5/1/07-03980

FINAL

Non Time-Critical Removal Action Work Plan
Site 35, Operable Unit No. 10
Building G533

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-0071

May 2007

Prepared by

AGVIQ
ENVIRONMENTAL SERVICES
CH2M HILL
JOINT VENTURE

Non Time-Critical Removal Action Work Plan
Site 35, Operable Unit No. 10
Building G533

Marine Corps Base Camp Lejeune
Jacksonville, North Carolina

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Executive Summary

This work plan describes the objectives and activities for a non time-critical removal action (NTCRA) which will be conducted for a portion of Operable Unit No. 10, Site 35 at Marine Corps Base (MCB), Camp Lejeune in Onslow County, North Carolina (Site 35). Groundwater at Site 35 is impacted by chlorinated volatile organic compounds (cVOCs), primarily trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene and vinyl chloride. The removal action will implement enhanced reductive dechlorination (ERD) using a combination of lactate and emulsified vegetable oil (EVO) via direct push injection. ERD involves stimulating the activity of microorganisms to enhance or speed up the natural degradation process. ERD involves the addition of electron donor/food source which depletes competing electron acceptors creating strong reducing conditions required for reductive dechlorination of cVOCs.

The target area for this NTCRA was identified from investigation activities where elevated concentrations of cVOCs were delineated. The target area is in the vicinity of Building G533.

The scope of work for the NTCRA is as follows:

- Installation and development of five new monitoring wells
- Baseline groundwater monitoring
- Injection of a combination of lactate and EVO in twenty-eight locations using direct push methods
- Performance monitoring by groundwater sampling and analysis

The monitoring plan for the NTCRA at Site 35 outlines the groundwater sampling program from baseline to twelve months following implementation. A project completion report will be prepared after completion of the NTCRA to summarize installation, implementation, and monitoring results.

The objectives of the NTCRA are:

- Reduce contaminant of concern (COC) (i.e., TCE and its daughter products) concentrations by 80% within the two "hot spot" areas at Site 35.

- Reduce the potential for contaminant dispersion from "hot spots" to surrounding areas through ERD.

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Acronyms and Abbreviations

µg/L	micrograms per liter
ARAR	Applicable and Relevant or Appropriate Requirement
ASTM	American Society of Testing and Materials
Baker	Baker Environmental, Inc.
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-Dichloroethene
COC	Contaminant of Concern
cVOC	Chlorinated Volatile Organic Compound
DCE	Dichloroethene
DO	Dissolved Oxygen
DPT	Direct Push Technology
EE/CA	Engineering Evaluation/Cost Analysis
ERD	Enhanced Reductive Dechlorination
EVO	Emulsified Vegetable Oil
Fe(III)	Ferric Iron
FS	Feasibility Study
ft/ft	feet per foot
FTL	Field Team Leader
gpm	gallons per minute
HSP	Health and Safety Plan
IDW	Investigation Derived Waste
MCB	Marine Corps Base
Mn(IV)	Manganese IV Ion
MSDS	Material Safety Data Sheet
NAVFAC	Naval Facilities Engineering Command
NCDENR	North Carolina Department of Environment and Natural Resources
NTCRA	Non-Time Critical Removal Action
ORP	Oxidation-Reduction Potential
OSHA	Occupational Safety and Health Administration
OU	Operational Unit

PCE	Tetrachloroethene
PHSM	Project Health and Safety Manager
PM	Project Manager
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/ Quality Control
RAC	Remedial Action Contractor
RI	Remedial Investigation
Shaw	Shaw Environmental Infrastructure
SHSP	Site-Specific Health and Safety Plan
SOP	Standard Operating Procedure
SOW	Scope of Work
SSC	Site Safety Coordinator
TCE	Trichloroethene
TOC	Total Organic Carbon
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
VOC	Volatile Organic Compound
ZVI	Zero Valent Iron

1. Introduction

This work plan describes the objectives and activities for a non time-critical removal action (NTCRA) for a portion of Operable Unit (OU) No. 10, Site 35 at Marine Corps Base (MCB), Camp Lejeune in Onslow County, North Carolina (Site 35). Site 35 is located within Camp Geiger, situated in the northwest corner of MCB Camp Lejeune. This NTCRA is intended to address a target area in the vicinity of Building G533. This NTCRA Work Plan will provide information and the technical approach for the remedial action selected in the Site 35 Building G533 Engineering Evaluation and Cost Analysis (EE/CA). Site 35 will be addressed in its entirety in a Feasibility Study (FS).

Environmental investigations at Site 35 have historically focused on the former Fuel Farm, which contained five 15,000-gallon above ground storage tanks (ASTs) storing various petroleum products over the years. In 1995, the Fuel Farm was decommissioned and dismantled to make way for the US Highway 17 Bypass. Reports of a release in an underground distribution line date back to 1957 or 1958. A Confirmation Study conducted by Environmental Science and Engineering, Inc. (ESE) from 1984 to 1987 identified both petroleum constituents and chlorinated solvents (cVOCs) at the Site (ESE, 1990); however the source of cVOC contamination was not identified. As a result, the Site was added to the Installation Restoration (IR) Program.

This NTCRA work plan was prepared by AGVIQ-CH2M HILL Joint Venture I (JV I) under the Naval Facilities Engineering Command (NAVFAC) - Mid-Atlantic (MIDLANT) Division, JV I Contract N62470-03-D-4401, Task Order (TO) 0071.

The NTCRA presented in this work plan is intended to reduce dissolved-phase contamination in a practical and cost-efficient manner, preventing further migration of impacted groundwater and allowing residual impacts to be addressed by monitored natural attenuation (MNA).

2. Site Background

2.1 Site Description

Site 35, formerly the Camp Geiger Fuel Farm, primarily refers to land associated with fuel storage and distribution including: five 15,000-gallon ASTs, underground fuel transmission lines, a pump house, a fuel unloading pad, an oil water separator, and a distribution island, situated north of the intersection of Fourth Street and 'G' Street. The target area for the NTCRA (shown on **Figure 2-1**) is located southwest of the former fuel farm and is bounded by Fourth Street on the north, 'F' Street on the east, Fifth Street on the south and 'C' Street to the west.

The NTCRA target area is currently in use by the Camp Geiger School of Infantry. Several roadways, buildings (including troop barracks), and large parking areas are currently located within the target area. The majority of the NTCRA target area is grass-covered and exhibits little topographical relief. Stormwater runoff at Site 35 is collected by a storm sewer system that discharges into Brinson Creek.

2.2 Site Geology and Hydrogeology

A detailed discussion of the soil and lithology at Site 35 is presented in the Amended Remedial Investigation (RI) (CH2M HILL, 2006). Information pertinent to the NTCRA target area is summarized herein.

2.2.1 Site Geology

Geologic cross-section locations are shown on **Figure 2-2.** Stratigraphic cross-sections generated from the boring logs of monitoring well installations at Site 35 are presented on **Figures 2-3** and **2-4**. These interpretations are based largely on field information collected by Baker Environmental, Inc. (Baker) and supplemented with field information collected by CH2M HILL.

Within the vicinity of Site 35, the uppermost Undifferentiated Formation consists of mostly fine to medium grained, medium dense sands with a lesser amount of silt and clay, present at depths of 0 to 3 feet below ground surface (ft bgs). Thin, 0.1 to 0.5 foot thick, discontinuous lenses of silt and clay are found within the Undifferentiated Formation. The Belgrade Formation, semi-confining unit of the Castle Hayne Aquifer, lies directly under the Undifferentiated Formation. The approximate thickness of the Belgrade semi-confining unit in the area of Site 35 is seven feet. The upper portion of the River Bend Formation underlies the Undifferentiated and Belgrade formations. Within the vicinity of Site 35, the River Bend Formation is composed of sands, silt, shell and fossil fragments, and trace amounts of clay. Sands tend to be cemented within the formation. The amount of shell fragments within the formation decreases with depth down to approximately 55 to 65 ft bgs, where a greenish-gray to olive very fine sand to silt is present.

Cross-section A-A′ (**Figure 2-3**) trends from the southwest to the northeast and passes through the southern portion of the NTCRA target area. The shallow soils consist of mostly fine silty sand with trace amounts of clay, which vary in depth across cross-section A-A′ ranging from 0 to 10 ft bgs. A discontinuous, plastic, silty clay layer is present from approximately 3 to 12 ft bgs and identified within the boring logs from nests 35-MW30, 35-MW32, and 35-MW72. Partially cemented sands and fossil shell hash are present between 15 and 55 ft bgs, but were discontinuous across the A-A′ cross-section. A light greenish-gray, fine silty sand layer, with a lower moisture content than the cemented sand layers above and below it, was discontinuous at 40 to 55 feet bgs throughout the A-A′ section.

Cross-section B-B′ (**Figure 2-4**) trends from the north-northwest to the south-southeast and passes through the center of the NTCRA target area. The shallow soils consist of silty sands near the surface. A plastic, silty clay layer is present within the vicinity of monitoring wells 35-MW09IW to 35-MW06DW along the B-B′ section. However, the clay layer pinches out north of monitoring well 35-MW09IW. Partially cemented sands and fossil shell hash are present between 15 and 60 ft bgs, but are discontinuous across the B-B′ cross section.

2.2.2 Site Hydrogeology

A detailed discussion of the hydrogeologic conditions at Site 35 is presented in the Amended RI (CH2M HILL, 2006) and summarized below.

2.2.2.1 Hydrologic and Hydrogeologic Information

Site 35 is underlain by an unconfined shallow aquifer, represented within the Undifferentiated Formation, and the Castle Hayne aquifer, represented within the River Bend Formation. The two aquifers are separated by the Castle Hayne confining unit, represented within the lower portion of the Belgrade formation, which appears to be laterally discontinuous, and therefore may only provide semi-confining conditions to the Castle Hayne aquifer below. The bottom of the shallow aquifer is approximately 20 to 25 ft bgs. The extent of shells and cemented sands within the upper portion of the Castle Hayne aquifer (i.e., intermediate aquifer zone) appears to provide a more conductive zone for groundwater movement as compared to the undifferentiated silty sands of the shallow aquifer.

Static water level elevations within the unconfined shallow aquifer zone measured during the June 2006 gauging event ranged from approximately sea level to 13.21 feet above mean sea level (msl). Static water level elevations within the intermediate aquifer zone measured during the June 2006 gauging event ranged from 2.04 feet msl to 13.98 feet msl. The close similarity of water levels in the shallow, intermediate, and deep aquifer zones indicates a close hydraulic connection.

2.2.2.2 Groundwater Flow Patterns

Groundwater potentiometric surface maps for Site 35 were produced using water level elevations measured in June 2006 as part of Amended RI activities. In general, groundwater flow direction within the shallow aquifer zone at Site 35 is to the northeast towards Brinson Creek, under a horizontal hydraulic gradient of approximately 0.003 feet per foot (ft/ft) in the vicinity of the NTCRA target area. A groundwater contour map of the shallow aquifer zone is shown on **Figure 2-5**. Groundwater flow direction within the intermediate aquifer

zone is to the northeast towards the New River, under a horizontal hydraulic gradient of approximately 0.0065 ft/ft. A groundwater contour map of the intermediate aquifer zone is shown on **Figure 2-6.**

Using the June 2006 water level data between adjacent wells, a slight downward hydraulic potential of approximately 0.002 ft/ft was calculated between the shallow and intermediate aquifer zones and a downward hydraulic potential of approximately 0.025 ft/ft was calculated between the intermediate and deep aquifer zones in the vicinity of the NTCRA target area.

