be conducted at Operable Unit (OU) 16, Site 89, Marine Corps Base (MCB) Camp Lejeune (Base) in Onslow County, North Carolina. Site 89 includes the Former Defense Reutilization and Marketing Office (DRMO), a larger, wooded area to the east and the south of the DRMO, and a portion of Camp Geiger to the west. This NTCRA Source Area Treatment Work Plan (WP) will provide information and the technical approach for the removal action selected in the Site 89 Action Memorandum (AGVIQ-CH2M HILL Joint Venture I, 2007).

1.2 Contractual Setting

AGVIQ-CH2M HILL Joint Venture I (JV I) has been tasked with submitting this Source Area Treatment WP under contract with the Naval Facilities Engineering Command (NAVFAC) – Mid-Atlantic Division, JV I Contract N62470-03-D-4401, Task Order (TO) 080.

1.3 Work Plan Organization

This Source Area Treatment WP consists of 11 sections. Brief descriptions of the sections are presented as follows:

1.0 **Introduction –** Presents an overview of the project and work plan.

2.0 **Site Background –** Discusses the site location, history, and previous investigations.

3.0 **Removal Action Design –** Presents the design for conducting the removal action.

4.0 **Removal Action Implementation –** Discusses how the removal action will be conducted.

5.0 **Monitoring –** Provides information on the monitoring that will be conducted for the project.

6.0 **Waste Management –** Provides details regarding the management and disposal of investigation derived waste.

7.0 **Health and Safety Considerations –** Discusses health and safety concerns to be considered during implementation of the design.

8.0 **Site Activity Considerations –** Discusses site activities to be considered during the project.

9.0 **Reporting –** Provides information on the reports that will be submitted as part of the project.

10.0 Schedule and Project Organization – Presents the schedule for the project and provides information on the project management, team, and organization.

11.0 References – Presents complete citations for other documents and publications cited in this document.

Tables and figures accompanying the main text of this work plan are at the end of each section.

2. Site Background

This section contains site characterization information including site description and background and nature and extent of contamination.

2.1 Facility and Site Description

MCB Camp Lejeune is located in Onslow County, North Carolina. The Base covers approximately 236 square miles and is bisected by the New River, which flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean. The southeastern border of the Base is the Atlantic Ocean shoreline (**Figure 2-1**, Camp Lejeune Site Location Map). The western and northeastern boundaries are United States (U.S.) Route 17 and State Route 24, respectively. The City of Jacksonville, North Carolina borders the Base to the north.

The generally flat topography of MCB Camp Lejeune is typical of the seaward portions of the North Carolina coastal plain. Elevations at the Base vary from sea level to 72 feet above mean sea level (msl), although the elevation of the majority of the Base lies between 20 and 40 feet above msl.

2.1.1 Facility and Site Physical Setting

The general location of Site 89 is shown on **Figure 2-2**. Site 89 is located to the west of the New River, on Camp Geiger near the intersection of G and 8th Street**.** The Site 89 investigative area includes the woods to the east and the south of the DRMO and a portion of Camp Geiger to the west.

The majority of the ground surface of the former DRMO area is covered with asphalt, as shown on **Figure 2-3**; however, the eastern and southern portions of the site are grass covered**.** The area east of the former DRMO and north of Edwards Creek is a wooded area that is also included in Site 89. The areas north and west of Site 89 are generally developed, covered with buildings, asphalt, and grass. The former DRMO area is surrounded by a fence with an access gate located near Building TC864.

Figure 2-4 shows the location of Site 89 relative to its topography and hydrologic features. The areas surrounding Site 89 to the north and west drain into stormwater ditches. Many of the stormwater ditches north and west of Site 89 flow and discharge into the source of Edwards Creek near the intersection of 8th and G Streets. The former DRMO of Site 89 drains into Edwards Creek and the drainage ditch along the east side of the site. Ground surface elevations are approximately 5 to 20 feet above msl. Underground utilities are shown in **Figure 2-5.**

2.1.2 Site History

The DRMO was operated by the Defense Logistics Agency (DLA) and, until 2000, was used as a storage yard for miscellaneous items such as scrap and surplus metal, electronic

equipment, vehicles, rubber tires, fuel bladders (mobile storage tanks), and other material that would be sent offsite.

Historical records indicate that the Base Motor Pool operated on the site until approximately 1988. The Base Motor Pool was then relocated to its current location, an asphalt paved area immediately north of the DRMO facility. The Base Motor Pool reportedly used various solvents, such as acetone, trichloroethene (TCE), and 2-butanone (methyl-ethyl-ketone [MEK]), for cleaning parts and equipment. Historical records also indicate that a 550-gallon UST, identified as UST STC-868, was installed at the site in 1983 and used to store waste oil. The UST was removed in 1993.

The site has not been used since the DRMO relocated in 2000. The only site activity since that time has been related to environmental investigation and remediation.

2.2 Geology and Hydrogeology

2.2.1 Geology

A detailed discussion of the soil and lithology at Site 89 is presented in the Comprehensive Remedial Investigation (RI) Report (CH2M HILL, 2007). Information pertinent to the source area is summarized herein.

Soils within the treatment areas consist primarily of interbedded sandy clays, silty sands, with occasional clays horizons. The surface soil at the site, approximately ground surface to two feet below ground surface (bgs), is predominantly a loose organic rich medium to dark brown silty sand. As the surface soils transition to subsurface soil, there appears to be only slight changes in soil textures with a significant decrease in organic matter. Within this transition, the soil continues to be a silty sand although the color changes from various shades of brown to a light tan with an occasional orange hue. This tan silty sand horizon is only one foot deep, on average, and is underlain by a dark brown loose to medium dense silty sand approximately four feet thick. At an average depth of nine feet bgs, the soils begin to have increased clay contents and transition from silty sands to sandy clays and clayey sands. These sandy clays and clayey sands range in thickness from one to two feet before transitioning back into silty sands and sands. The majority of the soil borings advanced within the source area encountered a dark grey, stiff clay layer at 15 feet bgs that ranges in thickness from two to four feet thick. The frequency of these clay encounters may indicate a laterally continuous clay layer throughout most of the treatment area. Underlying the clay layer at depths ranging from 15 to 19 feet bgs is a medium dense, partially cemented silty sand with shell fragments down to a maximum coring of depth of 25 feet bgs.

2.2.2 Hydrogeology

A detailed discussion of the hydrologic and hydrogeologic characteristics at Site 89 is presented in the Comprehensive RI Report (CH2M HILL, 2007). Information pertinent to the source area is summarized herein.

The static water level elevations of the unconfined surficial aquifer ranged from 12.1 feet msl to 5.8 feet msl in November 2005, as presented in the Comprehensive RI Report

(CH2M HILL, 2007). Groundwater flow within the unconfined surficial aquifer at Site 89 is influenced by Edwards Creek, generally to the south/southeast. A groundwater contour map of the surficial aquifer within the treatment area, based on data collected during November 2005, is shown on **Figure 2-6**. The fine silty and clayey sand is laterally discontinuous at Site 89 and therefore only provides semi-confining conditions to the Upper Castle Hayne aquifer below. The horizontal hydraulic gradient within the surficial aquifer averaged approximately 0.006 feet per foot (ft/ft) in November 2005.

Hydraulic conductivity values were determined for the surficial aquifer using slug tests (Baker, 1998). The average hydraulic conductivity value for the surficial aquifer unit (comprised of silty sands) was approximately 8.4 ft per day (ft/day). CH2M HILL performed slug tests in the shallow aquifer on January 26, 2006, which indicated consistent hydraulic conductivity values ranging from 3.9 ft/day to 6.3 ft/day, with an average of 5.1 ft/day.

Using effective porosity values for silts and sands in the range of 25 to 50 percent (Freeze and Cherry, 1979), a seepage velocity within the surficial aquifer at Site 89 was determined in the range from 0.047 to 0.151 ft/day (17 to 55 ft per year [ft/year]), based on the slug tests conducted by CH2M HILL.

2.3 Nature and Extent of Contamination

A detailed discussion of the nature and extent of contamination is presented in the Comprehensive RI Report (CH2M HILL, 2007).

Based on analytical data gathered during investigations at Site 89, a significant source area is in the southern portion of the former DRMO (the former vehicle maintenance and storage area), where substantial chlorinated solvents, including some in the form of dense non-aqueous phase liquid (DNAPL), have been detected in soil and groundwater. Of the volatile organic compounds (VOCs) detected at Site 89, 1,1,2,2-tetrachloroethane (PCA) and TCE were the most prevalent and were found at the highest concentrations. Other VOCs detected include tetrachloroethylene (PCE) and daughter products of PCE and TCE, such as 1,2-dichloroethene (1,2-DCE) and vinyl chloride.

2.4 Source Removal Area

2.4.1 Rationale for Area Selection

The estimated source zone is based primarily on data collected during investigative activities conducted in association with the Comprehensive RI (CH2M HILL, 2007) including membrane interface probe (MIP) profiling, direct push technology (DPT) groundwater sampling, and monitoring well groundwater sampling. Dissolved concentrations of VOCs in groundwater at approximately one to ten percent of a compound's solubility may suggest the presence of DNAPL in the subsurface. To treat the soil with the highest VOC concentrations, the source area identified for treatment under this NTCRA, as shown on **Figure 2-7,** is based on dissolved concentrations in exceedance of five percent of the solubility of either PCA or TCE.

2.4.2 Area Dimensions

Based on the chemical and physical data gathered during investigations at Site 89, the source area is approximately 32,400 square feet to a depth of 25 feet. The volume of soil within the source area is estimated to be 30,000 cubic yards. Assuming a pore space of 25%, the treatment area also contains approximately 1.5 million gallons of groundwater.

