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FINAL SUPPLEMENTAL INVESTIGATION WORK PLAN SITE 69 OPERABLE UNIT 14 (OU 14) MCB CAMP LEJEUNE NC

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CH2M HILL

Final

Supplemental Investigation Work Plan
Site 69, Operable Unit No. 14

Marine Corps Base, Camp Lejeune
Jacksonville, North Carolina

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Acronyms and Abbreviations

Baker	Baker Environmental, Inc.
CBRN	Chemical, Biological, Radiological and Nuclear
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
COC	Chain-of-Custody
COPC	Contaminant of Potential Concern
CTO	Contract Task Order
CWM	Chemical Warfare Materiel
DAAMS	Depot Area Air Monitoring System
DoN	United States Department of the Navy
DOT	Department of Transportation
DPT	direct push technology
DQO	Data Quality Objective
ECBC	Edgewood Chemical Biological Center
ERA	Ecological Risk Assessment
ESE	Environmental Science and Engineering, Inc
FFA	Federal Facilities Agreement
FS	Feasibility Study
ft bgs	feet below ground surface
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
I.D.	Inner Diameter
IDW	Investigation-derived Waste
IR	Installation Restoration
IROD	Interim Record of Decision
LTM	Long-Term Monitoring
MCB	Marine Corps Base
MEC	Munitions of Explosive Concern
MNICAMS	Miniature Continuous Air Monitoring System
MNA	Monitored Natural Attenuation
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MSL	mean sea level
NAA	Natural Attenuation Assessment
NAE	Natural Attenuation Evaluation
NAIP	Natural Attenuation Indicator Parameter

NAVFAC	Naval Facilities Engineering Command, Atlantic Division
NCAC	North Carolina Administrative Code
NCDENR	North Carolina Department of Environment and Natural Resources
NCP	National Contingency Plan
NC SRGs	North Carolina Soil Remediation Goals
NEESA	Naval Energy and Environmental Support Activity
NTU	Nephelometric Turbidity Unit
O.D.	Outer Diameter
ORP	Oxidation-Reduction Potential
OU	Operable Unit
PCB	Polychlorinated Biphenyl
PID	Photo-Ionization Detector
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/ Quality Control
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RI	Remedial Investigation
ROD	Record of Decision
RSL	Regional Screening Level
SVOC	Semi-Volatile Organic Compound
TAL	Target Analyte List
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
UXO	Unexploded Ordnance
VOC	Volatile Organic Compound
WQP	Water Quality Parameter

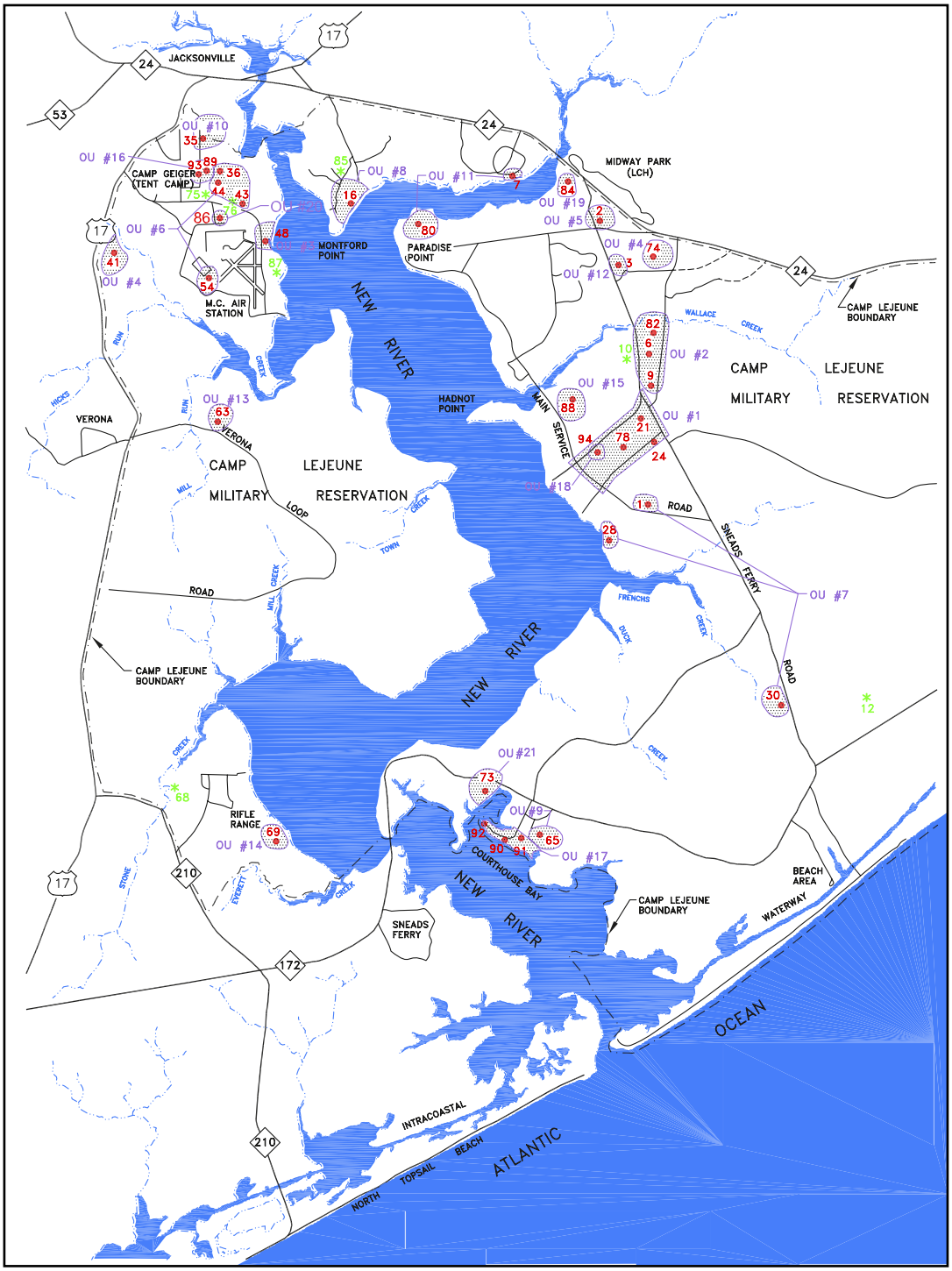
SECTION 1

Introduction

This Site-Specific Work Plan presents the strategy and technical approach for the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Supplemental Investigation under the Installation Restoration (IR) program at Operable Unit (OU) 14, Site 69 – Rifle Range Chemical Dump at Marine Corps Base (MCB) Camp Lejeune, North Carolina (the Base). A general location/index map of the Base showing the location of Site 69 is provided as **Figure 1-1**.