2.3 Nature and Extent of Contamination

A detailed discussion of the nature and extent of contamination within this portion of Site 35 is presented in the EE/CA (CH2M HILL, 2007).

Trichloroethene (TCE) and cis-1,2-dichloroethene (cis-1,2-DCE) were the most prevalent cVOCs detected during the Amended RI direct push technology (DPT) and monitoring well groundwater sampling events as shown in **Figure 2-7**. Other cVOCs were detected; however, TCE and cis-1,2-DCE are good indicators of the approximate extent of VOC contamination. The highest concentrations of cVOCs were generally within the intermediate aquifer zone (approximately 37 to 49 feet bgs), south of Fourth Street and east of Building G533. Elevated cVOC concentrations were also reported in the shallow aquifer zone (20 to 24 feet bgs), but were generally limited to the immediate area around Building G533.

The maximum TCE concentration reported was 294 micrograms per liter (µg/L) within the shallow aquifer zone at 35-IS105. The maximum cis-1,2-DCE concentration reported was 1,150 µg/L within the shallow aquifer zone at 35-IS101. In general, the concentration of cis-1,2-DCE was higher than the corresponding concentration of TCE. The widespread presence of cis-1,2-DCE across the target area at concentrations greater than those of TCE provides evidence that degradation is naturally occurring at Site 35. **Figures 2-8** and **2-9** show the TCE concentration gradients based on the Amended RI results in relation to the proposed injection and monitoring well locations.

2.4 Removal Area

2.4.1 Rationale for Area Selection

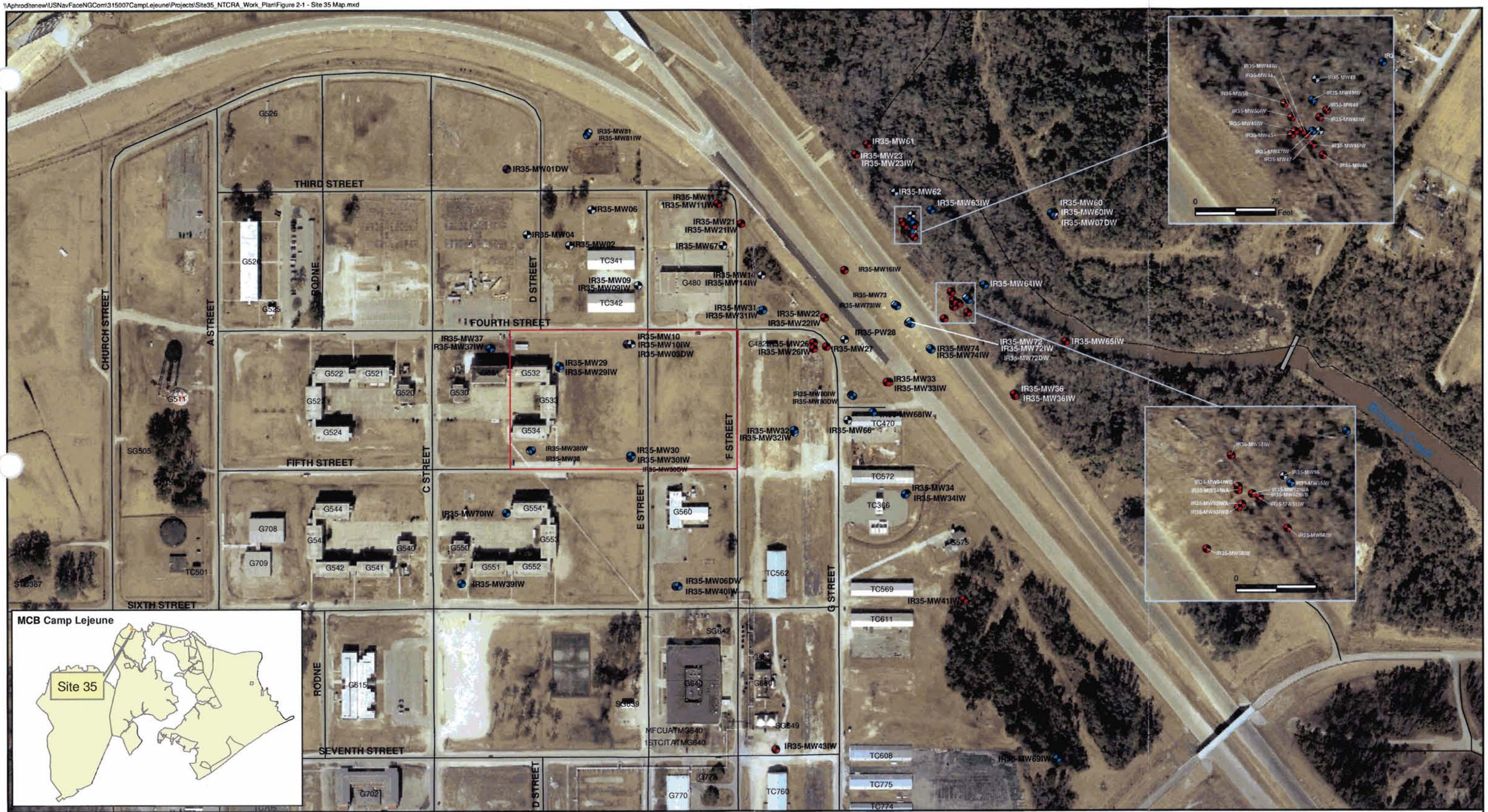
The "hot spot" areas are defined as having TCE concentrations greater than 100 µg/L. This resulted in two "hot spot" locations in an area bounded by Fifth, F, Fourth, and C streets: northern plume and southern plume as shown in **Figure 2-10**.

2.4.2 Area Dimensions

Based on the results of the DPT and monitoring well groundwater sampling events, the NTCRA target area contains two distinct plumes ("hot spot" areas), separated by a row of sample points including 35-IS102, 35-IS106, 35-IS110, 35-IS111 and 35-IS115. None of the shallow or intermediate samples from these five borings contained cVOC concentrations in excess of their North Carolina Groundwater Quality Standards (NCGWQS). The northern

plume is centered on borings 35-IS100, 35-IS101, and 35-IS105, with a target depth of 20 to 47 feet bgs. The northern plume is approximately 250 feet long by 130 feet wide. The southern plume is centered on borings 35-IS117 and 35-IS118 and monitoring well 35-MW30IW, with a target depth of 37 to 47 feet bgs. The southern plume is approximately 250 feet long by 80 feet wide.

\\Aphroditenew\USNavFaceNGCom\315007CampLejeune\Projects\Site35_NTCRA_Work_Plan\Figure 2-1 - Site 35 Map.mxd



Legend

- Shallow Monitoring Well
- Intermediate Monitoring Well
- Deep Monitoring Well
- Destroyed/Abandoned Monitoring Well
- NTCRA Target Area
- Installation Area
- Road Centerline
- Surface Water Course Centerline

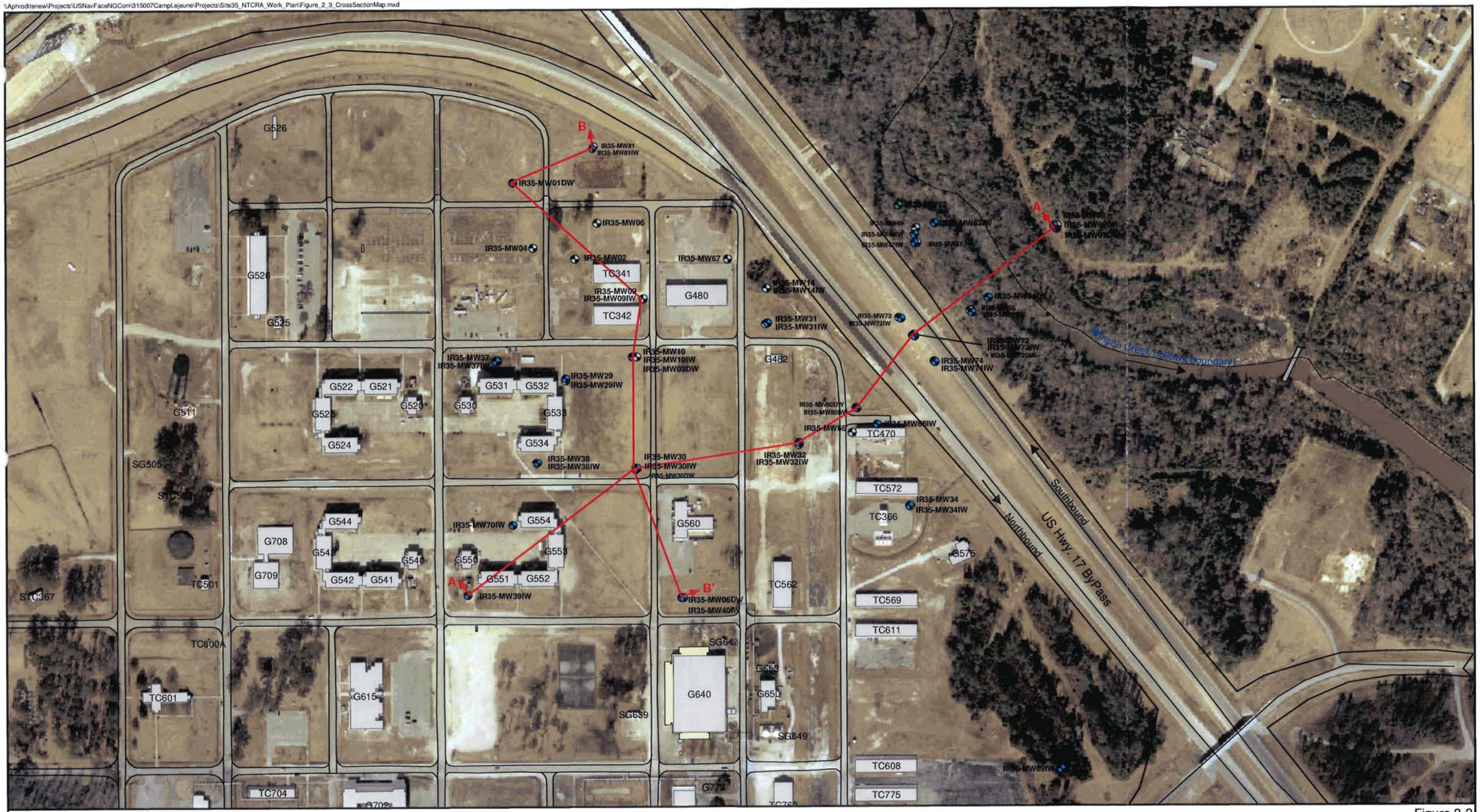
N

300 0 300 Feet

Figure 2-1
Site 35 Map
Operable Unit No. 10 (Site 35)
Non-Time Critical Removal Action Work Plan
MCB Camp Lejeune
Camp Lejeune, North Carolina

AGVIQ CH2M HILL

\\Aphroditenew\Projects\USNavFaceNGCom\315007CampLejeune\Projects\Site35_NTCRA_Work_Plan\Figure_2_3_CrossSectionMap.mxd



Legend

- Shallow Monitoring Well
- Intermediate Monitoring Well
- Deep Monitoring Well
- Cross Section
- Roads
- Buildings
- Surface Water Course Centerline

N
W E
S

300 0 300
Feet

Figure 2-2
Geologic and Hydrostratigraphic Cross-Section Location Map
Operable Unit No. 10 (Site 35)
Non-Time Critical Removal Action Work Plan
MCB Camp Lejeune
Camp Lejeune, North Carolina

AGVIQ CH2M HILL

A

A'

35-MW39IW
35-MW30
35-MW30IW
35-MW30DW
35-MW32
35-MW32IW
35-MW80IW
35-MW80DW
35-MW72DW
35-MW72
35-MW72IW
35-MW60
35-MW60IW
35-MW07DW

Northbound Lanes Hwy 17 Bypass

Southbound Lanes Hwy 17 Bypass

Undifferentiated

Belgrade

Clay

Silt

Clay

Fill

Surficial MWs

Brinson Creek

Sand with varying amounts of silt

Undifferentiated/River Bend

Cemented Sand

SM

River Bend

Sand with varying amounts of silt

Intermediate MWs

Cemented Sand

Sand with varying amounts of silt

Deep MWs

Silt

Elevation Relative to MSL (feet)

20
10
0
-10
-20
-30
-40
-50
-60
-70

0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2440

Distance in Feet from A to A'

Notes:

The NCAC 2L Standard for TCE is 2.8 µg/L.