\\Ariadne\groups\GIS\USNavFaceNGCom\315007CampLejeune\Projects\Site89_NTCRA\Figure_2_1_Base_Loc_Map.mxd

Legend

- Cities
- Limited Access Higwhay
- Highway
- Local Roads
- Installation Area

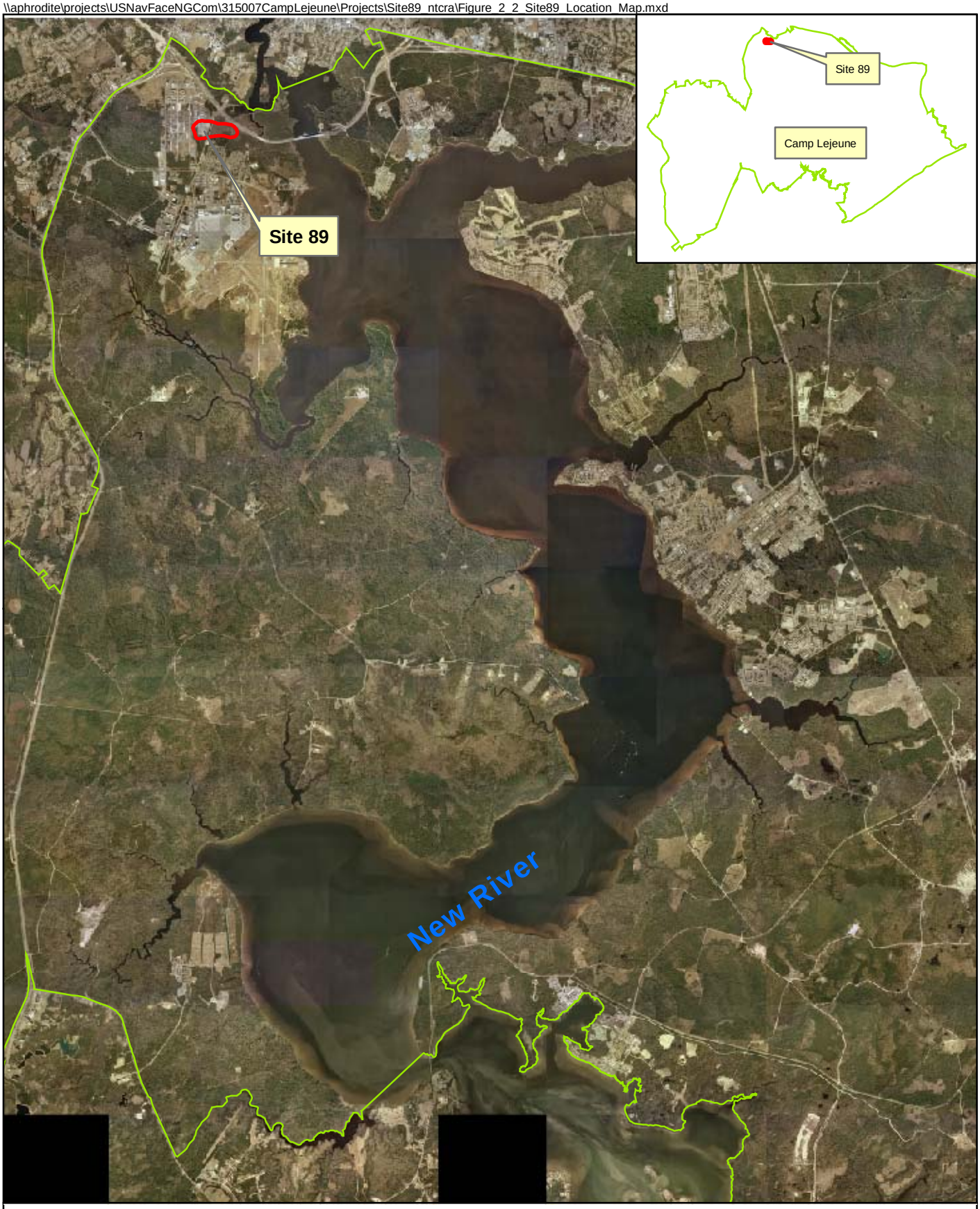
N

0 10 Miles

Figure 2-1
Base Location Map
Operable Unit No. 16 Site 89
MCB Camp Lejeune, North Carolina

AGVIQ CH2M HILL

\\aphrodite\projects\USNavFaceNGCom\315007CampLejeune\Projects\Site89_ntcra\Figure_2_2_Site89_Location_Map.mxd



Legend

Environmental Restoration Area

Installation Area

N

0 4,000 8,000 Feet

Aerial Photograph taken Feb. 2004

Figure 2-2

Site 89 Location Map

Operable Unit No. 16 Site 89

MCB Camp Lejeune, North Carolina

AGVIQ CH2M HILL

\\aphrodite\projects\USNavFacEngCom\315007CampLejeune\Projects\Site89_NTCRA_WP\Figure_2_3_Site89_Map.mxd

Legend

- Shallow Groundwater Monitoring Well
- Intermediate Groundwater Monitoring Well
- Deep Groundwater Monitoring Well
- CreekCopy
- Water Bodies
- Site 89 Boundary
- Surface Water Flow Direction

N

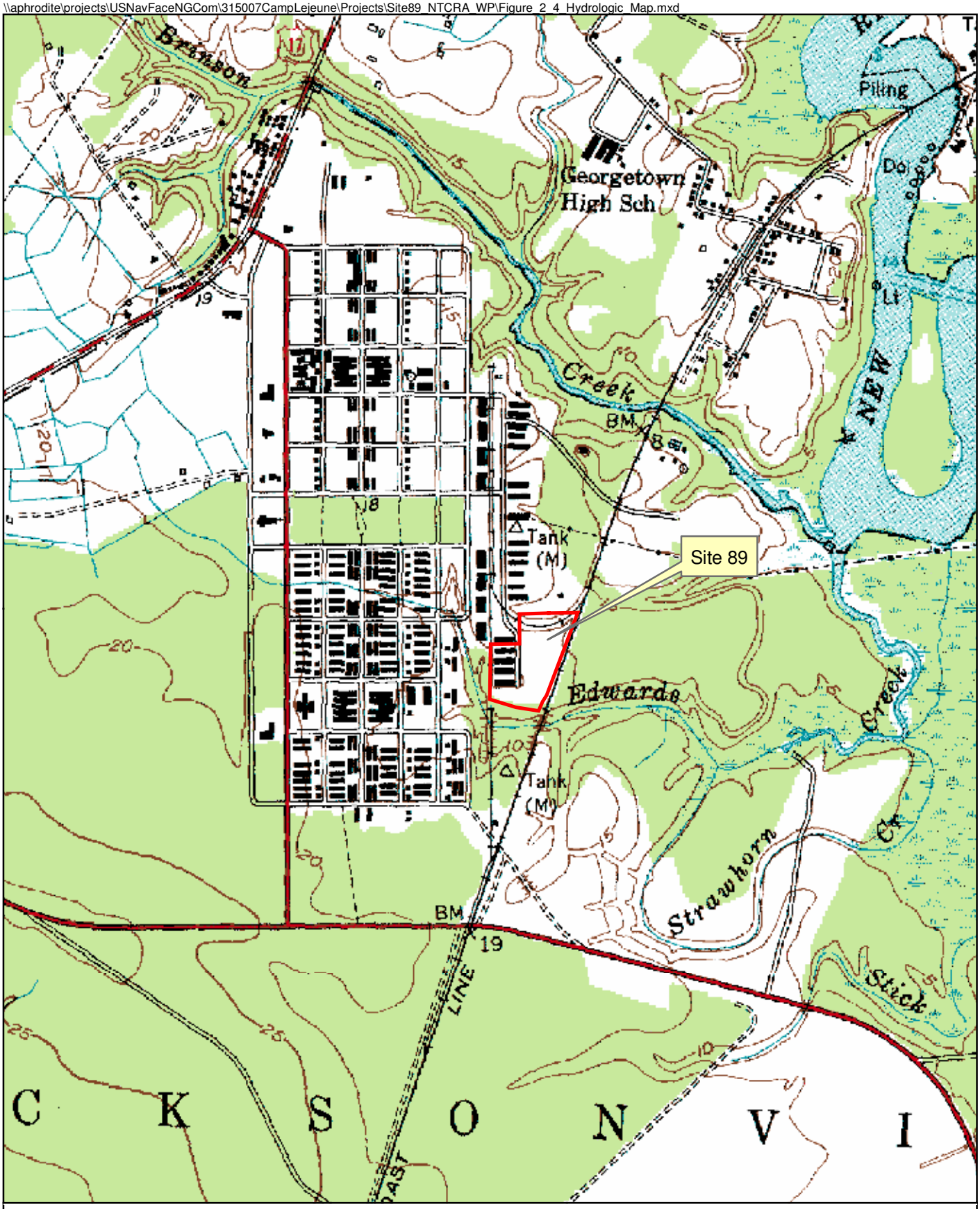
0 125 250 Feet

Aerial Photograph taken Feb. 2004

Figure 2-3
Site Map
Operable Unit No. 16 Site 89
MCB Camp Lejeune, North Carolina

AGVIQ ENVIRONMENTAL SERVICES
CH2M HILL JOINT VENTURE

\\aphrodite\projects\USNavFaceNGCom\315007CampLejeune\Projects\Site89_NTCRA_WP\Figure_2_4_Hydrologic_Map.mxd



Legend

Site 89 Boundary

Source: USGS Jacksonville South, NC, quad

N

0 625 1,250 Feet

Figure 2-4
Site 89 Camp Lejeune Hydrologic Features
Operable Unit No. 16 Site 89
MCB Camp Lejeune, North Carolina

AGVIO
CH2M HILL

Legend

- Monitoring Well Locations
- Water fire connection point
- Wastewater Septic Tank Point
- Wasterwater Oil Water Separator Point
- Manhole
- Valve Box
- Wastewater network junctions
- SWPPP GPS Inlet
- Storm Sewer Outfall Point
- Storm Sewer Pipe End Point
- FMAIN
- GMAIN
- Storm Sewer Line
- Storm Sewer Open Drainage Line
- Creek

N

0 50 100 Feet

Aerial Photograph taken Feb. 2004

Figure 2-5
Underground Utility Map
Operable Unit No. 16 Site 89
MCB Camp Lejeune, North Carolina

AGVIQ
CH2M HILL

File Path: V:\USNavFaceNGCom\315007CampLejeune\Projects\Site89_NTCRA_WP\Figure_2_5_Underground_Utility_Map.mxd

\\aphrodite\projects\USNavFaceNGCom\Projects\Site89_NTCRA_WP\Figure_2_6_GW_Contour_Surficial_Nov2005_Map.mxd

Legend

- Shallow Groundwater Monitoring Well
- Water Bodies
- Site 89 Boundary
- Surface Water Flow Direction
- Groundwater Flow Direction
- 8 Groundwater Elevation Contour

Note: All data reported in ft msl

N

0 50 100 Feet

Aerial Photograph taken Feb. 2004

Figure 2-6

Groundwater Contour Map of the Surficial Aquifer, November 2005

Operable Unit No. 16 Site 89

MCB Camp Lejeune, North Carolina

AGVIO CH2M HILL

Legend

- Monitoring Well Locations
- Creek
- Soil Mixing Treatment Areas

N

0 50 100 Feet

Aerial Photograph taken Feb. 2004

Figure 2-7
Source Area Identified for Treatment
Operable Unit No. 16 Site 89
MCB Camp Lejeune, North Carolina

AGVIQ CH2M HILL

File Path: V:\USNavFaceNGCom\315007CampLejeune\Projects\Site89_NTCRA_WP\Figure_2_7_Source_Area_Treatment.mxd

3. Removal Action Design

This section presents a conceptual removal action design.

3.1 Removal Action Overview, Objectives, and Goals

3.1.1 Project Overview

The rationale for selecting shallow soil mixing was presented in the Site 89 Source Removal Engineering Evaluation and Cost Analysis (EE/CA) (JV I, 2007). In summary, the proposed removal action at Site 89 in the DNAPL source area will include shallow soil mixing with zero valent iron (ZVI)-clay addition. A bench-scale study was conducted to evaluate the appropriate ZVI mix with clay enhancers.

Prior to mixing, roughly three feet of clean overburden will be removed from the treatment area and three foot high berms will be constructed around the treatment area to provide sufficient "free board" for mixing operations. The excavated material will be stockpiled on site and used for construction of containment berms and site restoration. Shallow soil mixing will be implemented using a 10-foot diameter auger constructing approximately 515 soil mixing columns.

3.1.2 Project Objectives and Goals

The primary objectives of the project are:

- Treat high VOC concentrations from the identified source areas at Site 89.
- Reduce exposure and risk to human and ecological receptors.
- Reduce the potential for contaminant mass flux from the source zone to groundwater.