Several appendices accompany this Site-Specific Work Plan including the Heath and Safety Plan (HASP), Low Probability Contingency Plan and the Geophysical Prove Out Work Plan. Each appendix provides additional details about specific aspects of the work being completed at Site 69.

This Site-Specific Work Plan was prepared by CH2M HILL under Contract Task Order (CTO) 0105 of the Department of the Navy's (DoN's) Comprehensive Long-Term Environmental Action Navy (CLEAN) Program. CH2M HILL is responsible for implementation of this project. It should be noted that this Site-Specific Work Plan is to be used in conjunction with the Master Project Plans, which include the Master Work Plan, Master Quality Assurance Project Plan (QAPP), and Master HASP (CH2M HILL, 2005). The Master Project Plans will be referenced to the greatest extent possible.



Vicinity Map

LEGEND

73 Denotes Site*

OU # 21 Denotes Operable Unit*

68 Denotes Pre-RI Site*

*not to scale

North

Figure 1-1
Base Map with Site 69 and Adjacent IR Sites
MCB Camp Lejeune, North Carolina

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SECTION 2

Background Information

Background information for the Base, including location, topography, geology, and CERCLA-related history, is presented in the Master Work Plan and is not repeated herein. Site-specific background information for Site 69 is presented below.

2.1 Site Description

Site 69, the Rifle Range Chemical Dump, is located west of the New River. The Site is approximately 14 acres and is situated in a topographically high area. The area is overgrown to the point that the boundary of the former dump is not easily discernable (**Figure 2-1**). In the 1980s, a six-foot high chain link fence was erected around the site to prevent access by trespassers and military personnel. The site is rather secluded; however, training exercises are conducted throughout the surrounding area. Three surface water bodies are located within a quarter mile of the site: the New River to the east, an unnamed tributary of the New River to the north, and Everett Creek to the south.

2.2 Site Operational History

From 1950 to 1976, Site 69 was used for the trench disposal of chemical wastes, including polychlorinated biphenyls (PCBs), solvents, and pesticides. A 1982 memorandum (United States Marine Corps, 1982) from the Office of the Staff Judge Advocate at MCB Camp Lejeune documents an interview with a former Base employee who stated that he buried approximately fifty 55-gallon drums in two trenches at the site in 1953. He stated that at the time of disposal he was told that the drums contained "either mustard gas or nerve gas" (G-series). No other documentation of chemical warfare materiel (CWM) use, storage or disposal at Camp Lejeune has been identified.

2.3 Previous Site Investigations and Remedial Actions

During the Initial Assessment Study (Water & Air Research, Inc., 1983) conducted at MCB Camp Lejeune, Site 69 was one of 76 sites identified as "potentially contaminated" and one of 23 sites warranting further investigation.

Investigations conducted at Site 69 to date have focused on non-CWM contaminants based on historic disposal and chemical wastes at the site. Monitoring for CWM was performed during all intrusive activities for health and safety reasons, but no CWM or CWM degradation products were ever detected.

From 1984 to 1986, Environmental Science and Engineering, Inc (ESE) performed a Confirmation Study of Site 69, which included installation of eight monitoring wells (69-GW01 through 69-GW08), collection of groundwater from the eight wells, and collection of three surface water and two sediment samples.

In 1990, a chain link fence was erected to restrict access to the disposal area. However, review of historical aerial photography, specifically from 1964, suggests that an area of disposal may lie to the north of the fenced area.

In 1991, ESE conducted a Supplemental Characterization, which included the collection of eight groundwater samples, seven surface water samples, and seven sediment samples. The results of these studies revealed that shallow groundwater exhibited elevated levels of volatile organic compounds (VOCs) in the southern portion of the site. Surface water samples obtained from on-site standing water in low-lying areas of the site revealed the same constituents as were detected in shallow groundwater, but at much lower concentrations (ESE, 1992).

From January 1994 through April 1996, remedial investigation (RI) activities were conducted in five stages in order to characterize the nature and extent of contamination. A total of 29 shallow soil borings and nine subsurface soil borings were completed to characterize soil quality; two geophysical surveys were conducted to identify subsurface anomalies; and a total of eight shallow, six upper zone Castle Hayne, three intermediate zone Castle Hayne, and three deep zone Castle Hayne monitoring wells were installed. Five rounds of groundwater samples were collected from various monitoring wells and via "hydropunch" technique. Samples were analyzed for VOCs, semi-volatile organic compounds (SVOCs), pesticides, PCBs, inorganics, and CWM degradation compounds. The analytical results indicated that groundwater in the shallow aquifer as well as in the upper and intermediate portions of the Castle Hayne aquifer under the former disposal area have been impacted by VOCs (primarily 1,2-dichlorethene). Based on groundwater concentrations and the results of the geophysical survey, which identified metallic debris in the subsurface, the source of the VOCs appeared to be associated with buried waste near well cluster 69-GW15. However, the true location of source material remained unconfirmed due to the suspected presence of buried CWM. Surface water samples indicated that on-site ponded water in the southern portion of the site has been impacted with VOCs; however, off-site surface water and sediment samples indicated the New River, Everett Creek, and an unnamed tributary north of the site had not been impacted by site activities. Additionally, acetophenone, a CWM degradation compound, was detected in several surface soil samples, and on-site and drainage sediment samples. Michael Baker Jr., Inc. (Baker) concluded that the presence of acetophenone was attributable to training activities using "riot gas" (Baker, 1997).