ND = non-detect

All units are presented in µg/L.

Horizontal : 1" = 200'
Vertical: 1" = 10'
V.E. = 20x

Legend

- Clay
- Sand with varying amounts of silt
- Cemented sand
- Silt
- Screened Interval
- Proposed injection intervals

Horizontal Scale: 1" = 200'
Vertical Scale: 1" = 10'

Figure 2-3
Geological Cross Section A-A'
Operable Unit. No 10 (Site 35)
Non-Time Critical Removal Action Work Plan
Marine Corps Base, Camp Lejeune
North Carolina

AGVIQ ENVIRONMENTAL SERVICES
CH2M HILL JOINT VENTURE

ES032007023WDC

B

B'

35-MW81
35-MW81IW
35-MW01DW
35-MW09
35-MW09IW
35-MW10
35-MW10IW
35-MW03DW
35-MW30
35-MW30IW
35-MW30DW
35-MW06DW
35-MW40IW

Undifferentiated

Clay

Belgrade

Surficial MWs

Sand with varying amounts of silt

Undifferentiated/River Bend

Cemented Sand

Intermediate MWs

River Bend

Sand with varying amounts of silt

Cemented Sand

Deep MWs

Silt

SM

Elevation Relative to MSL (feet)

20
10
0
-10
-20
-30
-40
-50
-60
-70

0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2440

Distance in Feet from B to B'

Horizontal : 1" = 200'
Vertical: 1" = 10'
V.E. = 20x

Legend

- Clay
- Sand with varying amounts of silt
- Cemented sand
- Silt
- Screened Interval
- Proposed injection intervals

Horizontal Scale: 1" = 200'
Vertical Scale: 1" = 10'

Figure 2-4
Geological Cross Section B-B'
Operable Unit. No 10 (Site 35)
Non-Time Critical Removal Action Work Plan
Marine Corps Base, Camp Lejeune
North Carolina

AGVIQ ENVIRONMENTAL SERVICES
CH2M HILL JOINT VENTURE

ES032007023WDC_v6

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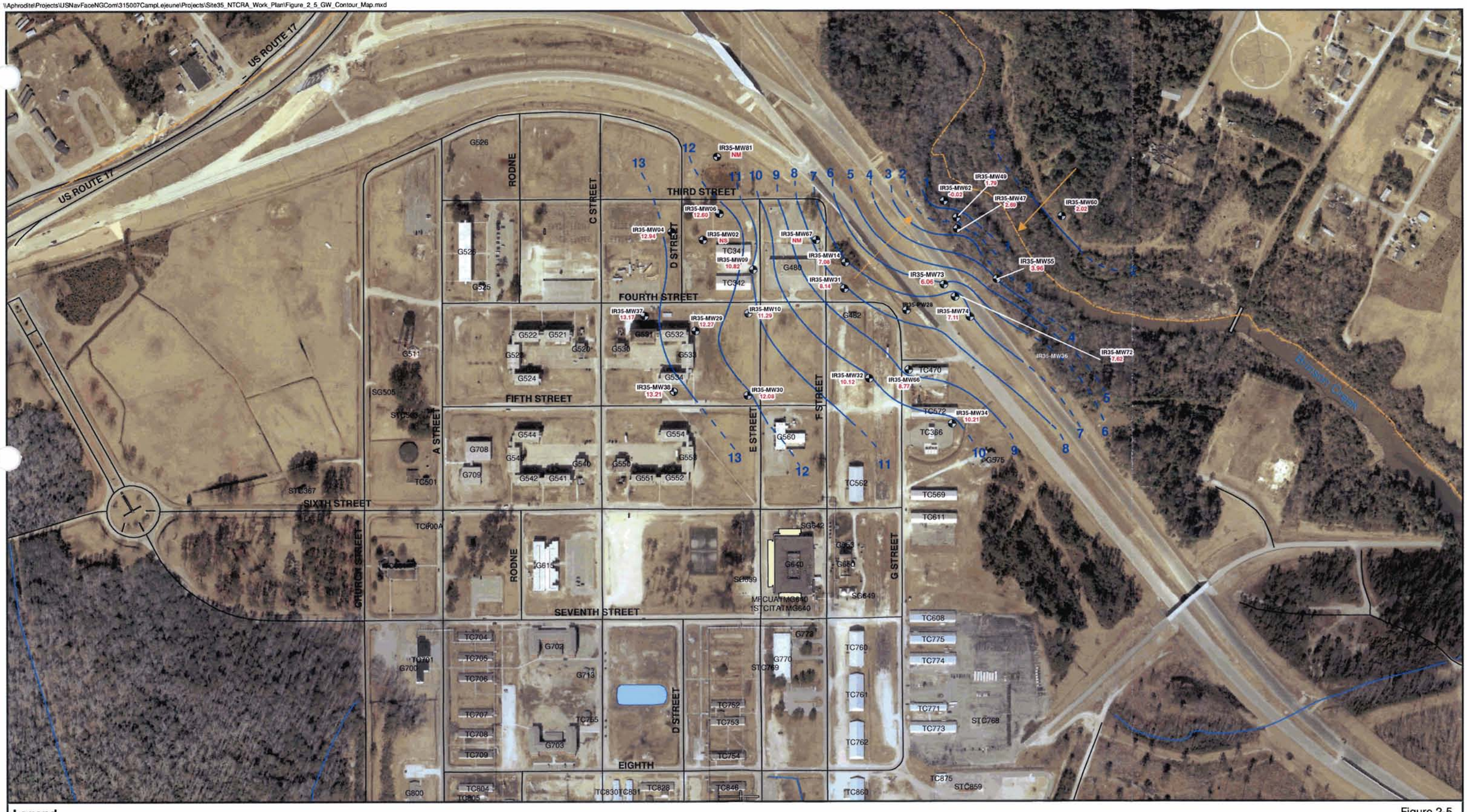

Legend

- Shallow Monitoring Well
- Base Boundary
- Road Centerline
- Potentiometric Surface Line (dashed where inferred)
- 12 Groundwater Elevation (feet mean sea level)
- Groundwater flow direction
- NM Water level not collected
- NS Monitoring well elevation not surveyed

N

200 0 200 Feet

1"=400'

Figure 2-5
Groundwater Contour Map of the Shallow Aquifer Zone
Operable Unit No. 10 (Site 35)
Non-Time Critical Removal Action Work Plan
MCB Camp Lejeune
Camp Lejeune, North Carolina

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\\Aphrodite\Projects\USNavFaceNGCom\315007CampLejeune\Projects\Site35_NTCRA_Work_Plan\Figure_2_6_GW_Contour_MapIntermediate.mxd

Legend

- Intermediate Monitoring Well
- Base Boundary
- Road Centerline
- Potentiometric Surface Line (dashed where inferred)
- 12.99 Groundwater Elevation (feet mean sea level)
- Groundwater flow direction
- NM Water level not collected
- NS Monitoring well elevation not surveyed

N

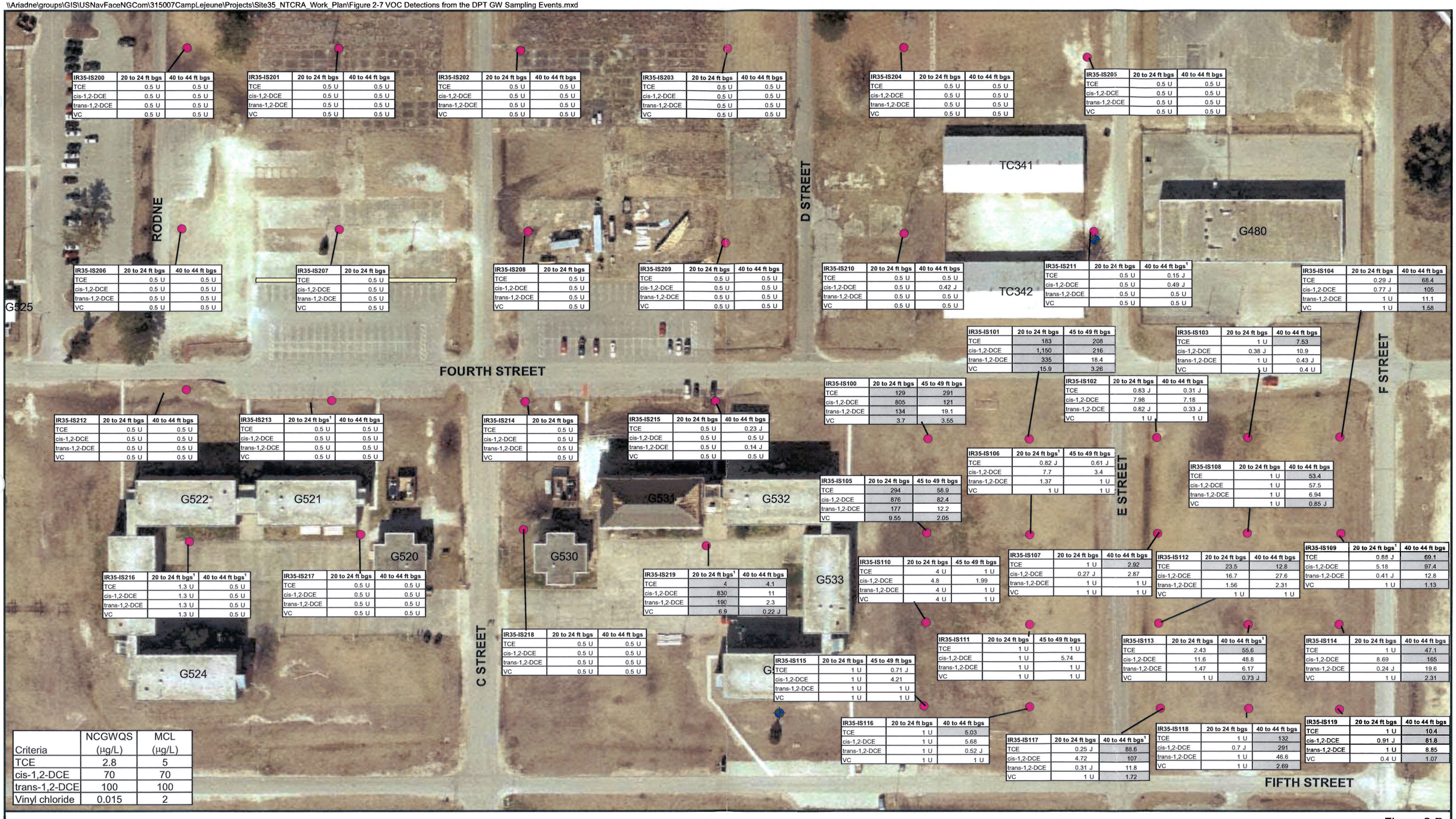
200 0 200 Feet

1"=400'