The effectiveness of the technology will be evaluated according to the following criteria:

- Reduction in contaminant mass, as quantified by pre- and post-treatment soil and groundwater data.
- Minimization of contaminant mobility, as quantified by aquifer testing and by comparing groundwater data collected prior to and after the source area treatment.

3.2 Technology Description

Soil mixing is an in-situ technology that uses an auger system with the ability to deliver a ZVI-clay slurry to the soil while mechanically breaking up and mixing the soil. Soil mixing with ZVI-clay has been shown to be effective at other sites with a relatively fast treatment time. Soil mixing creates a homogenous mixture of soil, clay, iron, and target contaminants by turning the auger while cycling up and down throughout the mixing column. This homogenous mixture becomes a reaction zone with low permeability to minimize flow out

of and into the zone. The iron treats the chlorinated VOCs through chemical reduction. The clay promotes uniform distribution of the iron during the mixing process. It also reduces the hydraulic conductivity of the source zone, so that contaminant discharge is reduced.

Slurry injection and mixing will create a temporary increase in soil volume, also known as fluff. The amount of resulting fluff, estimated to be 20 percent of the soil volume, is a function of the soil type, injection volume, reagent type, and operating conditions. To contain this fluff, five feet of freeboard is required. However, the depth to groundwater at Site 89 is shallow, so approximately the top three feet of soil will be excavated. A berm will be constructed to three feet above ground surface outside the treatment area to fully contain the fluff. Based on previous work, the top three feet of soil in the treatment zone are not contaminated; therefore, this excavated material will be stockpiled and used for construction of containment berms and site restoration.

Fugitive emissions may occur during the mixing of the ZVI-clay slurry. To be protective of site personnel and the environment, these emissions will be captured from a removable shroud over the mixing column. The removable shroud is an open bottom cylinder that covers the surface of the mixing column while mixing is performed directly beneath. Negative pressure is kept on the headspace of the shroud, pulling any VOCs to a vapor carbon treatment system. When mixing is completed, the mixing auger is retracted inside the shroud and the unit is moved to the next column.

3.3 Bench-Scale Testing

A bench-scale test was conducted by Colorado State University (CSU) to characterize the potential to treat the target compounds using ZVI-clay slurry. The test was conducted using soil collected from the target treatment area. The bench-scale study was conducted to optimize the addition of ZVI.

3.3.1 Sample Collection

For the bench-scale study, continuous soil cores were collected throughout the treatment area to a depth of 25 feet bgs using DPT, as shown on **Figure 3-1**. Once the cores were retrieved, the acetate liner tubes were cut into lengths of approximately two-feet. The tube ends were immediately sealed and stored in a cooler with a sufficient amount of bagged ice and packing material to provide cushioning. Additionally, two gallons of groundwater were collected from 89-MW20 in clean glassware. The containers were labeled, placed in coolers on ice, and shipped with the soil samples to CSU.

Two one-inch temporary monitoring wells (89-TW200 and 89-TW201) were installed within the treatment area, as shown on **Figure 3-1,** in an attempt to capture samples of DNAPL. The wells were set immediately above a clay lens, which was encountered 19 feet bgs. One week after installation, temporary monitoring wells 89-TW200 and 89-TW201 were sampled; however, DNAPL was not observed.

3.3.2 Bench-Scale Testing

The study was conducted in two phases. The Phase 1 study evaluated use of 0.5 percent to 1.5 percent iron and 1 percent bentonite clay. Soils collected from the site were spiked with

TCE and PCA to target levels of 1,000 milligrams per kilogram (mg/kg) TCE and 50 mg/kg PCA. The Phase 1 study results raised two items of concern: (1) concentrations in the no-iron control column showed a notable decline and (2) none of the columns treated with iron achieved significant levels of reduction, as compared to the control. These issues appear to be potentially related to the ZVI used in the test was from a supply that was approximately one year old and the spiked soil samples may not have had time to equilibrate. The Phase 2 study was conducted as the Phase 1 results were unusual and unexpected by CSU and the JV. The Phase 2 study incorporated several changes from Phase 1. These included use of more iron (2 to 3 percent), use of more bentonite clay (2 to 3 percent), use of unmodified bentonite (modified bentonite was used in Phase 1), use of new iron from an alternative source and allowing the spiked samples more time to equilibrate prior to testing. For the Phase 2 study, soils were spiked with TCE and PCA, each to target levels of 1,500 to 2,000 mg/kg.

Results of the Phase 2 study indicated that, under experimental conditions, ZVI-clay is capable of treating TCE and PCA at Site 89, as shown on **Table 3-1**. In general, similar levels of contaminant depletion were achieved with each of the treatments evaluated. The maximum TCE and PCA reductions were achieved using 2 percent iron and 3 percent bentonite.

TABLE 3-1
Bench-Scale Study Results
Site 89 NTCRA Work Plan
MCB Camp Lejeune, North Carolina

	Control (No ZVI / 2% clay)	2% ZVI / 2% clay	2% ZVI / 3% clay	3% ZVI / 2 % clay	2% GMA ZVI / 2% clay	3% GMA iron / 2 % clay
1,1,2,2-PCA Reduction (%)	51%	57%	78%	70%	64%	70%
1,1,2,2-PCA Half Life (days)		57.52	49.70	56.36	46.70	39.25
TCE Reduction (%)	41%	89%	96%	91%	86%	87%
TCE Half Life (days)		17.37	15.34	19.67	20.01	19.72

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\\aphrodite\projects\USNavFaceNGCom\315007CampLejeune\Projects\Site89_NTCRA\Figure_3_1_Site89_BenchScaleSampleLocs.mxd

Legend

- Bench Scale Soil Sample Locations
- Temporary Well Locations

N

0 75 150 Feet

Aerial Photograph taken Feb. 2004

Figure 3-1

Site 89 Bench Scale Sample Locations

Operable Unit No. 16 Site 89

MCB Camp Lejeune, North Carolina

AGVIQ CH2M HILL

4. Removal Action Implementation

The following discussion provides the details associated with implementation of in-situ soil mixing and includes:

- Baseline Sampling
- General Site Preparation
  - Monitoring well abandonment
  - Site clearing
  - Utility and obstruction location
- Soil Mixing Preparation
  - Silt fence installation
  - Overburden excavation
  - Containment berms
  - High visibility fencing installation and maintenance of existing chain-link fence
- Soil Mixing
- Water Management
- Site Restoration
- Survey

To efficiently manage the implementation of the removal action, the treatment area has been divided into three zones, defined as Phases 1, 2, and 3 (**Figure 4-1**). Site preparation, soil mixing, water management, and site restoration will be conducted for each phase in series. Soil mixing preparation will take place for the subsequent phase prior to completion of soil mixing in the preceding phase, so that soil mixing activities are continuous. Monitoring well installation and surveying will be conducted for all three phases at the same time, following the completion of site restoration in Phase 3.

All site operations will be implemented as presented in the Final NTCRA Source Area Treatment Work Plan, the Site-Specific Health and Safety Plan (HSP), Master Field Sampling and Analysis Plan (SAP) and the Master Quality Assurance Project Plan (QAPP) (CH2M HILL, 2004). All activities will be conducted in accordance with these plans.

4.1 Baseline Sampling

4.1.1 Groundwater Monitoring

Groundwater samples will be collected from eleven existing monitoring wells prior to soil mixing (89-MW11, 89-MW11IW, 89-MW18, 89-MW20, 89-MW22, 89-MW23, 89-MW26, 89-MW27, 89-MW28, 89-TW200 and 89-TW201).

Groundwater samples will be collected using low-flow sampling techniques, as described in the MCB Camp Lejeune Master Project Plans. Samples will be hand delivered or delivered via an overnight carrier to an off-site laboratory and analyzed for VOCs by United States Environmental Protection Agency (EPA) Method 8260B, and chloride by EPA Method

325.1/325.3. Geochemical parameters including ferrous iron, dissolved oxygen (DO), conductivity, pH, temperature, turbidity, and oxidation reduction potential (ORP) will be evaluated in the field.

During the pre-treatment groundwater monitoring event, slug tests will be performed on the seven permanent monitoring wells located in the treatment area. Slug testing will be conducted to provide the hydraulic conductivity prior to source area treatment.

4.1.2 Surface Water Monitoring

Four surface water samples will be collected from Edwards Creek prior to soil mixing. One surface water sample will be collected upgradient of the treatment area, two collected adjacent to the treatment area, and one collected downgradient of the treatment area. The locations of surface water samples are shown on **Figure 4-2**. These locations will be permanently marked to ensure that future samples are collected from the same locations.

Surface water sampling will be conducted as described in the MCB Camp Lejeune Master Project Plans. Samples will be hand delivered or delivered via an overnight carrier to an off-site laboratory and analyzed for VOCs by EPA Method 8260B. Parameters including DO, conductivity, pH, temperature, turbidity, and ORP will be evaluated in the field.

4.2 General Site Preparation

The field activity will begin with site preparation. Site preparation will include site clearing, location and removal of all underground utilities and obstructions, and abandonment of monitoring wells within the treatment area. Site preparation will extend to the 10-feet msl ground surface contour to the west, as shown on **Figure 4-1**, beyond which the ground surface slopes steeply towards Edwards Creek. All treatment activities and operations will be limited to this area.

4.2.1 Monitoring Well Abandonment

As shown on **Figure 4-1**, seven two-inch monitoring wells are located within the treatment area: 89-MW18, 89-MW20, 89-MW22, 89-MW23, 89-MW26, 89-MW27, and 89-MW28. The monitoring wells were constructed with both stainless steel and polyvinyl chloride (PVC) casings and screens. Additionally, two one-inch PVC temporary monitoring wells are located within the treatment zone: 89-TW200 and 89-TW201. All of the wells are completed in the shallow zone. These wells will be abandoned prior to implementation of soil mixing. Due to the intrusive nature of the treatment technology, the monitoring wells will not be grouted; rather, they will be removed using an excavator.

All well pads, casings, and screens will be removed and decontaminated. Stainless steel casings and screens recovered during monitoring well abandonment will be separated for recycling on Base. The remaining material will be disposed of at the Base Landfill.

4.2.2 Site Clearing

Prior to mobilizing any excavating or soil mixing equipment, vegetated portions of the treatment area will be cleared. All vegetation, including trees, brush, stumps, and roots, will be removed. This includes approximately 16,500 square feet on the southern and western

boundaries of the treatment area, as shown on **Figure 4-3**. All cleared vegetation will be spread in the woodlands on site south of the treatment area. Trees will be piled in this area as well.

Site 89 is currently bound by a chain link fence with a locked swing gate. Approximately 220 feet of chain link fence on the western site boundary, as shown on **Figure 4-1**, will be removed to allow unrestricted access to the treatment area. Fence poles and concrete bases within the treatment area will also be removed. All chain link fabric, fence poles, and concrete bases will be placed in a dumpster for disposal. To restore site security, approximately 305 feet of new chain link fence will be installed and tied into the remaining fence, as shown on **Figure 4-1**. Warning signs will be posted on the fence indicating that entry is restricted.