In March 1996, a Treatability Study was conducted to evaluate the use of in-well aeration to remediate groundwater. The study deemed in-well aeration ineffective after two years of operation.

Long-Term Monitoring (LTM) of the site began in April 1998 on a semi-annual basis in order to fully assess plume stability and monitor seasonal changes. Groundwater samples are collected from eight monitoring wells screened in the surficial aquifer, six monitoring wells screened in the upper zone of the Castle Hayne aquifer, and one monitoring well screened in the deep zone of the Castle Hayne aquifer. Groundwater samples collected under this program are analyzed for VOCs and natural attenuation indicator parameters (NAIP).

In June 2000, an Interim Record of Decision (IROD) was issued to address the human health and ecological risks due to VOCs in groundwater and human safety risks due to buried CWM. Institutional controls and monitored natural attenuation (MNA) were the selected remedial actions, which are required to remain in effect until the remedial goals have been achieved or the IROD is superseded by a final Record of Decision (ROD). The remedial actions included: implementing a groundwater monitoring program targeting the VOCs of concern; conducting groundwater monitoring of inorganics and CWM degradation products in select wells; and implementing land use and aquifer use controls (shallow and Castle Hayne aquifers) to prevent site access, control intrusive activities, and prevent future use of the aquifers (Baker, 2000).

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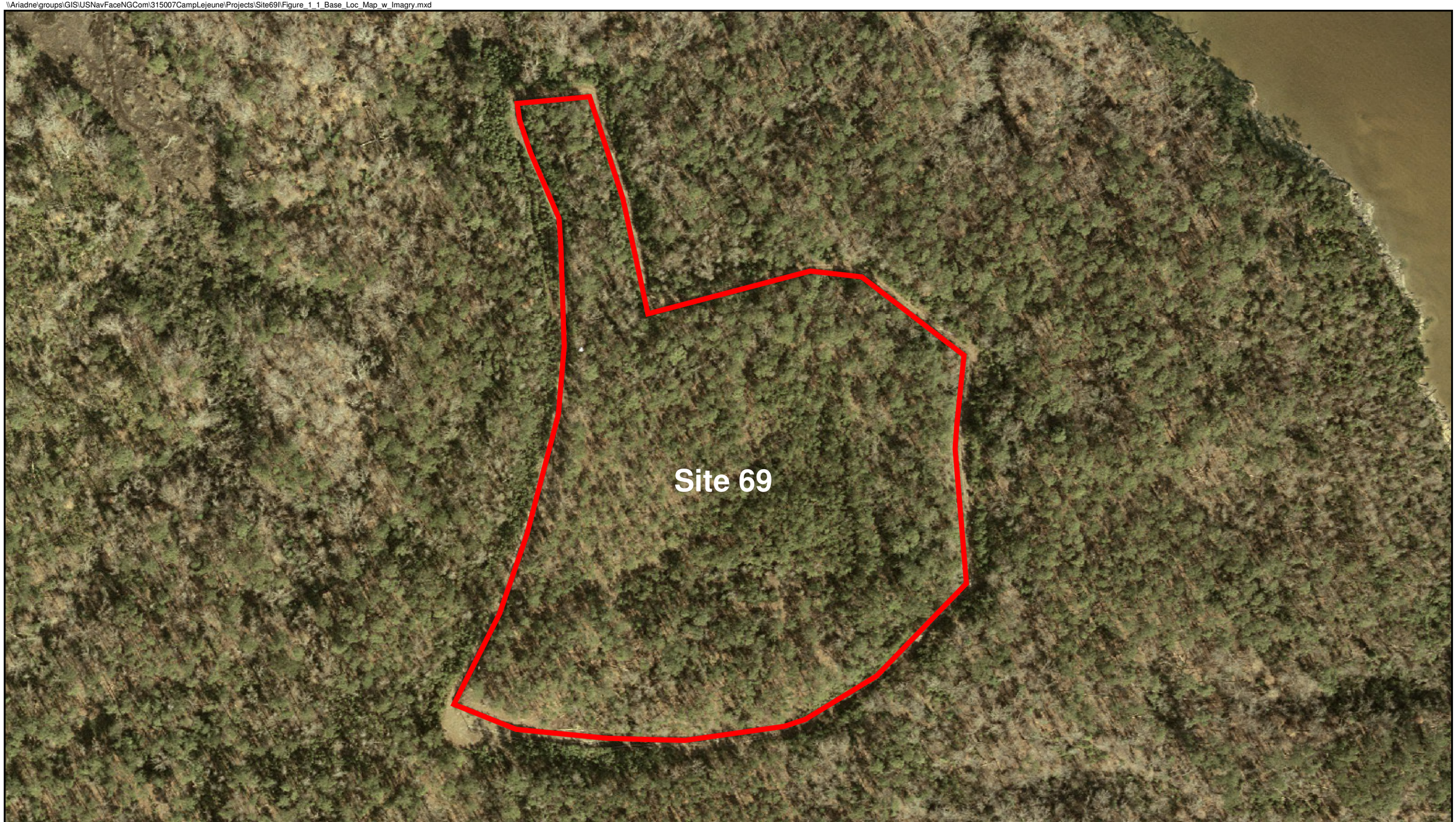

Legend

Site 69

N

0 25 50 100

Meters

Figure 2-1
Site 69 Boundary Map
Operable Unit No. 14 (Site 69)
Work Plan
Marine Corps Base, Camp Lejeune
North Carolina

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SECTION 3

Data Quality and Sampling Objectives

The site-specific objectives presented in this section have been developed using the United States Environmental Protection Agency (USEPA) seven-step data quality objective (DQO) process, as presented in the USEPA *Guidance for the Data Quality Objectives Process* (USEPA, 2000a) and USEPA *Data Quality Objectives Process for Hazardous Waste Site Investigations* (USEPA, 2000b).