Figure 2-6
Groundwater Contour Map of the Intermediate Aquifer Zone
Operable Unit No. 10 (Site 35)
Non-Time Critical Removal Action Work Plan
MCB Camp Lejeune
Camp Lejeune, North Carolina

AGVIQ CH2M HILL

\\Ariadne\groups\GIS\USNavFaceNGCom\315007CampLejeune\Projects\Site35_NTCRA_Work_Plan\Figure 2-7 VOC Detections from the DPT GW Sampling Events.mxd



IR35-IS200	20 to 24 ft bgs	40 to 44 ft bgs
TCE	0.5 U	0.5 U
cis-1,2-DCE	0.5 U	0.5 U
trans-1,2-DCE	0.5 U	0.5 U
VC	0.5 U	0.5 U

IR35-IS201	20 to 24 ft bgs	40 to 44 ft bgs
TCE	0.5 U	0.5 U
cis-1,2-DCE	0.5 U	0.5 U
trans-1,2-DCE	0.5 U	0.5 U
VC	0.5 U	0.5 U

IR35-IS202	20 to 24 ft bgs	40 to 44 ft bgs
TCE	0.5 U	0.5 U
cis-1,2-DCE	0.5 U	0.5 U
trans-1,2-DCE	0.5 U	0.5 U
VC	0.5 U	0.5 U

IR35-IS203	20 to 24 ft bgs	40 to 44 ft bgs
TCE	0.5 U	0.5 U
cis-1,2-DCE	0.5 U	0.5 U
trans-1,2-DCE	0.5 U	0.5 U
VC	0.5 U	0.5 U

IR35-IS204	20 to 24 ft bgs	40 to 44 ft bgs
TCE	0.5 U	0.5 U
cis-1,2-DCE	0.5 U	0.5 U
trans-1,2-DCE	0.5 U	0.5 U
VC	0.5 U	0.5 U

IR35-IS205	20 to 24 ft bgs	40 to 44 ft bgs
TCE	0.5 U	0.5 U
cis-1,2-DCE	0.5 U	0.5 U
trans-1,2-DCE	0.5 U	0.5 U
VC	0.5 U	0.5 U

IR35-IS206	20 to 24 ft bgs	40 to 44 ft bgs
TCE	0.5 U	0.5 U
cis-1,2-DCE	0.5 U	0.5 U
trans-1,2-DCE	0.5 U	0.5 U
VC	0.5 U	0.5 U

IR35-IS207	20 to 24 ft bgs
TCE	0.5 U
cis-1,2-DCE	0.5 U
trans-1,2-DCE	0.5 U
VC	0.5 U

IR35-IS208	20 to 24 ft bgs
TCE	0.5 U
cis-1,2-DCE	0.5 U
trans-1,2-DCE	0.5 U
VC	0.5 U

IR35-IS209	20 to 24 ft bgs	40 to 44 ft bgs
TCE	0.5 U	0.5 U
cis-1,2-DCE	0.5 U	0.5 U
trans-1,2-DCE	0.5 U	0.5 U
VC	0.5 U	0.5 U

IR35-IS210	20 to 24 ft bgs	40 to 44 ft bgs
TCE	0.5 U	0.5 U
cis-1,2-DCE	0.5 U	0.42 J
trans-1,2-DCE	0.5 U	0.5 U
VC	0.5 U	0.5 U

IR35-IS211	20 to 24 ft bgs	40 to 44 ft bgs[1]
TCE	0.5 U	0.15 J
cis-1,2-DCE	0.5 U	0.49 J
trans-1,2-DCE	0.5 U	0.5 U
VC	0.5 U	0.5 U

IR35-IS104	20 to 24 ft bgs	40 to 44 ft bgs
TCE	0.29 J	68.4
cis-1,2-DCE	0.77 J	105
trans-1,2-DCE	1 U	11.1
VC	1 U	1.58

IR35-IS101	20 to 24 ft bgs	45 to 49 ft bgs
TCE	183	208
cis-1,2-DCE	1,150	216
trans-1,2-DCE	335	18.4
VC	15.9	3.26

IR35-IS103	20 to 24 ft bgs	40 to 44 ft bgs
TCE	1 U	7.53
cis-1,2-DCE	0.38 J	10.9
trans-1,2-DCE	1 U	0.43 J
VC	1 U	0.4 U

IR35-IS100	20 to 24 ft bgs	45 to 49 ft bgs
TCE	129	291
cis-1,2-DCE	805	121
trans-1,2-DCE	134	19.1
VC	3.7	3.55

IR35-IS102	20 to 24 ft bgs	40 to 44 ft bgs
TCE	0.83 J	0.31 J
cis-1,2-DCE	7.98	7.18
trans-1,2-DCE	0.82 J	0.33 J
VC	1 U	1 U

IR35-IS212	20 to 24 ft bgs	40 to 44 ft bgs
TCE	0.5 U	0.5 U
cis-1,2-DCE	0.5 U	0.5 U
trans-1,2-DCE	0.5 U	0.5 U
VC	0.5 U	0.5 U

IR35-IS213	20 to 24 ft bgs[1]	40 to 44 ft bgs
TCE	0.5 U	0.5 U
cis-1,2-DCE	0.5 U	0.5 U
trans-1,2-DCE	0.5 U	0.5 U
VC	0.5 U	0.5 U

IR35-IS214	20 to 24 ft bgs
TCE	0.5 U
cis-1,2-DCE	0.5 U
trans-1,2-DCE	0.5 U
VC	0.5 U

IR35-IS215	20 to 24 ft bgs	40 to 44 ft bgs
TCE	0.5 U	0.23 J
cis-1,2-DCE	0.5 U	0.5 U
trans-1,2-DCE	0.5 U	0.14 J
VC	0.5 U	0.5 U

IR35-IS106	20 to 24 ft bgs[1]	45 to 49 ft bgs
TCE	0.82 J	0.61 J
cis-1,2-DCE	7.7	3.4
trans-1,2-DCE	1.37	1 U
VC	1 U	1 U

IR35-IS105	20 to 24 ft bgs	45 to 49 ft bgs
TCE	294	58.9
cis-1,2-DCE	876	82.4
trans-1,2-DCE	177	12.2
VC	9.55	2.05

IR35-IS108	20 to 24 ft bgs	40 to 44 ft bgs
TCE	1 U	53.4
cis-1,2-DCE	1 U	57.5
trans-1,2-DCE	1 U	6.94
VC	1 U	0.85 J

IR35-IS216	20 to 24 ft bgs[1]	40 to 44 ft bgs[1]
TCE	1.3 U	0.5 U
cis-1,2-DCE	1.3 U	0.5 U
trans-1,2-DCE	1.3 U	0.5 U
VC	1.3 U	0.5 U

IR35-IS217	20 to 24 ft bgs	40 to 44 ft bgs
TCE	0.5 U	0.5 U
cis-1,2-DCE	0.5 U	0.5 U
trans-1,2-DCE	0.5 U	0.5 U
VC	0.5 U	0.5 U

IR35-IS219	20 to 24 ft bgs[1]	40 to 44 ft bgs
TCE	4	4.1
cis-1,2-DCE	830	11
trans-1,2-DCE	190	2.3
VC	6.9	0.22 J

IR35-IS110	20 to 24 ft bgs	45 to 49 ft bgs
TCE	4 U	1 U
cis-1,2-DCE	4.8	1.99
trans-1,2-DCE	4 U	1 U
VC	4 U	1 U

IR35-IS107	20 to 24 ft bgs	40 to 44 ft bgs
TCE	1 U	2.92
cis-1,2-DCE	0.27 J	2.87
trans-1,2-DCE	1 U	1 U
VC	1 U	1 U

IR35-IS112	20 to 24 ft bgs	40 to 44 ft bgs
TCE	23.5	12.8
cis-1,2-DCE	16.7	27.6
trans-1,2-DCE	1.56	2.31
VC	1 U	1 U

IR35-IS109	20 to 24 ft bgs[1]	40 to 44 ft bgs
TCE	0.88 J	69.1
cis-1,2-DCE	5.18	97.4
trans-1,2-DCE	0.41 J	12.8
VC	1 U	1.13

IR35-IS218	20 to 24 ft bgs	40 to 44 ft bgs
TCE	0.5 U	0.5 U
cis-1,2-DCE	0.5 U	0.5 U
trans-1,2-DCE	0.5 U	0.5 U
VC	0.5 U	0.5 U

IR35-IS115	20 to 24 ft bgs	45 to 49 ft bgs
TCE	1 U	0.71 J
cis-1,2-DCE	1 U	4.21
trans-1,2-DCE	1 U	1 U
VC	1 U	1 U

IR35-IS111	20 to 24 ft bgs	45 to 49 ft bgs
TCE	1 U	1 U
cis-1,2-DCE	1 U	5.74
trans-1,2-DCE	1 U	1 U
VC	1 U	1 U

IR35-IS113	20 to 24 ft bgs	40 to 44 ft bgs[1]
TCE	2.43	55.6
cis-1,2-DCE	11.6	48.8
trans-1,2-DCE	1.47	6.17
VC	1 U	0.73 J

IR35-IS114	20 to 24 ft bgs	40 to 44 ft bgs
TCE	1 U	47.1
cis-1,2-DCE	8.69	165
trans-1,2-DCE	0.24 J	19.6
VC	1 U	2.31

IR35-IS116	20 to 24 ft bgs	40 to 44 ft bgs
TCE	1 U	5.03
cis-1,2-DCE	1 U	5.68
trans-1,2-DCE	1 U	0.52 J
VC	1 U	1 U

IR35-IS117	20 to 24 ft bgs	40 to 44 ft bgs[1]
TCE	0.25 J	88.6
cis-1,2-DCE	4.72	107
trans-1,2-DCE	0.31 J	11.8
VC	1 U	1.72

IR35-IS118	20 to 24 ft bgs	40 to 44 ft bgs
TCE	1 U	132
cis-1,2-DCE	0.7 J	291
trans-1,2-DCE	1 U	46.6
VC	1 U	2.69

IR35-IS119	20 to 24 ft bgs	40 to 44 ft bgs
TCE	1 U	10.4
cis-1,2-DCE	0.91 J	81.8
trans-1,2-DCE	1 U	8.85
VC	0.4 U	1.07

Criteria	NCGWQS (µg/L)	MCL (µg/L)
TCE	2.8	5
cis-1,2-DCE	70	70
trans-1,2-DCE	100	100
Vinyl chloride	0.015	2

Legend

- DPT Sample Location
- Intermediate-Depth Monitoring Wells

[1] - Duplicate sample, most conservative value used
Highlighted values exceed groundwater standards
All concentrations are in micrograms per liter
TCE - Trichloroethene
cis-1,2-DCE - cis-1,2-Dichloroethene
trans-1,2-DCE - trans-1,2-Dichloroethene
VC - Vinyl chloride
U - Analyte not detected
J - Reported value is estimated