4.2.3 Utility and Obstruction Location

There are no known utilities within the treatment area, as shown on **Figure 2-5**. Past investigations at Site 89 indicate that large metal debris has been buried in the southern portion of the treatment area, adjacent to Edwards Creek. A geophysical survey will be conducted in this area to determine if debris will interfere with soil mixing activities. Any debris or obstructions identified will be removed. The survey will also identify any utilities if they are present. Any utilities identified within the treatment area will be rerouted or abandoned.

4.3 Soil Mixing Preparation

Soil mixing preparation consists of those activities required to prepare each phase for treatment. Soil mixing preparation will include silt fence installation, overburden excavation, construction of containment berms, and fencing installation.

4.3.1 Silt Fence Installation

Prior to any excavation, silt fencing will be installed around the treatment area. Silt fences will be inspected daily to ensure that there are no rips, tears, or other issues requiring repair.

4.3.2 Overburden Excavation

Roughly the top three feet of the treatment area will be removed to allow for the volume increase due to fluff and the addition of the ZVI and clay. The excavation will not be shored or sloped. An estimated 3,600 cubic yards of overburden will be removed from the treatment area. It is not anticipated that the overburden is impacted by site contaminants. The soil will be screened with a flame ionization detector (FID) air monitoring device during the excavation. If screening results indicate the potential presence of contaminants, the soil will be stockpiled on plastic within the bermed area and covered until disposal. The soil will be sampled according to the Base Master Plans (CH2M HILL, 2007) to determine the appropriate disposal method. Clean soil will be used for containment berms, as described in Section 4.3.3. The remaining material, estimated to be approximately 2,936 cubic yards, will be stockpiled on site, as shown on **Figure 4-3**, and used for site restoration following soil mixing.

4.3.3 Containment Berms

Containment berms will be implemented to contain soil mixing activities and to protect Edwards Creek. Approximately 664 cubic yards of the excavated overburden will be utilized to construct the berms described below.

Three-foot high containment berms will be constructed on the downgradient side of each treatment area, as shown on **Figure 4-1**, to contain fluff, as described in Section 3.2, and to prevent the uncontrolled discharge of water or sediment from the treatment area to Edwards Creek. These berms will be constructed immediately adjacent to the treatment area, with a fourteen-foot wide base, two-foot wide crest, and a side slope of 2:1, as shown on **Figure 4-1**. The berms will be constructed around the treatment area so that surface runoff and/or displaced groundwater collect along the downgradient edge, facilitating water management.

Three-inch high containment berms will be constructed on the upgradient side, as shown on **Figure 4-1**, to redirect surface flow away from the treatment areas. These berms will be constructed with a 15-inch wide base, 3-inch wide crest, and a side slope of 2:1, as shown on **Figure 4-1**. These berms will be constructed topographically upgradient of the treatment areas to prevent surface flow from running on.

4.3.4 High Visibility Fencing Installation

Approximately 1,400 feet of high visibility fencing will be installed around each treatment area, as shown on **Figure 4-1**, to control access to the work zone. The existing chain-link fence will be maintained during treatment. Warning signs will be posted on the fence indicating that entry is restricted.

4.3.5 Water Management Preparation

A water management system will be set up prior to soil mixing to collect all storm water and displaced groundwater within the active treatment area. The water management system is described in Section 4.5.

4.4 Soil Mixing

In-situ soil mixing will be implemented over approximately 32,400 square feet and will treat approximately 30,000 cubic yards. The depth of the mixing will be approximately 28 feet bgs: mixing will be conducted in a 25-foot deep column after removing approximately the top three feet of soil.

4.4.1 Equipment

Soil mixing will be implemented using 10-foot diameter augers, constructing an approximate total of 515 soil mixing columns, with 18 percent column overlap. A soil mixing drill rig with over 400,000 foot pounds of torque will be utilized. The rig will be equipped with a rotary turntable with swivel and grout hose attachment and hollow stem tooling. The use of a crane may also be required to assemble the mixing equipment.

The mixing tool has three flights with cutting teeth attached to the leading edge. The teeth cut into the soil and the flights and mixing bars lift and mix. As the mixing tool is rotated and penetrates the soil, the ZVI-clay slurry will be pumped from a five cubic yard lightning mixer through the hollow shaft of the Kelly Bar, exiting through the ports located beneath the flights. The Kelly Bar will be graduated to confirm the total depth of treatment.

4.4.2 Materials

ZVI and bentonite super sacks will be stored on site in 1.75-ton and 1.3-ton super sacks, respectively. Each super sack will be delivered with manufacturer's tags specifying the unit weights. One super sack of ZVI and two super sacks of bentonite will be required for each column. While the super sacks are on site prior to use, they will be covered.

The super sacks containing ZVI and bentonite will be moved on site using an off-road fork lift. As needed, the sacks will be moved to the treatment area. Each sack will be equipped with four looped lifting straps (one on each corner) that allow for the contents to drain under gravity.

4.4.3 Process/Mix Recipe

Based on the results of the bench-scale test conducted by CSU, a mixing blend of 2 percent ZVI and 3 percent bentonite, by mass, will be used. The ZVI-bentonite slurry will be prepared in a five cubic yard lightning mixer with the capacity of producing up to 1,000 gallons of this mixture. For each 10-foot diameter column, an estimated 3,495 pounds of ZVI and 5,243 pounds of bentonite will be incorporated. The slurry will be delivered to the rig by way of transfer pumps and injected at the mixing head.

Shallow soil mixing will begin at the southern/downgradient edge of each treatment area. Mixing columns will be installed in a wall-like fashion, perpendicular to groundwater flow. The drill rig will progress towards the northern/upgradient portion of each treatment area. The mixing columns will be laid out using x-y coordinates for centerpoints of the columns, as shown on **Figures 4-4** through **4-6**. These centerpoints will be located in the field using a sub-meter accurate Global Positioning System (GPS) unit. The columns will be advanced as close to vertical as practical. A verticality check will be performed before advancing into the mixing column. The total depth of treatment will be confirmed visually in the field using graduations on the Kelly Bar.

The mixing shaft speed will be adjusted to accommodate a constant rate of mixing and shaft penetration based on the degree of drilling difficulty. Rotation and penetration rates will be adequate to ensure proper mixing and achieve projected production rates. The penetration rate is anticipated to be one to four vertical feet per minute. At a minimum, each column will be double-mixed by raising the mixing auger to the top of the target treatment zone and then re-inserting for further re-mixing.

Water will be added to the dry materials to create the ZVI slurry and hydrate the bentonite. The water will also assist in corroding the ZVI, assisting the degradation process. The amount of water added to the slurry will be tracked using a totalizer and overall use will be minimized. Water will be obtained from a fire hydrant located approximately 850 feet north of the treatment area, outside of the site boundary along G Street. A backflow preventer will be used with the fire hydrant.

4.4.4 Off-Gas Collection and Treatment

Due to high concentrations of chlorinated solvents within the source area, there is the potential risk of creating a hazardous atmosphere for workers on-site during the work.

These emissions will be captured from the mixing zone by a vapor extraction/treatment system connected to the drilling platform by vapor collection shroud. The removable shroud is an open bottom cylinder that covers the surface of the treatment zone while mixing is performed directly beneath. Organic vapors generated during mixing will be captured inside the shroud by applying a negative pressure of 1 to 3 pounds per square inch (psi) inside the shroud with a vacuum blower. The vapors are drawn by vacuum through hoses connected to the shroud to a treatment system. All vapors will be contained and treated using high efficiency particulate air (HEPA) filters and appropriately sized activated carbon unit before discharge to the atmosphere. Organic vapor concentrations within the vacuum lines and discharge port will be periodically monitored to determine the effectiveness of the vapor treatment system. When mixing is completed, the blades of the mixing auger are retracted inside the shroud and the unit is moved to the next location. Use of the removable shroud will allow workers to execute this WP in Level D modified personal protective equipment (PPE).

4.4.5 Quality Assurance and Quality Control

During soil mixing, field testing will be conducted for quality assurance and quality control purposes. Periodically during the mixing process, freshly blended slurry mixes will be sampled to ensure thorough mixing.

JV I will use several methods, as listed below, to verify that the soil mixing meets the design mix recipe:

- The quantities of materials will be confirmed by verifying the manufacturer tags on the ZVI and bentonite super sacks.
- Mixed soil samples will be collected, as described below.
- At the end of each day, JV I shall compare recorded results and quantities with the soil mixing Subcontractor's records. Any discrepancies shall be resolved. If resolution is not possible, discrepancies will be noted and the JV I project manager will be notified. A copy of this daily log is contained in **Appendix A**.

The soil mixing Subcontractor will collect samples of the treated soil so that JV I can test the iron content in the field to ensure adequate mixing throughout the column. A separation method will be used in the field in order to obtain results within a short time frame (results should be available within 2 hours). If the results indicate that thorough mixing throughout the treatment area has not been achieved (greater than 25 percent variation [ZVI range from 1.5 percent to 2.5 percent] across the column or large visual observations of unmixed material), the number of passes through the mixing column will be increased.

Initially, more samples will be collected so that adjustments can be made to the mixing method. During the first week of mixing, two locations per day will be sampled. Three samples will be collected from different depths of the first column mixed in each treatment area. Subsequent sampling will occur at two depths per location. After the first week, two

samples will be collected from one column per day for iron content analysis. Periodically, soil collected for QA/QC will be split and a sample will be sent to an off-site laboratory for analysis of VOCs, as described in Section 5.1.1.

Samples will be collected at discrete depths within mixing columns using a sampling device that will be driven and retrieved from the target depth. The iron content of the discrete sample will be analyzed by magnetic separation and water content testing as follows:

Water Content Test

1. Weigh out approximately 25 grams of treated soil sample
2. Dry sample on a hot plate
3. Weigh the dry sample and calculate the water content

Magnetic Separation Test

1. Weigh out approximately 150 grams of treated soil sample
2. Add 150 to 200 milliliters (mL) of deionized water to the treated soil sample
3. Mix solution until soil particles are dispersed
4. Pass a high powered magnet wrapped in cellophane through the slurry until all magnetic iron is removed
5. Remove the iron from the magnet and dry on a hot plate
6. Grind dry iron with mortar and pestle to remove any remaining soil adhering to iron
7. Use high powered magnet wrapped in cellophane to remove iron from dried soil
8. Weigh the iron and calculate the fraction of iron by dividing by the mass of iron by the dry mass of soil

4.4.6 Recordkeeping

A daily log will be used to document the soil mixing activities. The daily log will be updated for each mixing column and will include information such as start and end times of mixing, rate, ZVI-clay dose, volume of water incorporated, number of auger passes, rate of descent, and percent iron. A copy of this daily log is contained in **Appendix A.**

4.4.7 Overburden Backfilling

To minimize the duration of the open excavation, backfilling activities will commence once approximately 30 percent of each treatment area has been mixed, with the exception of Phase 3, which will be backfilled following the completion of soil mixing.

Each treatment area will be covered with an 8-ounce per square yard woven geotextile fabric. The liner panels will be overlapped in the field to cover the entire area and extend five feet beyond the area in all directions. Upon completion of lining the area, the panel will be secured at the edges with stake pins.