3.1 Data Quality Objectives Process

DQOs are qualitative and quantitative statements, developed using the USEPA DQO process, that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as a basis for establishing the quality and quantity of data needed to support decisions. DQOs define the performance criteria that limit the probabilities of making decision errors by considering the purpose of collecting data, defining the appropriate type of data needed, and specifying tolerable probabilities of making decision errors. The seven-step DQO process is as follows:

- Step 1 – State the Problem
- Step 2 – Identify the Decision
- Step 3 – Identify the Inputs to the Decision
- Step 4 – Define the Boundaries of the Study
- Step 5 – Develop a Decision Rule
- Step 6 – Specify Tolerable Limits on Decision Errors
- Step 7 – Optimize the Design for Obtaining Data

The following sections present the seven-step DQO process developed for the Supplemental Investigation at Site 69.

3.1.1 Step 1 – State the Problem

The first activity associated with this step is to establish the planning team. The planning team will include the North Carolina Department of Environment and Natural Resources (NCDENR), USEPA, Naval Facilities Engineering Command (NAVFAC) Atlantic Division, MCB Camp Lejeune, and CH2M HILL. These team members are decision-makers for the DQO process.

The planning team's primary goal is to determine the potential for future corrective action at Site 69. Specifically, the objectives of the Supplemental Investigation are as follows:

- Collect information to supplement and/or verify the environmental setting at the Site, including hydrogeology, geology, hydrology, topography, aquifer characteristics, and any other anthropogenic influences that may affect the hydrology or contaminant pathways at the site.

- Characterize the sources via the collection of analytical data, and evaluate the migration and dispersal characteristics of the release.
- Characterize the hazardous constituents (if any) via the collection of groundwater and soil samples in the vicinity of the Site. Characterization includes a definition of the extent, origin, direction and rate of movement of any contamination.
- Evaluate potential receptors by collecting data describing human populations and environmental systems susceptible to contaminant exposure.
- Evaluate the risk of any contaminants associated with the Site to human health and the environment.
- Provide recommendations for site management.

The problem is that Site 69 has not been adequately characterized and the extent of contamination has not been determined (i.e., a sufficient quantity of data does not exist to support a corrective action decision).

The final activity associated with this step is to identify available resources, constraints, and deadlines. The project team organization and project schedule are presented in Sections 5.0 and 6.0 of this Site-Specific Work Plan, respectively. The schedule presents the anticipated completion and/or submittal dates for specific tasks or documents.

3.1.2 Step 2 – Identify the Decision

The principal study question identified is:

- What is the nature and extent of contamination in the vicinity of Site 69?

Before a decision statement can be formulated, a definition of "contaminated" must be clarified. For the IR program, soil and groundwater will be considered "contaminated" if concentrations of contaminants of potential concern (COPCs) exceed the applicable North Carolina 2L Standards (NCAC, 2006), NC Soil Remediation Goals (NC SRGs) (NCDENR, 2009) and/or USEPA Residential and Industrial Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites (USEPA, April 2009) and the established background/secondary criteria (for metals only)(Baker 2001a, 2001b, 2002).

Considering the principal study question and definition of "contaminated," the decision statement is as follows:

- Define the nature and extent of contamination in the vicinity of Site 69 by determining whether or not the concentration of a given COPC at any given sampling point exceeds the regulatory driven criteria and established background/secondary criteria.

3.1.3 Step 3 – Identify the Inputs to the Decision

Existing information regarding the nature and extent of contamination in the vicinity of Site 69 comes from the previous RI performed by Baker. The results of these assessments are described in the *Final Site Assessment Report for Sites 6, 48 and 69* (ESE, 1992), the *Final Remedial Investigation* (Baker, 1997), and the *Annual Monitoring Report, Operable Unit 14 – Site 69* (Engineering & Environment, 2005). However, in order to determine the potential for

future corrective action or additional actions, additional data is required to characterize and define the extent of contamination at the Site. The nature and extent of contaminated media, hydrogeologic characteristics, and the engineering properties of the site soils will be used to resolve the decision statement.

The criterion for determining the presence of contamination will be based on analytical results and applicable regulatory driven criteria and background/secondary criteria as described in Section 3.1.2. Samples will be analyzed for VOCs, SVOCs, Target Analyte List (TAL) metals, PCBs and pesticides using a fixed-based laboratory as described in Section 4.3.6.

3.1.4 Step 4 – Define the Boundaries of the Study

Groundwater, surface water, surface soil, subsurface soil, and sediment samples will be collected at the locations shown in **Figure 4-1**. The estimated depth of sampling ranges from 0 to 85 feet below ground surface (ft bgs).

Temporal changes in the extent of contamination are expected to be limited. Loss of contaminant mass does occur through natural attenuation processes (e.g., dilution, biodegradation, dispersion). As a result, data collection is not time dependent and the decision regarding the nature and extent of contamination will be based on existing conditions at the time of the investigation.

Practical constraints to sample collection are moderate to severe. The most severe issues exist during the installation of monitoring wells on the site. Given the land use history of the site (Section 2), health and safety considerations are the primary constraint. In addition, the area is remote, undeveloped, heavily wooded and surrounded by a chain-link fence. Weather conditions (such as heavy rain or lightning) can delay the field activities but are not a serious constraint.

3.1.5 Step 5 – Develop a Decision Rule

The decision rule developed for the Supplemental Investigation at Site 69 is as follows:

- If a given concentration at a given sampling point exceeds the regulatory driven criteria and background/secondary criteria for that contaminant, then that sampling point will be considered to be within an impacted area.

3.1.6 Step 6 – Specify Tolerable Limits on Decision Errors

Specification of tolerable limits on the decision errors will not be performed at this time. The sampling scheme is flexible and will include points inside and outside the suspected contaminant source area/plume so that the extent of contamination should be sufficiently defined. Specification of tolerable limits on the decision errors may be developed at a later date as determined by the planning team.