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Figure 2-7
VOC Detections from the DPT and Monitoring Well Groundwater Sampling Events
Operable Unit No. 10 (Site 35)
Non-Time Critical Removal Action Work Plan
MCB Camp Lejeune
Camp Lejeune, North Carolina

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Figure 2-8
TCE Concentration Gradient (20-37 ft bgs)
Operable Unit No. 10 (Site 35)
Non-Time Critical Removal Action Work Plan
MCB Camp Lejeune
Camp Lejeune, North Carolina

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IR35-MW02
IR35-MW67
TC341
G480
TC342
IS208
IS209
IS210
IS211
IR35-MW09
IR35-MW09IW
D STREET
IR35-MW02DW
IR35-MW16
IR35-MW16IW
IR35-MW14
IR35-MW14IW
IR35-IS47
IR35-MW31IW
IR35-MW31
IR35-MW22
IR35-MW22IW
FOURTH STREET
IS214
IS215
IR35-MW37
IR35-MW37IW
IR35-MW03DW
IR35-MW10
IR35-MW10IW
IS100
IR35-MW82IW
IS101
IR35-MW84IW
IS102
IS103
IS104
G482
IR35-MW26
IR35-MW26IW
IR35-MW27
IR35-MW29IW
IR35-MW29
G521
G531
G532
IS217
IS218
G520
G530
IS219
IS105
IS106
IR35-MW83IW
IS107
IS108
IS109
IR35-IS49
IR35-MW22
IR35-MW22IW
G533
IS110
IS111
IS112
IS113
IS114
IR35-MW65
TC470
G534
IR35-MW86IW
IR35-MW32IW
IR35-MW85IW
C STREET
IS115
IS116
IS117
IS118
IS119
IR35-MW38
IR35-MW38IW
IR35-MW30
IR35-MW30DW
IR35-MW30IW
FIFTH STREET
E STREET
F STREET
G STREET
TC572
G554
G560

Legend

- Monitoring Wells
- Proposed Monitoring Wells
- DPT Groundwater Location
- Proposed Injection Points for ERD
- Slabs
- Structure Area
- Road Area
- 10-100 µg/L TCE
- >100 µg/L TCE

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W E
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100 0 100
Feet

Figure 2-9
TCE Concentration Gradient (37-47 ft bgs)
Operable Unit No. 10 (Site 35)
Non-Time Critical Removal Action Work Plan
MCB Camp Lejeune
Camp Lejeune, North Carolina

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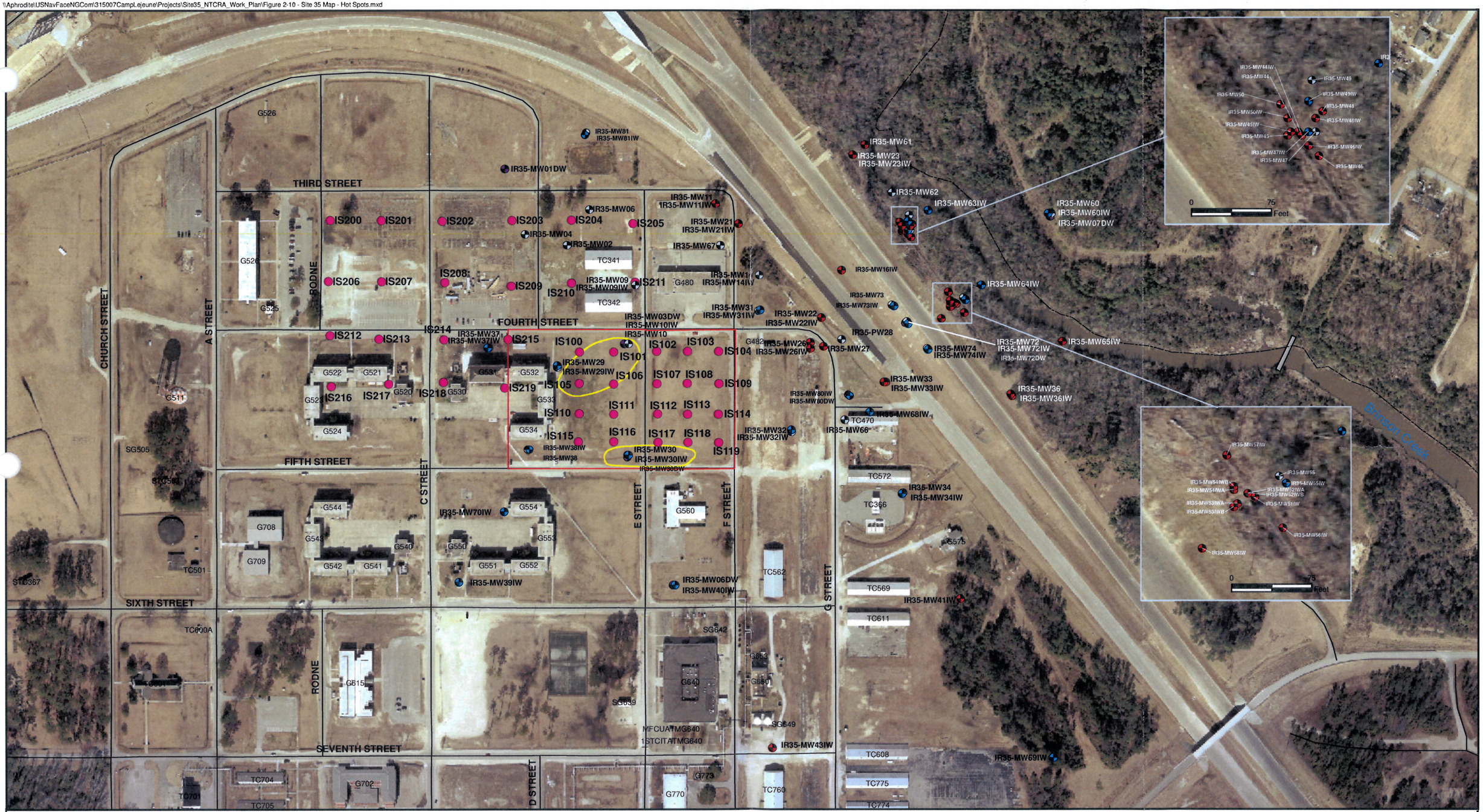
\\Aphrodite\USNavFaceNGCom\315007CampLejeune\Projects\Site35_NTCRA_Work_Plan\Figure 2-10 - Site 35 Map - Hot Spots.mxd



Legend

- Shallow Monitoring Well
- Intermediate Monitoring Well
- Deep Monitoring Well
- Destroyed/Abandoned Monitoring Well
- DPT Groundwater Location
- NTCRA Target Area
- Installation Area
- Hot Spots
- Road Centerline
- Surface Water Course Centerline

Figure 2-10
Site 35 NTCRA Area
Operable Unit No. 10 (Site 35)
Non-Time Critical Removal Action Work Plan
MCB Camp Lejeune
Camp Lejeune, North Carolina

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3. Removal Action Design

The selected remedial technology, ERD injections using DPT, is a potentially effective approach for remediation of dissolved chlorinated solvent contamination at Site 35. This section presents an overview, objectives, and goals of the removal action and describes the technology.

3.1 Removal Action Overview, Objectives, and Goals

The rationale for selecting ERD injections using DPT is presented in the Site 35 Building G533 EE/CA. In summary, the proposed remedial action at Site 35 will consist of injecting ERD substrate "a blend of 50% oil and 50% lactate" at the two identified "hot spots".

This section identifies the remedial action objectives (RAOs) for the NTCRA at Site 35.

The RAOs for Site 35 are:

- Reduce contaminants of concern (COC) (i.e., TCE and its daughter products) concentrations by 80% within the two "hot spot" areas at Site 35.
- Reduce the potential for contaminant dispersion from "hot spots" to surrounding areas.

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

- Reduction in contaminant concentration as quantified by pre and post treatment groundwater monitoring
- Reagent distribution/influence zone

The Partnering Team will evaluate the remedial action over time and compare it to the RAOs. It will be up to the Partnering Team to decide how long to monitor and take any actions as necessary. In no way is this action deemed to be performance based.

New and existing monitoring wells within the NTCRA area will be gauged and sampled prior to initiation of the NTCRA. The resulting laboratory analytical data and field geochemical data will be used to establish baseline conditions. Subsequent data will be compared to baseline conditions to evaluate performance during the NTCRA.

3.2 Technology Description

This section comprises a brief technical overview of the methodology associated with the technology to be employed at Site 35.

Reductive dechlorination is a process in which indigenous microorganisms (e.g., fungi, bacteria, and other microbes) degrade (metabolize) chlorinated organic contaminants found in the subsurface, converting them to innocuous non-regulated end products. Reductive dechlorination, also known as dehalorespiration, involves the transfer of electrons from an

electron donor source to the cVOC compound, resulting in the sequential replacement of a chlorine atom with a hydrogen atom. If sufficient electron donor is not available, an external electron donor source is required for the reaction to occur. Potential electron donor sources include biodegradable organic co-contaminants, native organic matter, or substrates intentionally added to the subsurface. Deeply anaerobic (reducing) conditions are required for reductive dechlorination of many cVOCs. In addition, competing electron acceptors, such as dissolved oxygen, nitrate, nitrite, manganese [Mn(IV)], ferric iron [Fe(III)], and sulfate, must be depleted.

The principal anaerobic biodegradation pathway for reductive dechlorination of chlorinated ethenes is:

$$\text{PCE} \rightarrow \text{TCE} \rightarrow \text{cis-1,2-DCE} \rightarrow \text{vinyl chloride} \rightarrow \text{ethene}$$

The transformation rates for each step vary but tend to become slower with progress along the breakdown sequence, often resulting in accumulation of cis-1,2-DCE and vinyl chloride. Further breakdown from cis-1,2-DCE and vinyl chloride to ethene varies and is based on site-specific conditions.

ERD of cVOCs is implemented by adding a suitable substrate to the subsurface. The introduced substrate serves two purposes: (a) depleting competing electron acceptors and creating strongly reducing conditions and (b) providing an electron donor source for reductive dechlorination. Nutrients, lactate, emulsified oil, or other substrates are often used to enhance reductive dechlorination. These substrates provide a carbon source for microbial growth and electron donors, stimulating dechlorination. Complete biological reductive dechlorination of chlorinated ethenes requires a number of different groups of anaerobic bacteria including acetogens (acetate producers), sulphate reducers, and halo respirers (specific anaerobic microorganisms that mediate certain dechlorination reactions). Sulphate reducers, and possibly methanogens, appear to be able to mediate the initial steps of dechlorination of tetrachloroethene (PCE) and TCE to cis-1,2-DCE, and specific halo-respiring microorganisms appear to be required to mediate further and complete dechlorination of cis-1,2-DCE to vinyl chloride and ethene. To date, a number of distinct types of halo-respiring bacteria have been identified, including *Dehalobactor sp.* (DHB), *Dehalospirillium multivorans* (Scholz-Muramatsu et al., 1995), *Dehalobacter restrictus* (Schumacher and Holliger, 1996), *Desulfuromonas sp.* (DSM) and *Dehalococcoides ethenogenes* (DHC) (Maymo-Gatell et al., 1997). These halo-respiring microorganisms do not appear to be ubiquitous at all sites. Alternatively, these microorganisms can be present but are not active due to prevailing geochemical conditions. As a result, dechlorination of PCE and TCE stalls at cis-1,2-DCE or possibly VC at many sites, resulting in a buildup of these dechlorination products. Conversely, at sites where DHC is robust, degradation of TCE often to ethene occurs without the build-up of cis-1,2-DCE. In the event that the DHC bacteria is not present or is not active at a site or the population is insufficient to facilitate complete dechlorination of TCE to ethene, bioaugmentation using specially adapted microbial cultures that are able to degrade TCE to ethene can be injected into groundwater containing the TCE.