When installation of the geotextile is complete, the stockpiled soil from the excavation will be spread across the treatment area to cover the mixed material and assist in consolidating the treatment matrix. The berms will be also be pushed over and spread across the treatment area. The site will be graded to provide drainage away from the treatment area.

4.5 Water Management

All storm water and displaced groundwater within the active treatment areas will be collected and treated prior to disposal to the Base sanitary sewer system. A low elevation collection sump pump will be placed in the downgradient corner of each treatment area and connected to 350 to 400 feet of hose/piping that leads to a 6,000 gallon storage container. A water treatment system will be installed to the northwest of Building TC952, as shown on **Figure 4-7**. As necessary, the contents of the storage container will be pumped into a 100-micron bag filter to remove solids, then to two 250-pound granular activated carbon units in series to remove VOCs. A generalized process flow diagram of the water treatment system is shown on **Figure 4-8**. One sample will be collected prior to the first carbon unit, prior to the second carbon unit, and following the second carbon unit. Samples will be collected at startup and for every 20,000 gallons treated and analyzed for VOCs by EPA Method 8260B with a 24-hour turnaround time. At startup, the first batch of treated water will be recirculated to the storage tank until analytical results are received. Treated water will be discharged to the Base sanitary sewer system through a manhole. A totalizer will be utilized to track the volume of water discharged.

4.6 Site Restoration

4.6.1 Seeding

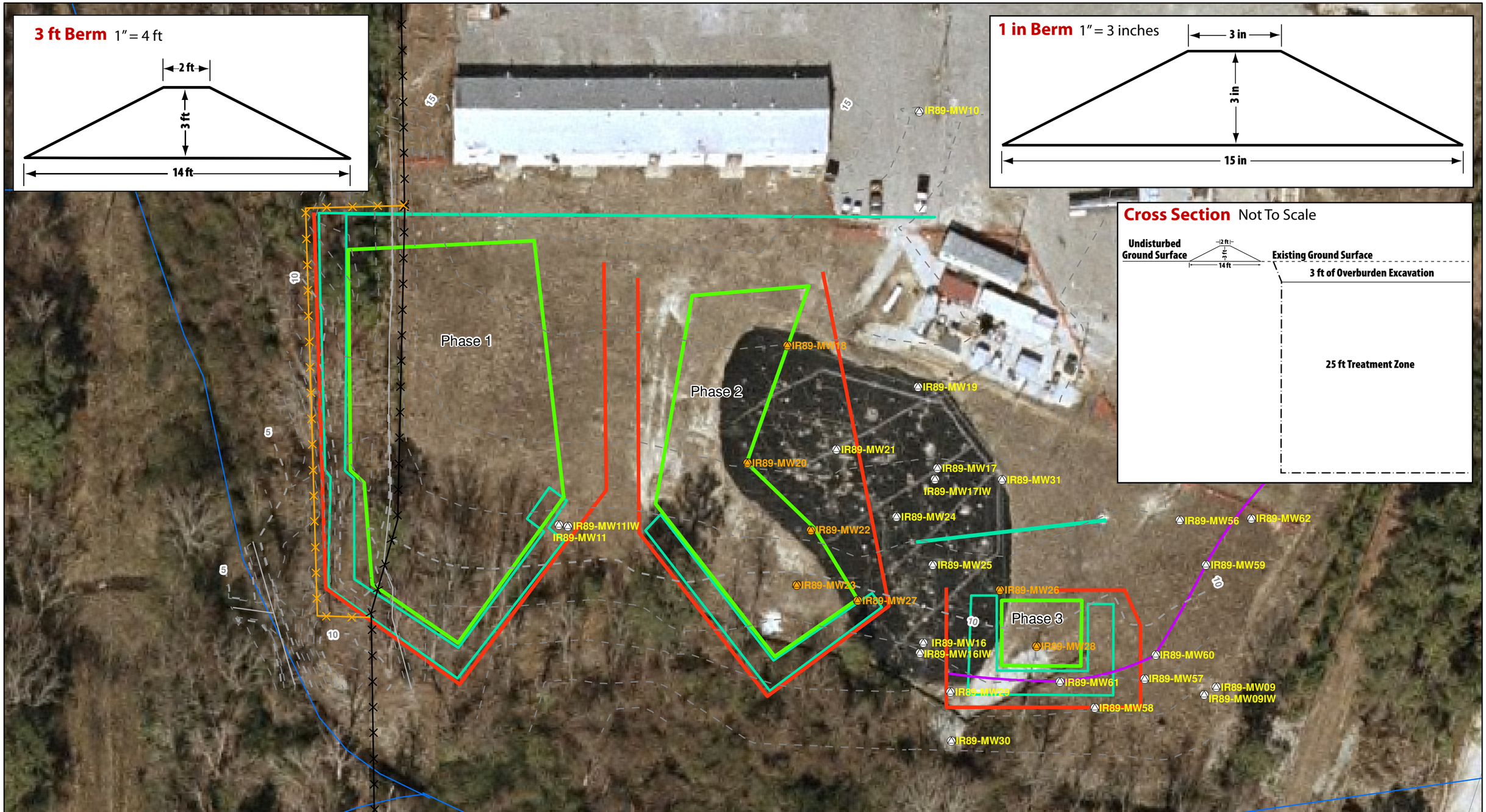
All disturbed areas will be graded and vegetated with seed. The seeding will consist of a fescue grass mix distributed evenly by hand across the area to ensure permanent grass cover and prevent soil erosion.

4.6.2 Monitoring Wells

Nine monitoring wells will be installed following source area treatment: 89-MW63 through 89-MW71. Proposed well locations are shown on **Figure 4-9**. All new monitoring wells will be set 23 feet bgs with 5 feet of PVC screen. Refer to the Master SAP (CH2M HILL, 2004) for well installation procedures.

4.7 Survey

Following the remedial action, post-construction conditions will be surveyed within and around the treatment zone. The limits of the treatment area, the extent of post-construction site restoration, and locations and elevations of monitoring wells and soil borings will be referenced both horizontally and vertically. The surveyor will provide coordinates of all horizontal points to the nearest 0.01 feet and vertical points to the nearest 0.01 foot (0.1 foot for unpaved ground surface elevations). Coordinates will be provided in the appropriate State Plane Coordinate System (SPCS) and zone (latest adjustment) for the area. The horizontal and vertical datum(s) will be the North American Datum (NAD) 83 (latest adjustment) for horizontal and North American Vertical Datum (NAVD) 88 for the vertical.



Legend

- Monitoring Wells to be Removed Prior to Treatment
- Monitoring Well Locations (Will not be abandoned during treatment. Care must be taken to avoid damage to or destruction of these wells)
- Fenceline (to be installed)
- Fenceline (to be removed within treatment area)
- High Visibility Fencing
- PRB
- Creek
- DTM Contours Major
- DTM Contours Minor
- Exist DTM Drainline
- Soil Mixing Treatment Areas
- Containment Berms

DTM = Digital Terrain Model

N

0 50 100 Feet

Aerial Photograph taken Feb. 2004

Figure 4-1
Soil Mixing Treatment Area Detail
Operable Unit No. 16 Site 89
MCB Camp Lejeune, North Carolina

AGVIQ CH2M HILL

ES022008003KNV cross sections_rev4.ai

\\ariadne\groups\gis\USNavFaceNGCom\Projects\Site89_NTCRA_WP\Figure_4_2_Proposed_SW_Sampling_Location.mxd

Legend

- Proposed Surface Water Sampling Locations
- Streams
- Site 89 Boundary
- Surface Water Flow Direction

N

0 75 150 Feet

Figure 4-2
Proposed Surface Water Sampling Locations
Operable Unit No.16 Site 89
MCB, Camp Lejeune
North Carolina

AGVIQ CH2M HILL

Legend

- Existing Fence With Locked Gate
- Proposed Staging Area
- Soil Mixing Treatment Areas
- Area to be cleared of vegetation

N

0 50 100 Feet

Aerial Photograph taken Feb. 2004

Figure 4-3
Soil Mixing Overview
Operable Unit No. 16 Site 89
MCB Camp Lejeune, North Carolina

AGVIQ CH2M HILL

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\\aphrodite\proj\USNavFaceNGCom\315007CampLejeune\Projects\Site89_NTCRA_WP\Figure_4-4_phase1_Soil_Mixing_Treatment_Area_Detail.mxd

Legend

- Proposed Soil Sample Locations
- Fenceline (to be installed)
- Fenceline (to be removed within treatment area)
- DTM Contours Major
- DTM Contours Minor
- Exist DTM Drainline

DTM - Digital Terrain Model

- Creek
- PRB
- High Visibility Fencing
- Containment Berms
- In-Situ Soil Mixing Columns
- Soil Mixing Treatment Areas

N

0 20 40 Feet

Aerial Photograph taken Feb. 2004

Figure 4-4
Phase 1 Soil Mixing Detail
Operable Unit No. 16 Site 89
MCB Camp Lejeune, North Carolina

AGVIQ ENVIRONMENTAL SERVICES
CH2M HILL JOINT VENTURE

\\aphrodite\proj\USNavFaceNGCom\315007CampLejeune\Projects\Site89_NTCRA_WP\Figure_4-5_Phase2_Soil_Mixing_Treatment_Area_Detail.mxd

Legend

- Proposed Soil Sample Locations
- DTM Contours Major
- DTM Contours Minor
- Exist DTM Drainline
- Creek
- PRB
- High Visibility Fencing
- In-Situ Soil Mixing Columns
- Containment Berms
- Soil Mixing Treatment Areas

DTM - Digital Terrain Model

N

0 20 40 Feet

Aerial Photograph taken Feb. 2004

Figure 4-5
Phase 2 Soil Mixing Detail
Operable Unit No. 16 Site 89
MCB Camp Lejeune, North Carolina

AGVIQ ENVIRONMENTAL SERVICES
CH2M HILL JOINT VENTURE

\\aphrodite\proj\USNavFaceNGCom\315007CampLejeune\Projects\Site89_NTCRA_WP\Figure_4-6_Phase3_Soil_Mixing_Treatment_Area_Detail.mxd

Legend

- Proposed Soil Sample Locations
- DTM Contours Major
- DTM Contours Minor
- Exist DTM Drainline
- Creek
- PRB
- High Visibility Fencing
- In-Situ Soil Mixing Columns
- Containment Berms
- Soil Mixing Treatment Areas