3.1.7 Step 7 – Optimize the Design for Obtaining Data

There are two fundamental goals for Step 7, and both rely on review of existing data and information:

- To evaluate the decision rule
- To design and optimize the sampling and analysis program

The decision rule developed in Step 5 has been shown to be valid following review of existing data. In this case, a simple statistical hypothesis test, broadly classified as a one-sample test was used. The test involved comparison of individual analytical data to a known value (regulatory driven criteria and established background/secondary criteria).

Existing information/data has been reviewed to evaluate and develop the data collection strategy for the field program. The referenced documents are the *Final Site Assessment Report for Sites 6, 48 and 69* (ESE, 1992), the *Final Remedial Investigation* (Baker, 1997), and the *Annual Monitoring Report, Operable Unit 14 – Site 69* (Engineering & Environment, 2005). In addition, the flexibility of the Site-Specific Work Plan optimizes resources in that the number and location of sampling points are determined by field conditions.

SECTION 4

Supplemental Investigation Tasks and Responsibilities

4.1 Project Management

Project management activities include such items as daily technical support and oversight; budget and schedule review and tracking; preparation and review of invoices; personnel resource planning and allocation; and coordination with NAVFAC, MCB Camp Lejeune, and subcontractors.

4.2 Subcontractor Procurement

This task includes procurement, scheduling and coordination of subcontractors. The primary subcontractors required for the Supplemental Investigation include drilling subcontractors, geophysical subcontractor, fixed-base analytical laboratory, independent data validator, utility locator and surveyor. Miscellaneous subcontractors may also be procured for various support services.

4.3 Field Activities

The Site 69 Supplemental Investigation field activities will include the following subtasks:

- Munitions of Explosive Concern (MEC) Avoidance
- Mobilization/demobilization
- Survey
- Vegetation clearance
- Geophysical investigation
- Surface water sampling
- Surface soil sampling
- Subsurface soil sampling
- Sediment sampling
- Monitoring well installation and development
- Monitoring well sampling
- Laboratory analytical program
- Quality Assurance/Quality Control (QA/QC)
- Sample preservation and handling
- Investigation-derived Waste (IDW) Management

The following subsections present a discussion of the proposed field activities.

Based on the possibility of encountering CWM or MEC during the investigation activities, additional Health and Safety measures will be required during the execution of all site

activities. Detailed procedures, provided in the HASP (**Appendix A**) and Low Probability Contingency Plan (**Appendix B**) will be followed at all times. In the unlikely event that items potentially related to chemical agents are encountered during investigation activities at the Site 69, the procedures outlined in **Appendix B** Low Probability Contingency Plan will be followed.

4.3.1 MEC Avoidance

As Site 69 is located within UXO-02, MEC hazards are applicable to this project site and as such, on-site (Unexploded Ordnance) UXO Technician support is required for all site activities.

MEC avoidance operations will be required during vegetation removal, surveying, sampling, and drilling operations. Avoidance operations will consist of a team composed of at least one UXO Technician III and the CH2M HILL field crew or subcontractor field crew. The UXO Team will not investigate any contacts of potential MEC encountered. All MEC contacts and suspected MEC anomalies will be reported to the Site Manager who will in turn notify the Project Manager who will contact the appropriate entities in accordance with contractual requirements.

4.3.2 Mobilization/Demobilization

Mobilization/demobilization consists of securing equipment and supplies necessary for the field activities and shipping or transporting those items both to and from the field. Travel time to and from the Base, construction of decontamination areas, location of IDW storage areas, field establishment of sampling locations (**Figure 4-1**), and underground utility clearance are also included under this task. MCB Camp Lejeune personnel will be consulted during mobilization efforts.

MEC Avoidance Procedures Prior to sampling or well drilling crews on site, the UXO Technicians will conduct a reconnaissance of the sampling area. The reconnaissance will include locating the designated sampling or drilling location(s) and insuring that they are free of anomalies. If anomalies are detected the point will be relocated as directed. Once the designated point has been cleared, an access route for the sampling crew's vehicles and equipment will be cleared. The access route, at a minimum will be twice the width of the widest vehicle and the boundaries will be clearly marked to prevent personnel from straying into non cleared areas. If surface MEC is encountered, the UXO Team will mark and report the item and divert the approach path around the MEC. A magnetometer will be used to ensure there are no subsurface MEC with the approach path. If a subsurface magnetic anomaly is encountered, it will be assumed to be a possible MEC and the path diverted to avoid it.

4.3.3 Survey

MEC Avoidance Procedures Survey activities will be performed under the direction of an UXO Technician; all activities will be conducted after a visual and/or electronic (magnetic) sweep of the area by the UXO Technician.

A North Carolina-licensed land surveyor will be retained to identify the various sampling locations, geophysical transects, and other site features (**Figure 4-1** and **Appendix C –**

Figure 2). The sampling locations will be surveyed for topographic elevation relative to mean sea level (MSL) and horizontal position within the North Carolina State Plane Coordinate System. The vertical accuracy of the survey will be within 0.01 feet and the horizontal accuracy will be within 0.1 feet. Specific surveying procedures are presented in the Master Project Plan.

4.3.4 Vegetation Clearance

MEC Avoidance Procedures Vegetation removal will be performed under the direction of an UXO Technician; all activities will be conducted after a visual and/or electronic (magnetic) sweep of the area by the UXO Technician. Mechanical and manual vegetation removal teams will include one or more UXO Technicians using appropriate geophysical instruments and observations to avoid MEC. Disturbance of the ground surface will not be permitted during vegetation clearance activities. All vegetation will be cut to no less than 6 inches from the ground surface.

Vegetation will be cleared along several corridors ("transects") to facilitate the geophysical investigation described in Section 4.3.4 and the well installation tasks described in Section 4.3.9. Vegetation less than three inches in diameter will be removed from the area of investigation to allow site access for geophysical survey crews, and sampling teams. Vegetation clearing will be accomplished using a combination of non-intrusive mechanical and manual methods. Trees greater than 3 inches in diameter will not be removed unless absolutely necessary.