This remedial action will use a substrate blend containing emulsified soybean oil and lactate. Fermentation of substrates yields fermentation products that supply electron donors. Hydrogen is the primary electron donor. In the subsurface, lactate is fermented into

hydrogen. Lactate is more soluble than oil; therefore, it releases hydrogen more quickly. Emulsified soybean oil degrades to fatty acids, which are then fermented to hydrogen. Oil is a long-lasting, slow release substrate, as it is relatively insoluble, and produces moderate concentrations of hydrogen required for ERD. EVO has a low viscosity, which makes it more mobile, allowing for more uniform distribution in the aquifer (Moretti, 2005). The substrate blend is expected to stimulate dechlorination relatively quickly and also provide long-lasting effects.

4. Removal Action Implementation

4.1 Pre-Implementation Activities

Preliminary activities associated with the implementation of the removal action include:

- Coordination with Camp Lejeune personnel on the location of utilities in the area and utility locating
- NTCRA monitoring well installation;
- Gauging and baseline groundwater sampling event;
- Designation of areas for temporary storage of equipment and materials;
- Installation of fencing to delineate site boundaries/reduce pedestrian traffic; and
- Site-specific security and safety concerns.

Applications will be submitted for any required drilling and/or injection permits. The start of the NTCRA period is considered the injection of the ERD substrate.

4.1.1 Utility Location

JV I will coordinate with Base personnel and a professional utility locator to define all subsurface structures that might be impacted by monitoring well drilling and/or injection activities in the immediate area of the removal action.

The field engineer will mark the locations of the direct push injections. All utilities will be marked by a professional utilities locating service prior to the start of direct push activities. Known subsurface utilities are shown on **Figure 4-1.**

4.1.2 Monitoring Well Installation and Sampling

Five new two-inch monitoring wells (35-MW82IW, 35-MW83IW, 35-MW84IW, 35-MW85IW, and 35-MW86IW) will be installed in the vicinity of the Site 35 removal action, as shown on **Figure 4-2.** Well designations are similar to what has been used at the Site in the past. Monitoring wells 35-MW82IW through 35-MW86IW will be installed using hollow stem auger drilling methods prior to injection of the ERD substrate.

Well casings will consist of factory-made flush threaded two-inch diameter, Schedule 40 polyvinyl chloride (PVC). Well screens will consist of factory-made flush-threaded 0.010-inch machine-slotted 2-inch diameter, Schedule 40 PVC. A factory-made flush-threaded 2-inch diameter, Schedule 40 PVC end cap will be placed on the bottom of each well screen. The new monitoring wells will be screened as presented in **Table 4-1**. Monitoring wells will be finished at grade with a flush mounted 8.5-inch steel protective locking cover set in two foot square concrete aprons.

All monitoring wells will be constructed and developed in accordance with the standard operating procedures (SOPs) as described in the Base Master Project Plans. Generation, characterization, and proper disposal of drilling and development fluids and well cuttings are discussed in Section 4.6.

All new well installations will be referenced both horizontally and vertically. Each new well will be surveyed relative to permanent land monuments and the Universal Transverse Mercator (UTM) coordinate system and will be referenced to a US Geological Survey (USGS) datum/benchmark. Elevation will be surveyed to the nearest 0.01 foot, while horizontal location will be established to the nearest 0.1 foot.

4.2 Contractor Mobilization and Demobilization

The subcontractor will mobilize all resources necessary to efficiently and completely perform the scope of work tasks. These resources include, but are not limited to, personnel, equipment, materials, supplies, lower tier Subcontractor, and support facilities.

The subcontractor will be responsible for having all equipment properly decontaminated prior to mobilization to the Site. Personnel and equipment will be satisfactorily decontaminated in accordance with the Subcontractor's site-specific Health and Safety Plan (SHSP) prior to being removed from the site. Any debris or rinsate generated during decontamination will be properly collected and containerized. The subcontractor will furnish all equipment to safely and legally collect and store water encountered during the performance of the SOW for off-site disposal. Containers for and disposal of investigation-derived waste (IDW) will be coordinated with the Base Remedial Action Contractor (RAC).

The subcontractor will stage its equipment and temporary facilities within the areas designated by JV I and/or the Base.

The Base will provide a source of potable water. The subcontractor will provide JV I with all appropriate Material Safety Data Sheet (MSDS) documentation of the reagents prior to mobilization.

Mobilization and demobilization will occur in stages, as the field activities are completed. After completion of the NTCRA, all above-grade components will be demobilized. Injection borings will be abandoned by using a grout mixture with Portland cement conforming to American Society of Testing and Materials (ASTM) requirements and North Carolina Department of Environment and Natural Resources (NCDENR) guidelines.

4.3 Site Preparation

The site preparation task will include the following activities:

- Identification and marking of subsurface utilities
- Establishment of work zones and equipment staging areas
- Establishment of operations area
- Establishment of equipment and personnel decontamination areas

Work zones will be delineated at the Site for the different types of project activities. Personnel and equipment access will be controlled during project activities. The establishment of the work zones will accomplish the following:

1. Properly protect personnel against the hazards that are present
2. Confine work activities and contamination to the designated areas
3. Locate and evacuate personnel in the event of an emergency

Three types of work zones will be established during site operation activities: the exclusion zone, the contamination reduction zone, and the support zone. The SHSP will specifically address these zones as well as personal protective equipment (PPE), ambient air monitoring, and health and safety hazard assessments.

4.4 Enhanced Reductive Dechlorination Implementation

4.4.1.1 Location and Layout

Twenty-eight DPT borings will be installed, with 16 DPT points associated with the northern plume and 12 DPT points associated with the southern plume as depicted in **Figure 4-2**. The DPT points will be spaced 50 feet apart, which assumes a 25 foot radius of influence.

4.4.1.2 Enhanced Reductive Dechlorination Substrate Concentration

A combination of emulsified soybean oil and lactate has been selected as a semi-soluble and soluble substrate to enhance reductive dechlorination. Soluble substrate added in combination with emulsified oil accelerates reductive dechlorination promoting chemical reactions at little additional cost to emulsified oil alone. Soybean oil was selected because of its long-term, slow-release characteristics. Lactate was selected as it has generally been shown to be an effective electron donor for promoting reductive dechlorination.

A combination of 50% lactate and 50% emulsified soybean oil was assumed for the electron donor solution, diluted in water to approximately 2% by weight. The target dose is 2,526 pounds of ERD substrate per DPT point in the northern plume and 842 pounds of ERD substrate per DPT point in the southern plume (total mass of 50,520 pounds of ERD substrate). The target dose of ERD substrate is based on an assumed 8% mobile porosity and an ERD solution that is approximately a 1% mixture of emulsified soybean oil and lactate in water by volume.

4.4.1.3 Enhanced Reductive Dechlorination Substrate Injection

All injection borings in the NTCRA target area will be advanced using DPT. A direct push hydraulic rig will be used to inject the substrate into the subsurface. Drive rods will be pushed to the target depth of 47 feet bgs. The ERD substrate will be injected using a combination of piston and progressive cavity pumps. For the Northern Plume, injections will be conducted in five-foot treatment intervals from 20 to 47 feet bgs, while the Southern Plume will be on a five-foot treatment interval from 37 to 47 feet bgs. The substrate is expected to be injected at a rate of 2 to 4 gpm.

Direct push drilling methods will be utilized in accordance with SOPs as described in the Base Master Project Plans. After injection, the borehole will be abandoned in place in accordance with SOPs as described in the Base Master Project Plans.

4.5 Waste Management Plan

Wastes generated during the removal action of potentially contaminated sites are classified as IDW and will be managed to protect the public and the environment, as well as to meet legal requirements. Section 3.17, "Investigation Derived Waste Handling" of the Master Project Plans provides general information for the characterization, disposal, and handling of contaminated wastes expected to be encountered or generated during this work. This Waste Management Plan section describes the waste management requirements and procedures for remediation construction activities for this project.

Remediation activities at Site 35 are addressed under the provisions of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Waste generated from removal activities will be managed and disposed of in accordance with NCDENR and federal hazardous and solid waste regulations, as specified in Title 40 of the Code of Federal Regulations (CFR) Parts 240 through 258, 260 through 268, and 270. These regulations have been identified in the CERCLA process as applicable or relevant and appropriate requirements (ARARs).

4.5.1 Waste Streams

The waste streams associated with this scope of work may include:

- Equipment and personnel decontamination water
- Contaminated development water from the monitoring wells
- Soil cuttings from installation of injection borings and monitoring wells
- PPE
- Spent sampling equipment
- Uncontaminated general construction debris (such as caution tapes, barricades, signs, packing materials)

4.5.2 Waste Generation, Containerization, and Staging

The field team leader (FTL) will be responsible for the documentation, generation, containerization, and on-site staging of IDW. Prior to commencing fieldwork, the FTL will contact the RAC and complete an IDW Management Form. A copy of the IDW Management Form will be maintained by the RAC at all times. During fieldwork, IDW will be placed in the containers specified on the IDW Management Form. The containers may be drums, roll-off boxes, poly tanks, or other. The containers will then be labeled (visible marker) corresponding to the appropriate IDW Classification (i.e. media, container type, waste source, etc.) All IDW will be staged at the location specified on the IDW Management Form. The Site 35 staging area is planned to be north of Building G532.

Soil cuttings from injection borings will be adequately contained in 55-gallon drums. In general, wastes will be removed from the Site as soon as possible. At the completion of the field effort, the FTL will contact the RAC to have the IDW containers removed from the Site.

The RAC will check to see that all IDW Management Forms are complete and correct and transport the IDW containers to the secondary staging areas. The Investigative Contractor will also be responsible for providing site-specific data to the RAC if required. All IDW management actions should be documented in the field notes/logbook.

4.5.3 Waste Characterization and Disposal

The RAC will be responsible for the documentation, secondary staging, characterization and disposal of most IDW generated during the Site 35 NTCRA. All wastes will be classified according to 40 CFR 261 to determine if they are hazardous using both generator knowledge of the materials and sample results. It is assumed that environmental media generated from these activities may contain listed waste because of the area's history of use.

In accordance with the MCB Camp Lejeune Master Project Plans, the RAC will perform appropriate sampling/analysis of the IDW including development water from monitoring wells, equipment and personnel decontamination water, soil cuttings from injection borings and/or review site-specific data to characterize the waste for disposal.

All other liquid IDW generated during implementation of the ERD substrate injection will be coordinated for disposal with the Base RAC. Discarded PPE, general construction refuse, and general demolition debris will be placed in trash bags and placed in dumpsters temporarily staged on-site. Large amounts of construction debris, if accumulated, will be segregated, placed in a dumpster, and subsequently hauled to the Base landfill. Typically, uncontaminated wastes such as general construction debris will be characterized using process knowledge and generally will be classified as municipal solid waste. All IDW management actions should be documented in the field notes.