DTM - Digital Terrain Model

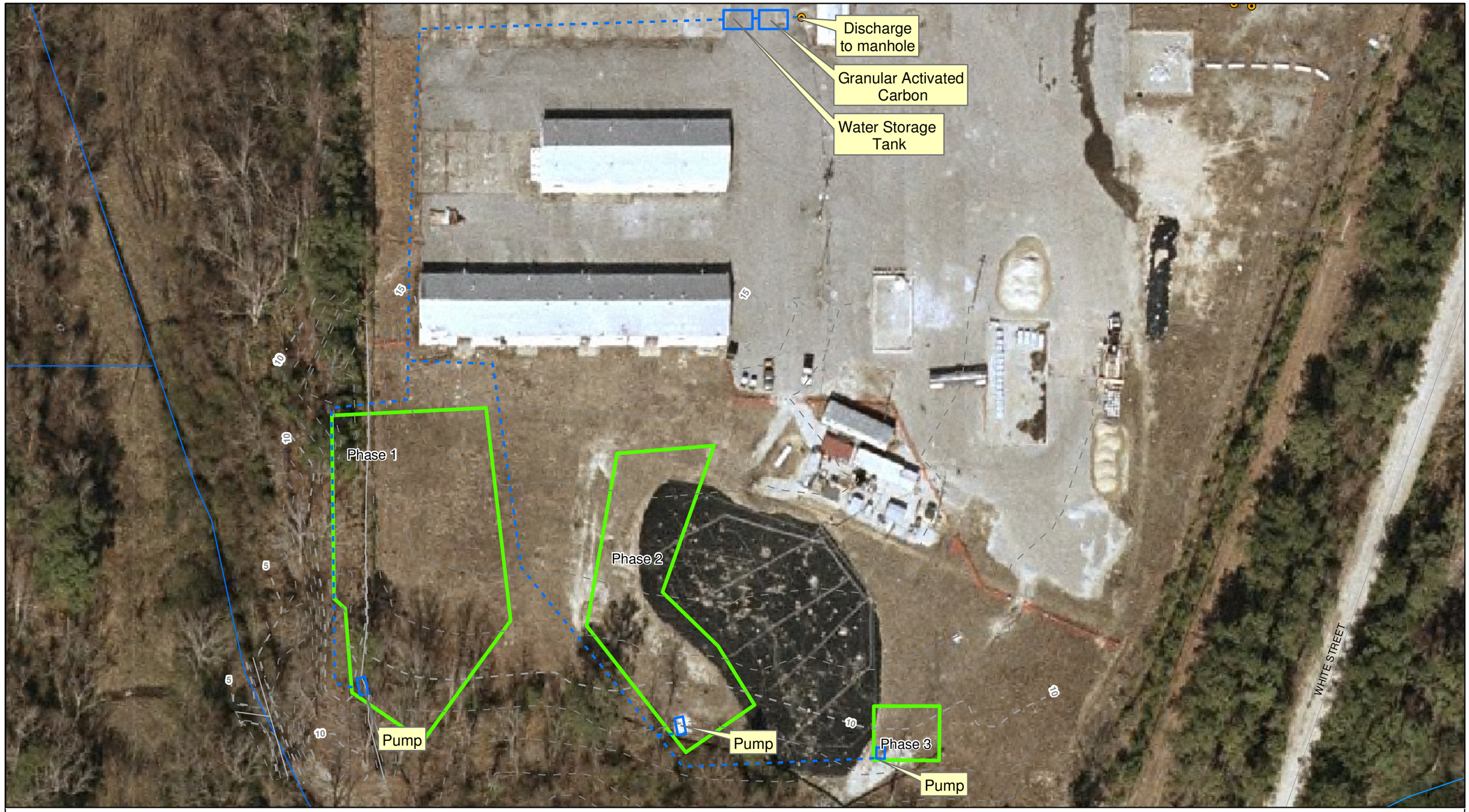
N

0 20 40 Feet

Aerial Photograph taken Feb. 2004

Figure 4-6
Phase 2 Soil Mixing Detail
Operable Unit No. 16 Site 89
MCB Camp Lejeune, North Carolina

AGVIQ CH2M HILL



Legend

- Soil Mixing Treatment Areas
- Creek
- Hose/pipe layout (depending on phase of work)
- DTM Contours Major
- DTM Contours Minor
- Exist DTM Drainline

DTM - Digital Terrain Model

N

0 50 100 Feet

Aerial Photograph taken Feb. 2004

Figure 4-7
Water Management Layout
Operable Unit No. 16 Site 89
MCB Camp Lejeune, North Carolina

AGVIO
CH2M HILL

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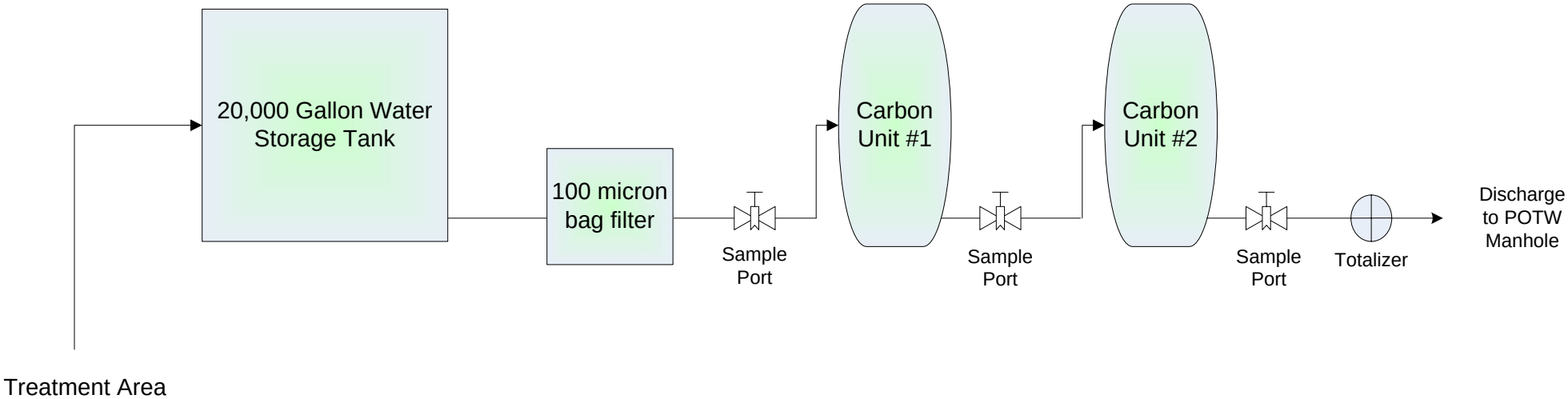

Figure 4-8
General Water Treatment Process Flow Diagram
Operable Unit No. 16, Site 89
MCB Camp Lejeune, NC

Legend

- Proposed Monitoring Well Locations
- Monitoring Well Locations
- PRB
- Creek
- DTM Contours Major
- DTM Contours Minor
- Exist DTM Drainline
- Soil Mixing Treatment Areas

DTM - Digital Terrain Model

N

0 50 100 Feet

Aerial Photograph taken Feb. 2004

Figure 4-9
Proposed Monitoring Well Locations
Operable Unit No. 16 Site 89
MCB Camp Lejeune, North Carolina

AGVIQ CH2M HILL

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5. Monitoring

As part of this NTCRA, post-treatment monitoring of soil, groundwater, and surface water will be conducted. Post-treatment data will be compared to baseline monitoring with the intent of evaluating the overall effectiveness of the remedial action. Additionally, surface water will be monitored during treatment to evaluate impact to Edwards Creek.

5.1 Monitoring During Treatment

5.1.1 Soil Sampling

Periodically throughout treatment, a soil sample will be split from the soil collected for QA/QC for baseline laboratory analysis, as described in Section 4.4.5. It is anticipated that 10 to 20 samples will be collected over the course of the soil mixing. Samples will be hand delivered or delivered via an overnight carrier to an off-site laboratory and analyzed for VOCs by EPA Method 8260B. Proposed soil sampling locations are identified on **Figures 4-4** through **4-6**; however, actual sampling locations may differ based on field production.

5.1.2 Surface Water Sampling

Surface water samples will be collected on a monthly basis during soil mixing activities to evaluate any effects of soil mixing on the creek. Samples will be collected from the four surface water locations identified during the pre-treatment monitoring event, as shown on **Figure 4-2**.

Surface water sampling will be conducted as described in the MCB Camp Lejeune Master Project Plans. Samples will be hand delivered or delivered via an overnight carrier to an off-site laboratory and analyzed for VOCs by EPA Method 8260B. Parameters including DO, conductivity, pH, temperature, turbidity, and ORP will be evaluated in the field.

5.2 Post-Treatment Monitoring

5.2.1 Soil Sampling

Post-treatment soil sampling will be conducted at approximately one, three, six, nine, and twelve months after soil mixing.

Based on the analytical results of the baseline soil sampling described in Section 5.1.1, twelve sample locations will be identified for post-treatment monitoring. During each soil sampling event, twelve borings will be advanced using DPT to a depth of 20 feet bgs immediately following soil mixing. The boring locations will be permanently marked during the initial post-treatment sampling event and recorded with a handheld GPS unit to ensure that samples are collected from similar locations during future events.

Two soil samples will be collected from each soil boring at depths of 10 feet bgs and 20 feet bgs. Soil sampling will be conducted as described in the MCB Camp Lejeune Master Project

Plans. Samples will be hand delivered or delivered via an overnight carrier to an off-site laboratory and analyzed for VOCs by EPA Method 8260B.

5.2.2 Groundwater Monitoring

Ten monitoring wells (89-MW11 and 89-MW63 through 89-MW71) will be sampled at one, three, six, nine, and twelve months after soil mixing.

Groundwater sampling will be conducted as described in the MCB Camp Lejeune Master Project Plans. Samples will be hand delivered or delivered via an overnight carrier to an off-site laboratory and analyzed for VOCs by EPA Method 8260B, and chloride by EPA Method 325.1/325.3. Geochemical parameters including ferrous iron, DO, conductivity, pH, temperature, turbidity, and ORP will be evaluated in the field.

During the six-month post-treatment groundwater monitoring event, slug tests will be performed on the nine new wells to evaluate the hydraulic conductivity following source area treatment.

5.2.3 Surface Water Monitoring

Post-treatment surface water sampling will be conducted quarterly for one year (3, 6, 9, and 12 months) following soil mixing. Samples will be collected from the four surface water locations identified during the pre-treatment monitoring event, as shown on **Figure 4-2**.

Surface water sampling will be conducted as described in the MCB Camp Lejeune Master Project Plans. Samples will be hand delivered or delivered via an overnight carrier to an off-site laboratory and analyzed for VOCs by EPA Method 8260B. Parameters including DO, conductivity, pH, temperature, turbidity, and ORP will be evaluated in the field.

6. Waste Management

Wastes generated during the project will be managed to protect the public and the environment. Where possible, material will be reused and recycled. Section 3.17, "Investigation Derived Waste (IDW) Handling" of the Master SAP provides general information for the characterization, handling, and disposal of contaminated wastes expected to be encountered or generated during this work (CH2M HILL, 2005).

6.1 Waste Streams

The waste streams associated with this scope of work may include, but is not limited to:

- Removed surface vegetation
- Removed chain-link fence
- Monitoring well abandonment debris
- Impacted soil overburden
- Water collected from treatment area
- Development water from the monitoring wells
- Decontamination fluids
- Soil cuttings from installation of monitoring wells and soil borings
- PPE
- Used sampling supplies
- Uncontaminated general construction debris

6.2 Waste Management

All IDW management actions should be documented in the field notes. Specific waste management procedures are documented in the IDW Standard Operating Procedure (SOP) and summarized in **Table 6-1**.