The Base will coordinate with Camp Lejeune's Environmental Management Division office to identify federally protected species or archeological sites that may be encountered during vegetation clearing activities.

4.3.5 Geophysical Survey

MEC Avoidance Procedures Geophysical surveying will be performed under the direction of an UXO Technician; all activities will be conducted after a visual and/or electronic (magnetic) sweep of the area by the UXO Technician.

Historical aerial photography for Site 69 indicates the presence of a cleared area located north of the current fenced area. In order to evaluate the potential for historical waste management practices in this area, a geophysical survey will be conducted using a G-858 magnetometer and an EM31 terrain conductivity meter. These instruments were selected for their ability to detect buried ferrous materials and variations in soil properties related to trenching, respectively. Geophysical survey transects will traverse the area of investigation using a separation of approximately 10 ft.

Geonics EM31 Terrain Conductivity Meter The Geonics EM31 is a non-intrusive frequency domain instrument used to map average variations of electrical conductivity at depths between 0 and 10 to 15 feet. Frequency domain instruments work by transmitting a sinusoidally varying electro-magnetic signal at one or more frequencies through a transmitter coil. A separate receiver coil measures a signal that is a function of the primary signal and the induced currents in the subsurface. The EM31 operates at a single frequency of 10 kilohertz (kHz), has an intercoil spacing of 12 ft and provides two measurements, quadrature (apparent conductivity) and in-phase (metallic response). One transmitter coil

generates the EM energy and a second receiver coil detects EM fields caused by the transmitter as well as fields induced in subsurface conductive regions.

Geometrics G-858 The G-858 is an optically pumped cesium vapor instrument that measures the intensity of the earth's magnetic field in nanoTeslas (nT). During operation of the magnetometer, a direct current is used to generate a polarized monochromatic light. Absorption of the light occurs within the naturally precessing cesium atoms found in the instrument's two vapor cells. When absorption is complete, the precessing atoms become a transfer mechanism between light and a transverse radio-frequency (RF) field at a specific frequency of light known as the Larmor frequency. The light intensity is used to monitor the precession and adjusts the RF frequency allowing for the determination of the magnetic field intensity.

Anomalies in the earth's magnetic field are caused by remnant or induced magnetism. Remnant magnetism is caused by naturally occurring magnetic materials. Induced magnetic anomalies result from the induction of a secondary magnetic field in a ferromagnetic material by Earth's magnetic field. The shape and amplitude of an induced magnetic anomaly over a ferromagnetic object depend on the geometry, size, depth, and magnetic susceptibility of the object and on the magnitude and inclination of the earth's magnetic field in the study area. Induced magnetic anomalies over buried objects such as drums, pipes, tanks, and buried metallic debris and UXO generally exhibit an asymmetrical, south high/north low signature (maximum amplitude on the south side and minimum on the north).

Additional site-specific details relating to the geophysical survey are presented in **Appendix C** Geophysical Prove Out Work Plan.

4.3.6 Surface Water Sampling

MEC Avoidance Procedures – Surface water sampling will be performed under the direction of an UXO Technician; all sampling activities will be conducted after a visual and/or electronic (magnetic) sweep of the area by the UXO Technician.

Three surface water samples (designated as IR69-SW-01 through IR69-SW-03) will be collected at locations which correspond with previous monitoring locations. The locations of the proposed surface water samples are shown on **Figure 4-1**. Sample locations may be adjusted at the time of sampling based on site-specific conditions. Deviations from the proposed locations will be noted and explained in the Supplemental Investigation Report.

Field parameters (e.g., dissolved oxygen, temperature, specific conductance, salinity, hardness, and pH) will be measured prior to sample collection with a water quality meter and HACH kits. Surface water samples will then be collected by submersing the sampling container directly into the surface water body or by using a “thief” type sampler and then transferring the sample to the sample container. The body of the immersed sampling container will face downstream so that any sediment disturbed during the immersion of the container does not enter the sampling vessel. If the volume of surface water encountered is insufficient to allow the direct submersion of the sampling containers, a new, clean glass interim vessel will be used to transfer the surface water sample to the sample containers. The glass interim vessel will be laboratory cleaned to the same specifications as the sample containers. For VOC samples, the bottles will be filled so as to minimize aeration of the

samples. During the collection of surface water samples, care will be taken to ensure that any pre-added preservative is not rinsed from the sampling container during sample collection. Sample vials will be filled completely and capped to prevent the entrapment of any air bubbles in the vial.

Samples will be analyzed by a fixed base laboratory for VOCs, SVOCs, TAL metals, pesticides, PCBs, and CWM degradation products.

4.3.7 Sediment Sampling

MEC Avoidance Procedures Sediment sampling will be performed under the direction of a UXO Technician; all sampling activities will be conducted after a visual and/or electronic (magnetic) sweep of the area by the UXO Technician.

Three sediment samples (designated as IR69-SD01 through IR69-SD03) will be collected at locations which correspond with the surface water sample locations. The sediment sample locations are shown on **Figure 4-1**.

The samples will be collected at a depth of approximately 0 to 0.5 foot into the sediment using decontaminated stainless steel spoons/trowels or other appropriate sampling tools. General sampling procedures are presented in the Master Project Plans.

Samples will be analyzed by a fixed base laboratory for VOCs, SVOCs, TAL metals, pesticides, PCBs, and CWM degradation products.

4.3.8 Surface Soil Sampling

MEC Avoidance Procedures Surface soil sampling will be performed under the direction of an UXO Technician; all sampling activities will be conducted after a visual and/or electronic (magnetic) sweep of the area by the UXO Technician.

A total of six discrete surface soil samples will be collected from depths of 0 to 1 ft bgs at the locations shown on **Figure 4-1**. Actual sample locations will be surveyed by professional land surveyor at the conclusion of sampling activities.