TABLE 4-1
Well Construction Details
Site 35 NTCRA Work Plan
MCB Camp Lejeune, North Carolina

Well Identification	Year Installed	Top of Casing Elevation (feet msl)	Ground Surface Elevation (feet msl)	Well Depth (feet bgs)	Screened Interval (feet bgs)	Depth to Sandpack (feet bgs)	Depth to Bentonite (feet bgs)
Existing Monitoring Wells in NTCRA Target Area							
IR35-MW03DW	1994	19.03	16.7	65	60 to 64	57	44
IR35-MW10	1991	19.01	16.6	14	4.5 to 13.5	2	1
IR35-MW10IW	1991	19.01	16.6	30	25.5 to 29.5	19	16
IR35-MW29	1994	20.62	18.6	16	6 to 15	4.5	2.5
IR35-MW29IW	1994	20.28	18.5	47	42 to 46	37	35
IR35-MW30	1994	18.38	16.3	16	6 to 15	4.5	3
IR35-MW30IW	1994	18.38	16.2	42	37 to 41	33	30
IR35-MW30DW	2006	NM	NM	77	60 to 65	58	52
IR35-MW37	1994	20.30	18.3	15	5 to 14	4	2.5
IR35-MW37IW	1994	20.33	18.3	45	40 to 44	36	32
IR35-MW38	1994	19.74	18.1	15	5 to 14	3.5	2
IR35-MW38IW	1995	20.00	18.2	44	39.5 to 43.5	36	32
Proposed Monitoring Wells							
IR35-MW82IW	2007			45	40-45		
IR35-MW83IW	2007			45	40-45		
IR35-MW84IW	2007			45	40-45		
IR35-MW85IW	2007			45	40-45		
IR35-MW86IW	2007			45	40-45		

NM - Not surveyed

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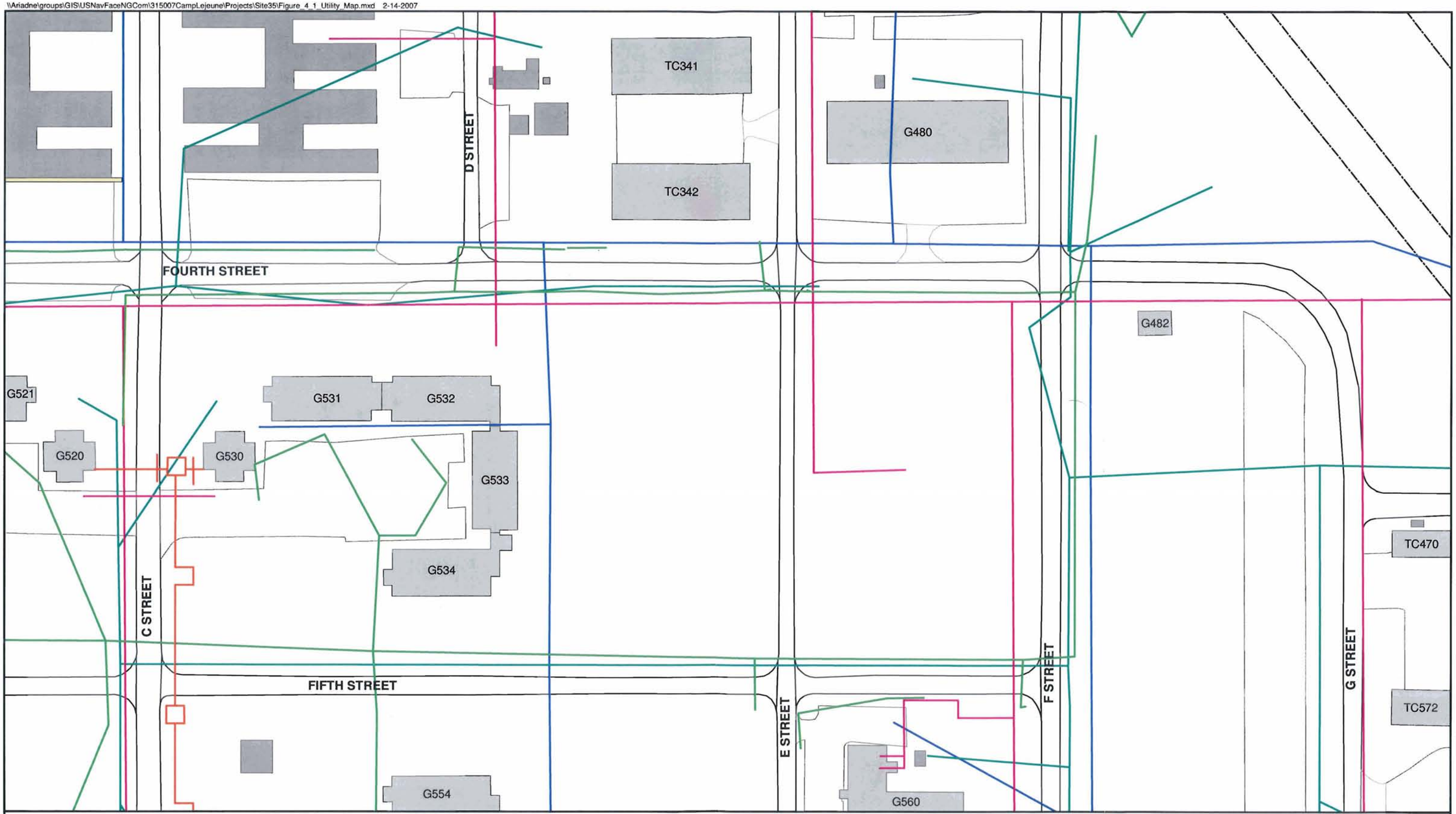

Legend
- Structure Area
- Slabs
- Road Area
- Wastewater Line
- Electrical Line
- Natural Gas Line
- Water Line
- Stormwater Line
- Steam Line

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W E
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100 0 100 Feet

Figure 4-1
Utility Location Map
Operable Unit No. 10 (Site 35)
Non-Time Critical Removal Action Work Plan
MCB Camp Lejeune
Camp Lejeune, North Carolina

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IR35-MW02
IR35-MW67
TC341
TC342
G480
IS208
IS209
IS210
IS211
IR35-MW09
IR35-MW09IW
D STREET
IR35-IS47
IR35-MW02DW
IR35-MW16
IR35-MW16IW
IR35-MW14
IR35-MW14IW
IR35-MW31IW
IR35-MW31
IR35-MW22
IR35-MW22IW
FOURTH STREET
IS214
IS215
IR35-MW37
IR35-MW37IW
IR35-MW03DW
IR35-MW10
IR35-MW10IW
IR35-MW84IW
IS100
IR35-MW82IW
IS101
IS102
IS103
IS104
G482
IR35-MW26
IR35-MW26IW
IR35-MW27
G521
IR35-MW29IW
IR35-MW29
G531
G532
IR35-MW83IW
IS105
IS106
IS107
IS108
IS109
IR35-IS49
IR35-MW22
IR35-MW22IW
IS217
IS218
IS219
G520
G530
G533
IS110
IS111
IS112
IS113
IS114
IR35-MW65
TC470
IR35-MW86IW
IR35-MW32IW
G534
IR35-MW85IW
IS115
IS116
IS117
IS118
IS119
C STREET
IR35-MW38
IR35-MW38IW
IR35-MW30
IR35-MW30DW
IR35-MW30IW
FIFTH STREET
E STREET
F STREET
G STREET
TC572
G554
G560

Legend
- Monitoring Wells
- DPT Groundwater Location
- Proposed Injection Points for ERD
- Proposed Monitoring Wells
- Structure Area
- Slabs
- Road Area

N
W E
S

100 0 100 Feet

Figure 4-2
Proposed Layout of ERD Injection Points and Monitoring Wells
Operable Unit No. 10 (Site 35)
Non-Time Critical Removal Action Work Plan
MCB Camp Lejeune
Camp Lejeune, North Carolina

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5. Monitoring

The monitoring plan for the NTCRA at Site 35 will address groundwater at the following project stages:

- baseline,
- three months following injection,
- six months following injection,
- nine months following injection, and
- one year following injection.

Five new monitoring wells (35-MW82IW through 35-MW86IW) and twelve existing monitoring wells (35-MW03DW, IR35MW10, IR35-MW10IW, IR35-MW29, IR35-MW29IW, IR35-MW30, IR35-MW30IW, IR35-MW30DW, IR35-MW37, IR-35-MW37IW, IR35-MW38, and IR35-MW38IW) will be monitored during the NTCRA. Locations of these wells are shown on **Figure 5-1**.

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. Select monitoring wells will also be analyzed for dissolved gases (methane, ethane, and ethene) by RSK 175; chloride, nitrate, nitrite, and sulfate by EPA Method 300.0; alkalinity by 310.1; and total organic carbon (TOC) and dissolved organic carbon by EPA Method 415.1. Geochemical parameters, including DO, conductivity, pH, temperature, turbidity, and ORP will be evaluated in the field. **Table 5-1** summarizes the monitoring wells and parameters to be sampled.

Changes in groundwater contaminant concentrations will be tracked over the course of one year. The percent reduction in concentrations for individual wells and an average percent reduction of the seventeen monitoring wells will be examined following the final groundwater monitoring event.

TABLE 5-1
Monitoring Wells to be Sampled- Frequency and Analytes
Site 35 NTCRA
MCB Camp Lejeune, North Carolina

Well Identification	Frequency	Analytes					
		VOCs (EPA Method 8260B)	Dissolved Gases (Methane, Ethane, Ethene) (RSK175)	Chloride, Nitrate, Nitrite, and Sulfate (EPA Method 300.0)	Alkalinity (EPA Method 310.1)	TOC and DOC (EPA Method 415.1)	Geochemical Parameters
IR35-MW03DW	Quarterly	X	X	X	X	X	X
IR35-MW10	Quarterly	X	X	X	X	X	X
IR35-MW10IW	Quarterly	X	X	X	X	X	X
IR35-MW29	Quarterly	X					X
IR35-MW29IW	Quarterly	X	X	X	X	X	X
IR35-MW30	Quarterly	X					X
IR35-MW30IW	Quarterly	X	X	X	X	X	X
IR35-MW30DW	Quarterly	X					X
IR35-MW37	Quarterly	X					X
IR35-MW37IW	Quarterly	X					X
IR35-MW38	Quarterly	X					X
IR35-MW38IW	Quarterly	X	X	X	X	X	X
IR35-MW82IW	Quarterly	X	X	X	X	X	X
IR35-MW83IW	Quarterly	X					X
IR35-MW84IW	Quarterly	X	X	X	X	X	X
IR35-MW85IW	Quarterly	X	X	X	X	X	X
IR35-MW86IW	Quarterly	X	X	X	X	X	X

Geochemical Parameters (DO, conductivity, pH, temperature, ORP, and turbidity) will be collected in the field.