Table 6-1
Summary of Waste Management Procedures
Site 89 NTCRA Work Plan
MCB Camp Lejeune, North Carolina

Waste Material	Description	Management Procedure
Removed Surface Vegetation	Vegetation, including heavy brush and trees, cleared from 16,500 square feet of the treatment area.	All removed vegetation will be spread on site in the woodlands south of the treatment area. Trees will be piled in this area as well.
Removed Chain Link Fence	Approximately 300 feet of chain link fence, including fence poles and concrete bases, will be removed from the treatment area.	All fence debris will be placed in a dumpster for disposal at the Base Landfill.
Monitoring Well Abandonment Debris	Well pads, casings, and screens of seven monitoring wells to be abandoned	Recovered stainless stell will be decontaminated and recycled on Base. Remaining materials will be decontaminated on site and disposed of at the Base Landfill.
Impacted Overburden	Any soil removed during excavation of overburden that exceeds a sustained reading of 50 ppm VOCs as detected by a FID.	Impacted soil will be stockpiled on liner and covered to prevent contamination of surrounding areas. The soil will be sampled according to the Base Master Plans (CH2M HILL, 2007) to determine the appropriate disposal method.
Water Collected from Treatment Area	Surface runoff and/or displaced groundwater from the treatment areas	Will be collected, treated, and discharged, as described in Section 4.5
Decontamination Fluids/Development Water	Decontamination fluids from equipment, development water generated during monitoring well installation and monitoring well sampling.	Any decontamination fluids or development water from monitoring wells generated while the water treatment system is on site will be treated and discharged as described in Section 4.5. Any decontamination fluids or development water from monitoring wells generated after the water treatment system has been decommissioned will be contained either in Department of Transportation (DOT) approved 55-gallon drums or in bulk containers. The drums will be moved by an IDW subcontractor to a temporary storage area located near the site access gate. Samples will be collected to characterize the waste. The containers will be stored there until analytical results are available and then disposed of appropriately by the IDW subcontractor.

Table 6-1
Summary of Waste Management Procedures
Site 89 NTCRA Work Plan
MCB Camp Lejeune, North Carolina

Waste Material	Description	Management Procedure
Soil Cuttings	Soil cuttings will be generated during the installation of monitoring wells and soil borings.	Soil cuttings generated during the installation of monitoring wells will be containerized in DOT-approved 55-gallon drums and moved to a temporary storage area located near the site access gate. Soil samples will be collected to characterize the waste and to determine if the soil may be disposed of at the Base Landfill. A hand-auger will be used to collect representative soil samples from the storage drums. Samples will be analyzed for VOCs, full toxic characteristic leaching procedure (TCLP), reactivity, ignitability, corrosivity, total petroleum hydrocarbons (TPH), gasoline range organics (GRO), and diesel range organics (DRO). If analysis indicates that soil may not be disposed of at the Base Landfill, the IDW subcontractor will remove the material for off-site treatment and disposal. Soil cuttings generated during the installation of soil borings will be returned to the borehole.
PPE and Trash	PPE associated with the generation of non-hazardous waste and PPE associated with the potential generation of hazardous waste	PPE associated with the generation of non-hazardous waste will be collected in black, non-translucent trash bags and disposed of in a dumpster aboard MCB Camp Lejeune for disposal in the Base Landfill. PPE associated with the generation of hazardous waste will be properly containerized and disposed of at an offsite Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-approved, Resourc Conservation and Recovery Act (RCRA) Subtitle C treatment, storage, or disposal facility.

7. Health and Safety Considerations

7.1 Health and Safety Plans

Development of a comprehensive HSP will be the combined responsibility of JV I and Subcontractors. The HSP will address the potential hazards associated with heavy equipment use, and will be maintained on-site during all field activities. A JV I site representative will be on-site at all times to ensure that all tasks are completed in compliance with this HSP. Any Subcontractor-developed plans will be secondary to the JV I HSP.

As project activities become better defined over time, addenda to the HSP will be prepared by the JV I Project Health and Safety Manager (PHSM) to address specific activities and the hazardous control measures associated with them. In this manner, the HSP will be considered a "living document", to be reviewed and updated as necessary.

The HSP does not address hazards associated with specialized remedial implementation tasks and equipment (such as operation of a drill rig). Accordingly, specialty Subcontractors are responsible for health and safety procedures specific to their particular work components, and are required to develop and submit a HSP to JV I for review prior to the start of fieldwork. Subcontractors must comply with the established HSP. JV I must monitor and enforce compliance with the established HSP.

The Subcontractors will be responsible for generating activity hazard analyses (AHAs) prior to commencement of that activity (soil mixing, drilling, etc.) AHAs identify potential hazards associated with a task (pinch points, chemical exposure, heat exposure, etc.) and describe the critical safety practices to protect workers from those hazards. PPE is identified for each task. AHAs are to be reviewed during daily health and safety briefings, whenever starting a new task, or if conditions change.

7.2 Technology-Specific Consideration

Soil mixing requires the use of heavy equipment, including, but not limited to, a drill rig and an excavator. Physical safety associated with the use of this equipment will be a major concern. Barriers around the site, clear worker communication, and a proactive operation and maintenance program will be required.

Due to high concentrations of VOCs in the subsurface within the treatment area and the low threshold limit values (TLVs) of site contaminants, there is the potential risk of creating a hazardous atmosphere for workers during soil mixing; therefore, as described in Section 4.4.4, a vapor collection shroud will be utilized and is expected to maintain the quality of the atmosphere in the breathing zone. In addition, a strict air monitoring program will be implemented. An exclusion zone will be established and only necessary personnel will be permitted within this area during soil mixing. The breathing zone of all site personnel will be monitored.

7.3 General Hazards

Inclement weather conditions may occur without warning and are a concern during soil mixing activities. It will be the responsibility of the Site Safety Coordinator (SSC) to halt work in the case of eminent danger. In the event that extreme weather conditions caused by high winds, hurricanes, etc., arise, site personnel will secure or remove all site facilities, materials, and equipment; secure temporary utilities where possible; verify equipment tie-downs; and cover all exposed openings in existing facilities to minimize potential wind and water damage. The SSC will also be responsible to commence work once the danger has passed.

The hurricane season in the immediate area surrounding Camp Lejeune begins on June 1 and continues through November 30. Storms of non-tropical origins such as frontal passages, local thunderstorms, and tornadoes are much more frequent and can occur year-round.

Housekeeping and maintaining the cleanliness of the site will be a priority during construction activities to minimize the potential of foreign object debris dangers to personnel and equipment during inclement weather conditions.

8. Site Activity Considerations

Several considerations related to the execution of the source area treatment at Site 89 include, but are not limited to, the following:

- During working hours, Subcontractors or JV I will secure the working area (to be determined in the field).
- During non-working hours, the soil mixing Subcontractor will be responsible for securing their equipment and other appurtenances at the site.
- Site access during the project will be limited to authorized personnel only.

9. Reporting

A Summary Report will be prepared to document the source area treatment field activities and analytical activities and results. The report will include:

- Results of baseline sampling and subsequent sampling for soil, groundwater, and surface water;
- Summary of construction activities.

The draft Summary Report will be submitted to the Partnering Team for review. Review comments will be addressed in the final Summary Report.

10. Schedule and Project Organization

This section of the WP briefly describes the schedule, project management organization, responsibilities of project personnel, procedures for WP deviations, and internal quality control. The implementation of an effective management plan will help ensure that the objectives of the WP are achieved.

10.1 Schedule

The proposed schedule for implementing the source area treatment at Site 89 is presented in **Figure 10-1**. The tasks presented in the source area treatment schedule correspond to the tasks identified in this WP.

As described in Section 4, the treatment area has been divided into three zones, defined as Phases 1, 2, and 3. General site preparation activities will be conducted for all three phases at the same time. Soil mixing preparation, soil mixing, water management, and site restoration will then be conducted for each phase in series. Soil mixing preparation will take place for the subsequent phase prior to completion of soil mixing in the preceding phase, so that soil mixing activities are continuous. Monitoring well installation and surveying will be conducted for all three phases at the same time, following the completion of site restoration in Phase 3.

10.2 Project Organization

The project organization is presented in **Figure 10-2**. The Partnering Team includes representatives from NAVFAC Mid-Atlantic, MCB Camp Lejeune, North Carolina Department of Environment and Natural Resources (NCDENR), and EPA Region IV.

Ms. Jessica Skeean, Professional Engineer (P.E.) is the JV I/CH2M HILL Project Manager for the source area treatment. She is the primary JV I contact and is responsible for overall project management and the overall quality assurance and quality control (QA/QC) of project deliverables.

Mr. Matt Louth, Professional Geologist (P.G.) will serve as JV I's Activity Manager for MCB Camp Lejeune by providing overall guidance with regards to NAVFAC and Camp Lejeune.

Mr. Chris Bozzini, P.E. will serve as Senior Consultant for the source area treatment. Mr. Bozzini will review the technical aspects of the work from project scoping to project completion.

Mr. Rich Rathnow, Certified Industrial Hygienist (CIH), Certified Safety Professional (CSP), and Mr. Glen Jackson, CIH, CSP, are the Project Health and Safety Managers. They will determine appropriate hazardous control measures for the various site activities.

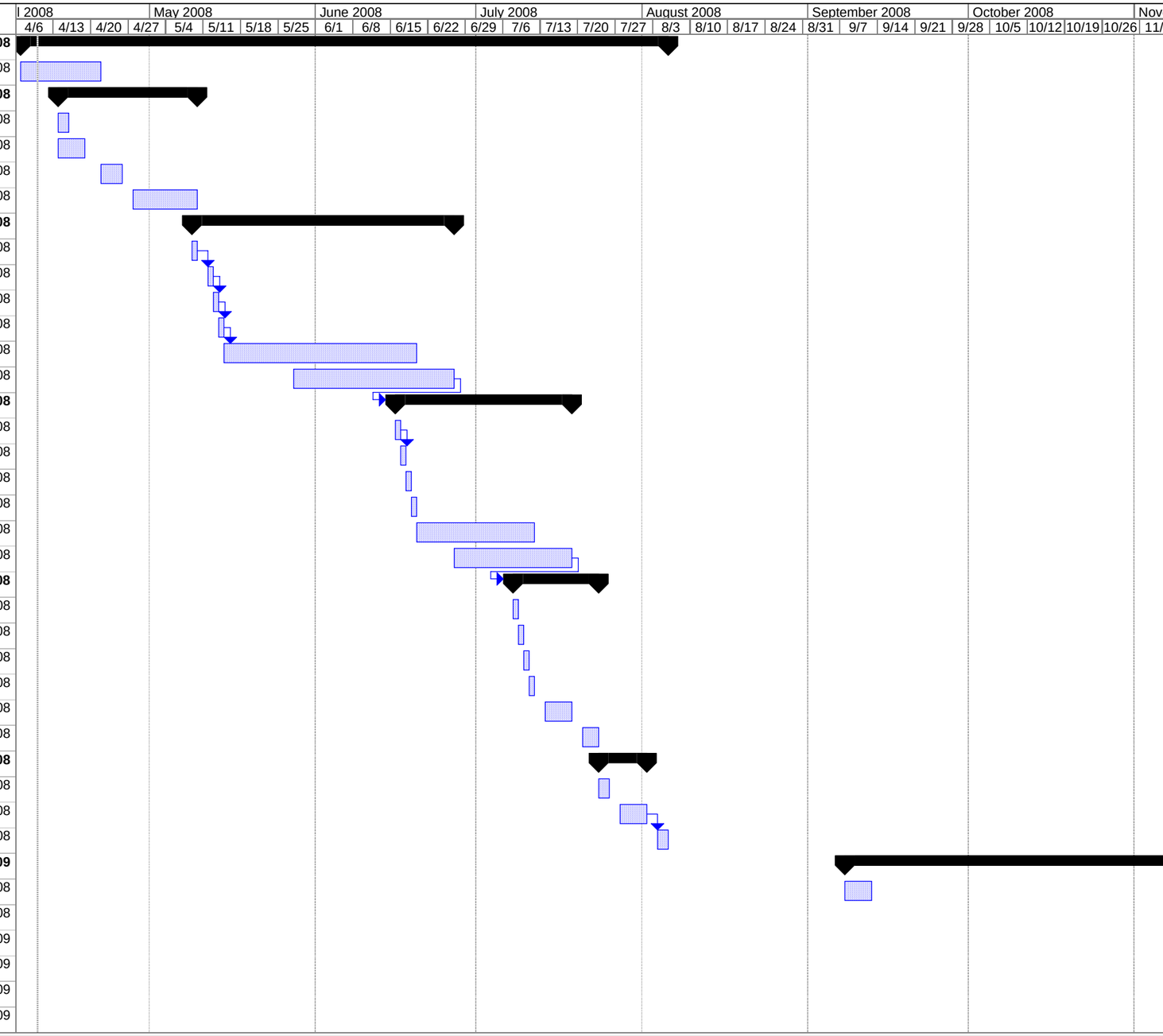
The project team will include: Task Managers, Project Engineer, Project Hydrogeologist, field team leader (FTL)/SSC, and Data Manager. All field and Subcontractor activity will be under the direction of the FTL.