Samples will be analyzed by a fixed base laboratory for VOCs, SVOCs, TAL metals, pesticides, PCBs, and CWM degradation products

4.3.9 Subsurface Soil Sampling

CWM Health and Safety Procedures Subsurface soil sampling inside the Site 69 fence will be performed in Level C as indicated in the HASP, including a MSA Millennium respirator with CBRN (chemical, biological, radiological and nuclear) canisters or equivalent. Subsurface soil sampling outside the Site 69 fence will be performed in Modified Level D as indicated in the HASP. All subsurface soil sampling conducted at the site (inside and outside the Site 69 fence) will require continuous air monitoring using the Miniature Continuous Air Monitoring System (MINICAMS) near-real-time continuous air monitoring system (portable flame photometric detector) and Depot Area Air Monitoring System (DAAMS) tubes operated by personnel from the Edgewood Chemical Biological Center (ECBC). Specific procedures and health and safety requirements are detailed in the HASP (**Appendix A**) and Low Probability Contingency Plan (**Appendix B**).

MEC Avoidance Procedures The UXO Technician will clear a work site for the well drilling and clearly mark the boundaries. The area will be large enough to accommodate the sampling equipment and provide a work area for the sampling crew. If a pre-selected area indicates magnetic anomalies, a new sampling site will be chosen. Down hole avoidance support will be practiced every one foot to a maximum depth of 15 feet or until positively below any trench depth.

A hand auger will be used to collect subsurface soil samples in accordance with the Master Project Plans. A total of six subsurface soil samples will be collected from just above the water table (estimated to range from 5 to 15 feet bgs) at the locations shown in **Figure 4-1**.

Subsurface soil samples will be analyzed by a fixed base laboratory for VOCs, SVOCs, TAL metals, pesticides, PCBs, and CWM degradation products.

4.3.10 Monitoring Well Installation and Development

CWM Health and Safety Procedures Drilling activities inside the Site 69 fence will be performed in Level C as indicated in the HASP, including a MSA Millennium respirator with CBRN canisters or equivalent. Drilling activities outside the Site 69 fence will be performed in Modified Level D as indicated in the HASP. All drilling activities conducted at the site will require continuous air monitoring using the MINICAMS near-real-time continuous air monitoring system (portable flame photometric detector) and DAAMS tubes operated by personnel from the ECBC. Specific procedures and health and safety requirements are detailed in the HASP (**Appendix A**) and Low Probability Contingency Plan (**Appendix B**).

MEC Avoidance Procedures The UXO Technician will clear a work site for the well drilling and clearly mark the boundaries. The area will be large enough to accommodate the drilling equipment and provide a work area for the crews. At a minimum, the cleared area will be a square, with a side dimension equal to twice the length of the largest vehicle or piece of equipment for use on site. If a pre-selected area indicates magnetic anomalies, a new sampling / drill site will be chosen. Down hole avoidance support will be practiced every one foot to a maximum depth of 15 feet or until positively below any trench depth.

A total of 15 monitoring wells will be installed to evaluate intermediate (50 to 55 ft bgs) and deep (80 to 85 ft bgs) portions of the aquifer. The new monitoring wells will be installed to complete the horizontal and vertical delineation of the contaminant plume in the intermediate and deep aquifer zones particularly in the central and northern portions as well as east of the fence line. It is anticipated that intermediate and deep zone wells will be installed adjacent to existing shallow aquifer wells 69-GW04, 69-GW05, 69-GW09, 69-GW10, and 69-GW11. However, the well locations may be adjusted based on information obtained during the geophysical investigation. If the geophysical data suggests evidence of potentially buried material north of the fence line, well clusters will also be installed north of the fence line to evaluate potential groundwater impacts in this area.

Additionally, the horizontal extent of VOCs in the Upper Castle Hayne aquifer has not been defined north and east of 69-GW13 and 69-GW13DW, therefore one deep aquifer well will be installed adjacent to 69-GW13DW. Two additional intermediate and deep well couplets

will be installed east of 69-GW13 and northeast of 69-GW04. Existing and proposed monitoring well locations are shown on **Figure 4-1**.

In order to limit potential cross-contamination during construction, all wells will be constructed as 'Type III-equivalent' wells, utilizing rotosonic drilling equipment. The rotosonic drilling method will eliminate the need for permanent surface casings (required for mud or air rotary drilling), which significantly reduces the volume of IDW generated and allows completion of double and triple-cased wells in roughly one-third of the time required for traditional methods. The rotosonic method advances an isolation casing to prevent cross-contamination, the hole is grouted, and the casing is removed.

Well installation procedures are presented in the Master Project Plans and summarized below. All monitoring wells will be constructed using Schedule 40 PVC casing and five feet of 0.010-inch machine-slotted well screen. The annular space around the well screen will be backfilled with well-graded, fine sand as the rotosonic casings are being withdrawn from the borehole. The sand will extend to approximately two feet above the top of the screened interval. An approximately two-foot thick layer of bentonite pellets will be placed above the sand pack and hydrated with potable water, as necessary. The annular space above the bentonite seal will be backfilled with cement/bentonite grout to prevent surface water from infiltrating into the screened groundwater-monitoring zone. Above grade well covers will be installed at each well and surrounded by a concrete pad with protective bollards. All wells will have a water-tight, locking cap installed on the PVC riser. A padlock will be installed on each of the stick-up covers.

Each new well will be developed using pumping and surging methods. Typical limits placed on well development may include any of the following:

- A maximum time period (typically two hours)
- A maximum borehole volume (typically three to five borehole volumes plus the amount of any water added during the drilling or installation process)
- Stability of pH, specific conductance, and temperature measurements (typically less than 10 percent change between three successive measurements)
- Clarity based on turbidity measurements [typically less than 20 Nephelometric Turbidity Units (NTU)].

Well development procedures are detailed in the Master Project Plans.

4.3.11 Groundwater Sampling

CWM Health and Safety Procedures Initial headspace readings will be collected from each monitoring well by ECBC using the MINICAMS and DAAMS tubes. The CH2M HILL field sampler will open each of the monitoring well caps and place the MINICAMS sample line and DAAMS tube sampler at the well head while in Level C. Data from two cycles of the MINICAM S will be collected. If no CWM-related constituents are detected, the DAAMS tubes will not be analyzed and groundwater sampling activities will be performed in Modified Level D as indicated in the HASP. If any CWM-related constituents are detected the DAAMS tube will be analyzed and the Low Probability Contingency Plan will be

initiated. Specific procedures and health and safety requirements are detailed in the HASP (**Appendix A**) and Low Probability Contingency Plan (**Appendix B**).