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IR35-MW02
IR35-MW67
IR35-MW02DW
IR35-MW16
IR35-MW16IW
IR35-MW14
IR35-MW14IW
TC341
TC342
G480
IS208
IS209
IS210
IS211
IR35-MW09
IR35-MW09IW
D STREET
IR35-IS47
IR35-MW31IW
IR35-MW31
IR35-MW22
IR35-MW22IW
FOURTH STREET
IS214
IS215
IR35-MW37
IR35-MW37IW
IR35-MW03DW
IR35-MW10
IR35-MW10IW
IR35-MW84IW
IS100
IR35-MW82IW
IS101
IS102
IS103
IS104
G482
IR35-MW26
IR35-MW26IW
IR35-MW27
IR35-MW29IW
IR35-MW29
G521
G531
G532
IS217
IS218
IS219
IS105
IS106
IR35-MW83IW
IS107
IS108
IS109
IR35-IS49
IR35-MW22
IR35-MW22IW
G520
G530
G533
G534
IS110
IS111
IS112
IS113
IS114
IR35-MW86IW
IR35-MW85IW
IR35-MW32IW
IR35-MW65
TC470
IS115
IS116
IS117
IS118
IS119
IR35-MW38
IR35-MW38IW
IR35-MW30
IR35-MW30DW
IR35-MW30IW
C STREET
FIFTH STREET
E STREET
F STREET
G STREET
TC572
G554
G560

Legend

- Monitoring Wells
- DPT Groundwater Location
- Proposed Injection Points for ERD
- Proposed Monitoring Wells
- Structure Area
- Slabs
- Road Area

IR35-MW82IW Indicates Monitoring Location

N
W E
S

100 0 100 Feet

Figure 5-1
Monitoring Locations
Operable Unit No. 10 (Site 35)
Non-Time Critical Removal Action Work Plan
MCB Camp Lejeune
Camp Lejeune, North Carolina

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6. Health and Safety Considerations

Development of a comprehensive SHSP will be the combined responsibility of JV I and Subcontractors. The SHSP will address the potential hazards associated with the NTCRA, and will be maintained on-site during all field activities.

Addenda to the SHSP may be prepared by the JV I Project Health and Safety Manager (PHSM) to address changes to specific activities and the hazardous control measures associated with the specific projects. In this manner, the SHSP will be considered a "living document", to be reviewed and updated as necessary.

The SHSP does not address hazards associated with specialized remedial implementation tasks and equipment. 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, and JV I must monitor and enforce compliance with the established HSP.

Inclement weather conditions may occur without warning and are a concern during drilling activity. 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 tiedowns; 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.

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

7. Reporting

A Summary Report will be prepared to present an overview of procedures, material quantities, field observations, analytical results, and conclusion for the NTCRA. The report will include:

- Description of the remedial activities, as summarized from field notes and daily logs;
- Photographs;
- Chronology of significant events that occurred during the project;
- Analytical data from baseline sampling through the one year post-implementation period;
- Assessment of the ERD performance
- Problems encountered; and
- Conclusions.

A draft report will be issued to allow for a comment period. Any comments received will be addressed in the final version.

8. Schedule

8.1 Project Schedule

The proposed schedule for implementing the removal action at Site 35 is presented in **Figure 8-1**. The tasks presented in the schedule correspond to the tasks identified in this work plan.

8.2 Project Organization

The Partnering team includes representatives from CH2M HILL, Naval Facilities Engineering Command (NAVFAC), MCB Camp Lejeune, NCDENR, US Environmental Protection Agency (USEPA) Region 4, and Shaw.

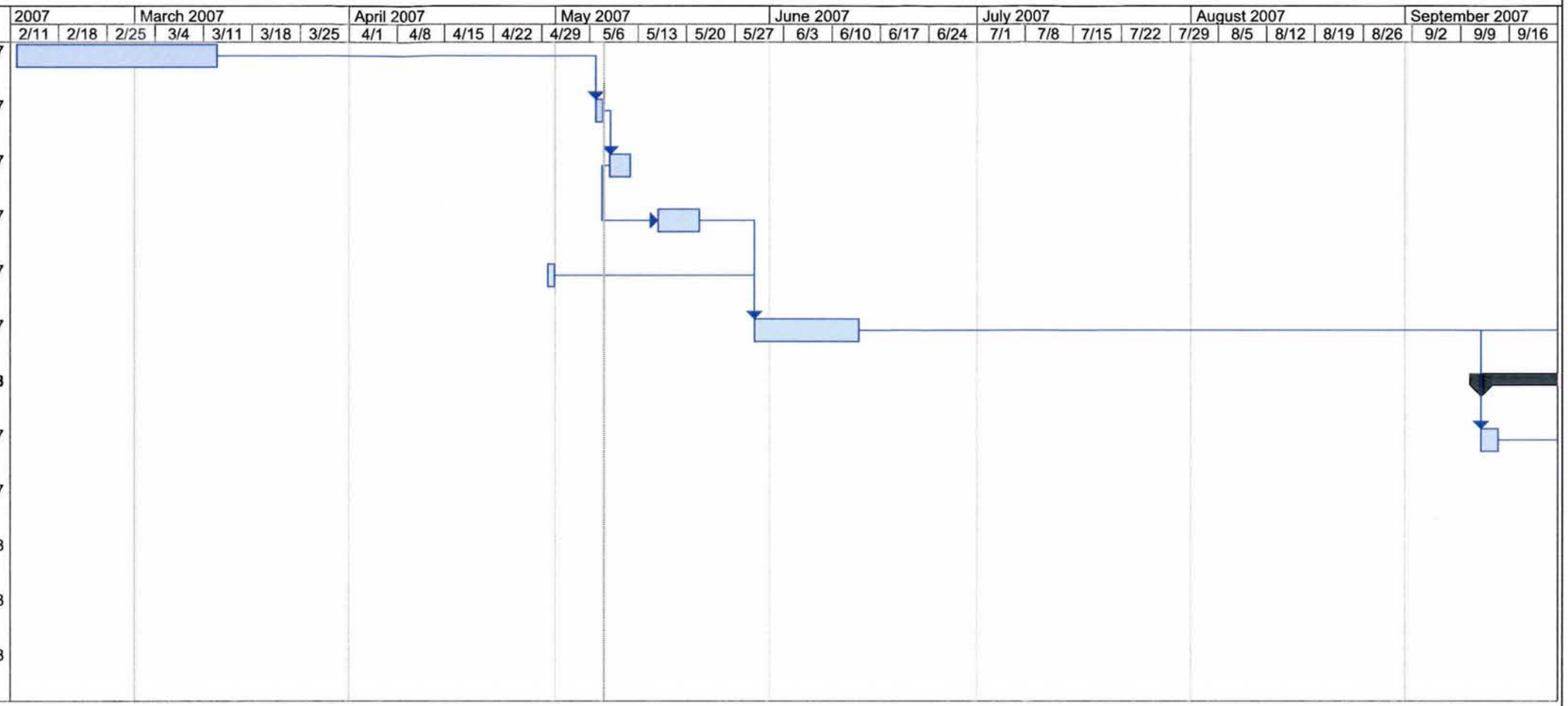
Ms. Jessica Skeean, P.E. of CH2M HILL will serve as the Project Manager (PM) for the removal action and as the primary JV I contact. The PM is responsible for overall project management and the overall quality assurance and quality control (QA/QC) of project deliverables.

Mr. Christopher Bozzini, P.E., of CH2M HILL will serve as the Senior Consultant for the removal action. He will work with the PM to ensure the quality of project execution. Mr. Bob Tossell of CH2M HILL will serve as the Senior Reviewer and will review the technical aspects of the work from project scoping to project completion.

The project team will include: the Project Engineers, FTL, and SSC. All field and subcontractor activity will be under the direction of the FTL.

NTCRA Schedule
Site 35 NTCRA Work Plan
MCB Camp Lejeune, North Carolina

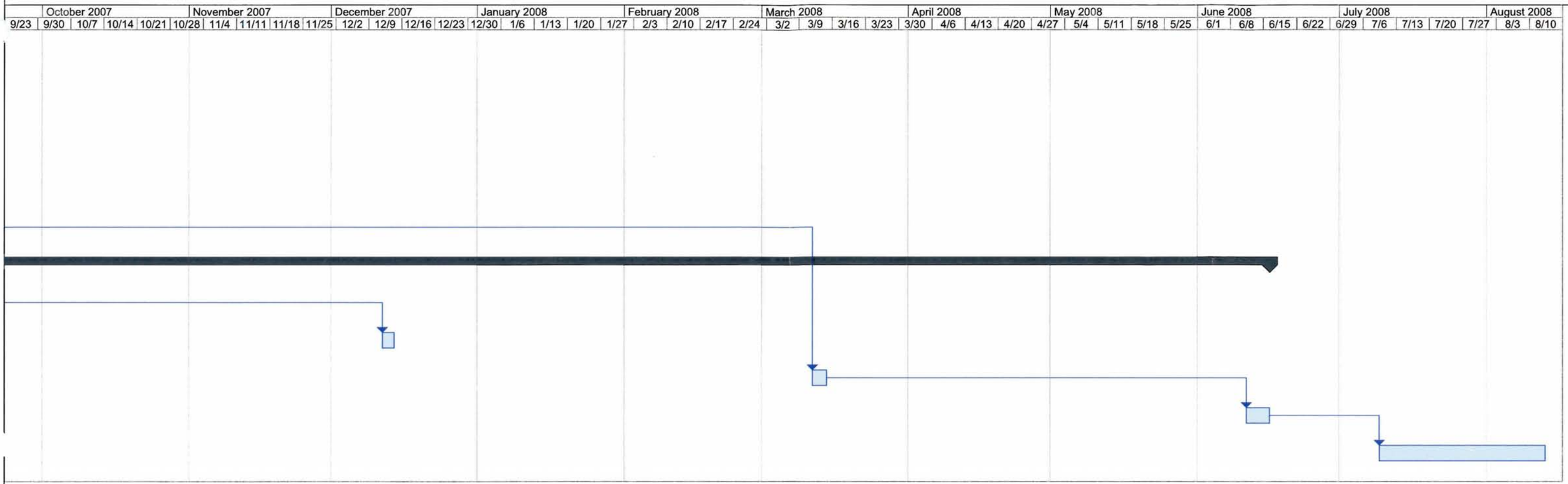
ID	Task Name	Start	Finish
1	Site 35 NTCRA Work Plan - draft	Mon 2/12/07	Mon 3/12/07
2	Utility locate	Mon 5/7/07	Mon 5/7/07
3	MW installation	Wed 5/9/07	Fri 5/11/07
4	Site 35 ER Monitoring - Baseline	Wed 5/16/07	Mon 5/21/07
5	Material Delivery	Mon 4/30/07	Mon 4/30/07
6	ERD injection	Wed 5/30/07	Wed 6/13/07
7	**Site 35 ER Monitoring**	**Wed 9/12/07**	**Mon 6/16/08**
8	Site 35 ER Monitoring - 3 month	Wed 9/12/07	Fri 9/14/07
9	Site 35 ER Monitoring - 6 month	Wed 12/12/07	Fri 12/14/07
10	Site 35 ER Monitoring - 9 month	Wed 3/12/08	Fri 3/14/08
11	Site 35 ER Monitoring - 12 month	Wed 6/11/08	Mon 6/16/08
12	Site 35 NTCRA Summary Report	Wed 7/9/08	Wed 8/13/08



Project: Figure_8_1_35 NTCRA Schec
Date: Tue 5/8/07

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

NTCRA Schedule
Site 35 NTCRA Work Plan
MCB Camp Lejeune, North Carolina



Project: Figure_8_1_35 NTCRA Schec
Date: Tue 5/8/07

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

9. References

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Environmental Science and Engineering, Inc., 1990. *Final Site Summary Report, Marine Corps Base Camp Lejeune.* (Also referred to as the Confirmation Study). September 1990.

Moretti, Lisa, 2005. In Situ Bioremediation of DNAPL Source Zones. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Technology Innovation and Field Services Division. August 2005.

U.S. Environmental Protection Agency, 1993. *Guidance on Conducting Non-Time Critical Removal Actions under CERCLA.* EPA/540-R-93-057, OERR, USEPA, August 1993.