10.3 Work Plan Deviations

If in the event that significant deviation is made from the WP, the Partnering Team will be notified prior to any decision. The issue will be identified and consensus on a course of action will be obtained. Deviation would be the significant elimination of work described in this WP – such as eliminating samples, eliminating phases of work, or changing analytical parameters. Deviations such as moving or adding sample location in order to assess treatment effectiveness will not be considered significant and will be conducted at the discretion of the project team.

Figure 10-1
Proposed Project Schedule
Site 89 NTCRA Work Plan
MCB Camp Lejeune, North Carolina

ID	Task Name	Start	Finish
1	**Remedial Action**	**Mon 4/7/08**	**Tue 8/5/08**
2	Mobilization	Mon 4/7/08	Mon 4/21/08
3	**General Site Preparation**	**Mon 4/14/08**	**Fri 5/9/08**
4	Utility Locate/Geophysical Survey	Mon 4/14/08	Tue 4/15/08
5	MW and SW Baseline Sampling and Abandonment	Mon 4/14/08	Fri 4/18/08
6	Site Clearing	Tue 4/22/08	Fri 4/25/08
7	Site Preparation/Material Staging	Mon 4/28/08	Fri 5/9/08
8	**Phase 1 Soil Mixing**	**Fri 5/9/08**	**Thu 6/26/08**
9	Install Silt Fence	Fri 5/9/08	Fri 5/9/08
10	Overburden Excavation	Mon 5/12/08	Mon 5/12/08
11	Install Berms and Water Management System	Tue 5/13/08	Tue 5/13/08
12	Fencing Installation	Wed 5/14/08	Wed 5/14/08
13	Soil Mixing	Thu 5/15/08	Thu 6/19/08
14	Overburden Backfill	Wed 5/28/08	Thu 6/26/08
15	**Phase 2 Soil Mixing**	**Mon 6/16/08**	**Fri 7/18/08**
16	Install Silt Fence	Mon 6/16/08	Mon 6/16/08
17	Overburden Excavation	Tue 6/17/08	Tue 6/17/08
18	Install Berms and Water Management System	Wed 6/18/08	Wed 6/18/08
19	Fencing Installation	Thu 6/19/08	Thu 6/19/08
20	Soil Mixing	Fri 6/20/08	Fri 7/11/08
21	Overburden Backfill	Fri 6/27/08	Fri 7/18/08
22	**Phase 3 Soil Mixing**	**Tue 7/8/08**	**Wed 7/23/08**
23	Install Silt Fence	Tue 7/8/08	Tue 7/8/08
24	Overburden Excavation	Wed 7/9/08	Wed 7/9/08
25	Install Berms and Water Management System	Thu 7/10/08	Thu 7/10/08
26	Fencing Installation	Fri 7/11/08	Fri 7/11/08
27	Soil Mixing	Mon 7/14/08	Fri 7/18/08
28	Overburden Backfill	Mon 7/21/08	Wed 7/23/08
29	**Site Restoration**	**Thu 7/24/08**	**Fri 8/1/08**
30	Topsoil Addition and Seeding	Thu 7/24/08	Fri 7/25/08
31	MW Installation	Mon 7/28/08	Fri 8/1/08
32	Post-Treatment Survey	Mon 8/4/08	Tue 8/5/08
33	**Monitoring**	**Mon 9/8/08**	**Fri 8/14/09**
34	Monitoring - 1 month (soil and gw)	Mon 9/8/08	Fri 9/12/08
35	Monitoring - 3 month (soil, gw, sw)	Mon 11/10/08	Fri 11/14/08
36	Monitoring - 6 month (soil, gw, sw)	Mon 2/9/09	Fri 2/13/09
37	Monitoring - 9 month (soil, gw, sw)	Mon 5/11/09	Fri 5/15/09
38	Monitoring - 12 month (soil, gw, sw)	Mon 8/10/09	Fri 8/14/09
39	Summary Report	Mon 8/17/09	Fri 9/25/09



Project: Figure 10-1 TO-80 schedule.n
Date: Thu 4/10/08

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Figure 10-1
Proposed Project Schedule
Site 89 NTCRA Work Plan
MCB Camp Lejeune, North Carolina

Project: Figure 10-1 TO-80 schedule.n
Date: Thu 4/10/08

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

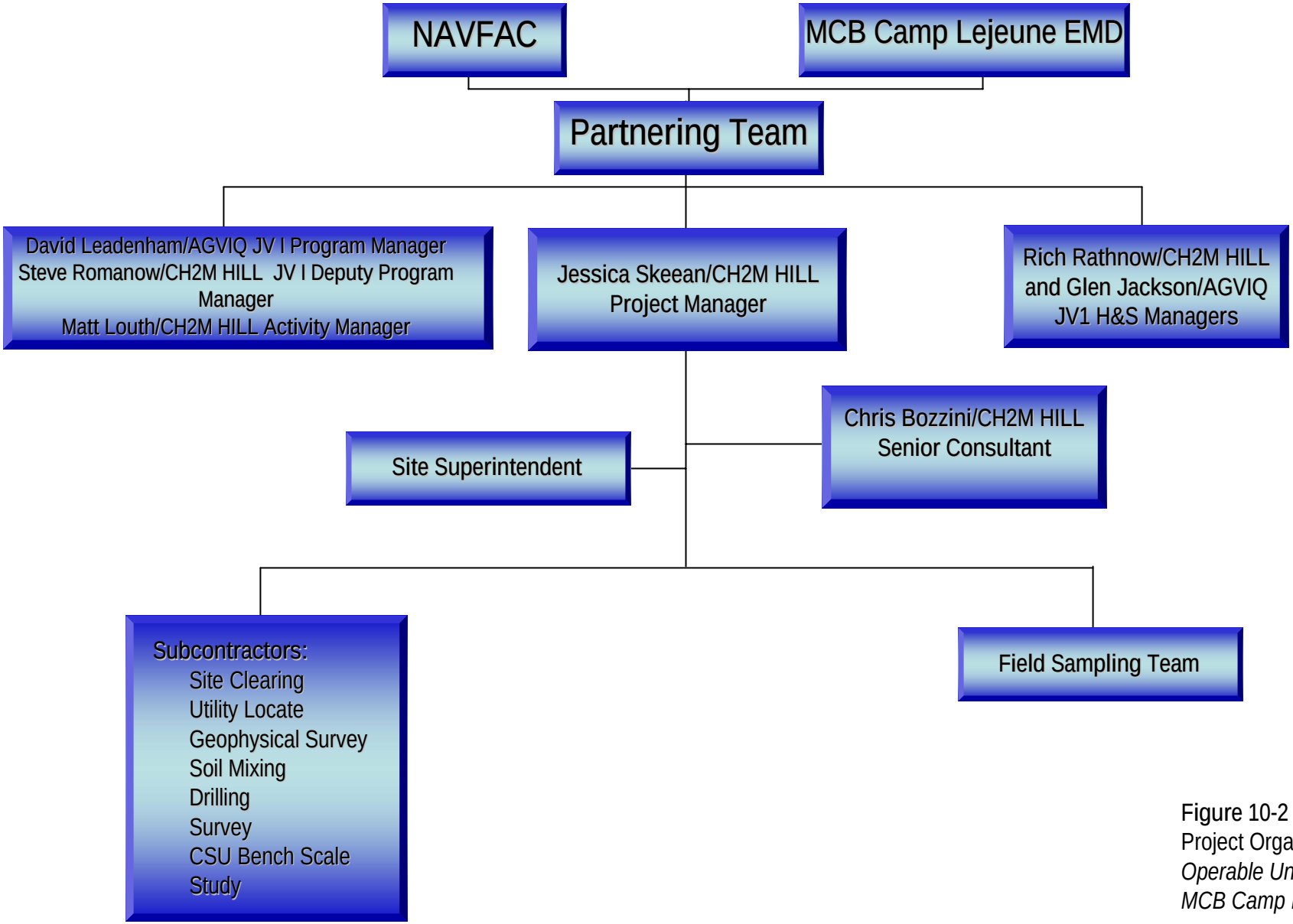


Figure 10-2
Project Organization
Operable Unit No. 16, Site 89
MCB Camp Lejeune, NC

11. References

(Draft) Action Memorandum, Site 89 Operable Unit No. 16. AGVIQ-CH2M HILL Joint Venture I, August 2007

(Draft Final) Comprehensive Remedial Investigation, Site 89 – Operable Unit No. 16, Former Defense Reutilization and Marketing Office. CH2M HILL, August 2007.

(Draft) Master Project Plans, Marine Corps Base Camp Lejeune, North Carolina. CH2M HILL, June 2004.

(Final) Engineering Evaluation/Cost Analysis, Operable Unit No. 16 Site 89, Source Removal. AGVIQ-CH2M HILL Joint Venture I, July 2007.

Groundwater. Freeze, R.A. and J.A. Cherry. 1979.

Remedial Investigation of Operable Unit 16 (Sites 89 and 93). Baker Environmental. June 1998.

Appendix A

Soil Mixing Quality Control Daily Log

Soil Mixing Quality Control Daily Log

Site 89 NTCRA

MCB Camp Lejeune, North Carolina

Date: _____

Weather Conditions: _____

Column ID	Super Sacks of ZVI	Super Sacks of Bentonite	Volume of Water (gallons)	Mixing Start Time	Mixing Stop Time	Number of Passes	Rate of Descent (ft/min)	Percent Iron - Shallow	Percent Iron - Deep

Notes:

1. One pass is defined as the full advancement of the auger to depth and return to surface (down and up)
2. Rate of descent = depth of column (25 feet assumed) / mixing time

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