MEC Avoidance Procedures Groundwater sampling will be performed under the direction of an UXO Technician; all sampling activities will be conducted after a visual and/or electronic (magnetic) sweep of the area by the UXO Technician.

All pre-existing wells and newly installed wells will be sampled. Monitoring well sampling will take place no sooner than two days after completion of well development. This will allow an adequate amount of time for the wells to equilibrate. The wells will be purged and sampled using peristaltic pumps and low-flow purging/sampling methods. If high volume/high yield wells are present, multiple pumps can be used. New disposable tubing will be used for each well. Specific sampling procedures are presented in the Master Project Plans and summarized below:

- The well cap will be removed and the ambient air above the well head will be screened in accordance with the HASP (Appendix A).
- The static water level will be measured, however, the total depth of the monitoring well will not be measured, to prevent the disturbance of sediment within the well casing. The total well depth will be obtained from the Well Construction Records. The water volume in the well will then be calculated.
- The sampling device intake will be slowly lowered until the bottom end is two to three feet below the top of the well screen or the top of the water level, whichever is greater. Next, the water level probe will be placed into the monitoring well just above the water.
- Purging will begin. The pumping rate will be set to create a sustainable flow (approximately 0.3 to 0.5 liters/minute) without causing a significant drop in water level in the well. The static water level will be periodically measured throughout purging to verify that a significant drop in water level has not occurred.
- Water quality parameters (WQPs), including pH, specific conductance, temperature, oxidation-reduction potential (ORP), turbidity, and dissolved oxygen will be measured frequently.
- Purging will be complete when three successive readings of pH, specific conductance, and temperature have stabilized within 10 percent (0.1 Standard Units for pH), turbidity is less than 10 NTUs, or there is no further discernable upward or downward trend. A minimum of one well volume will be removed from the well prior to sampling. If a well is purged dry, the well will be allowed to recharge (preferably to 70 percent of the static water level) prior to sampling.
- Upon WQP stabilization, groundwater samples will be collected and placed into the appropriate sample container(s).
- Samples will be analyzed by a fixed base laboratory for VOCs, SVOCs, TAL metals, pesticides, PCBs, CWM degradation products, and natural attenuation indicator parameters.

4.4 Field Quality Assurance/Quality Control

Specific QA/QC requirements are presented in the Master QAPP, which is contained in the Master Project Plans. The Master QAPP describes the different levels of sample analysis and the associated QC procedures required with each. Adherence to established USEPA chain-of-custody (COC) procedures during the collection, transport, and analysis of the samples will be maintained throughout the project. Laboratory analyses of the samples will conform to accepted QA requirements.

The following QA/QC samples will be collected during the field activities to ensure precision, accuracy, representativeness, completeness, and comparability:

- Equipment rinsate blanks
- Field blanks
- Field duplicates
- Matrix Spike/Matrix Spike Duplicates (MS/MSDs)

Equipment rinsate blanks will be collected by running laboratory-supplied de-ionized water over/through the sampling equipment and placing it into the appropriate sample containers for laboratory analyses. Equipment rinsate blanks will be collected from selected disposable sampling equipment (i.e., roll of tubing, stainless steel spoon, etc.); one equipment rinsate blank will be collected each day for reusable sampling equipment. The results will be used to verify that the sampling equipment has not contributed to contamination of the samples.

One field blank will be collected from each source of water used in decontamination. The field blanks will be collected by pouring the water from the original container or spigot directly into the sample bottle set. Field blanks will not be collected in dusty environments. The results will be used to verify that the water used in decontamination has not contributed to contamination of the samples.

Field duplicate samples will consist of one unique sample, split into two aliquots, and analyzed independently. Duplicate soil samples analyzed for parameters other than VOCs will be homogenized and split. Samples for VOC analyses will not be mixed, but select segments of the soil will be collected. Duplicate water samples will be collected simultaneously. The duplicate samples will be analyzed to verify the reproducibility of the laboratory results and degree of variability of reported concentrations. Duplicate samples will be collected at a frequency of 10 percent.

MS/MSD samples will be prepared in the field to address aliquoting reproducibility and to provide information on matrix reproducibility otherwise unobtainable from samples reported below analytically reproducible and statistically valid levels. MS/MSD samples will be prepared at a frequency of 5 percent for each group of samples of a similar matrix.

4.5 Sample Handling and Analysis

Each environmental sample collected will be homogenized and then divided into a minimum of three split samples prior to monitoring or analysis. Homogenization of the sample is required to ensure that each split sample is adequately representative (USACE,

2004). Samples for chemical analyses will be placed into laboratory-prepared sample containers with the appropriate preservatives and stored on ice in a cooler at 4° Celsius (or less) until shipped to the laboratory. Prior to off-site shipment, unless the sampled media is aqueous, one of the split samples will be screened for agent using MINICAMS to ensure that concentrations are below the airborne exposure limit. Once agent concentrations are determined to be below the airborne exposure limit, the sample will be analyzed using soil and water extraction methods to ensure concentrations are below detectable levels in accordance with Department of Army Pamphlet 385-61 (Department of the Army [DA], 2004). The sample will be driven to an off-site fixed surety lab (Edgewood Chemical Biological Center [ECBC]) to analyze for chemical agents or chemical agent breakdown products.

The split samples of environmental samples are to be analyzed by the non-surety laboratory following these procedures: (1) Split samples will be created and screened/analyzed for chemical agent as described above. (2) Split samples created for Hazardous Toxic Reactive Waste analyses will be retained on-site until they have been analyzed by extraction and determined to have no detectable concentrations of chemical agent. Equipment blanks do not require headspace analysis prior to sample shipment. (3) The receiving laboratory to conduct the analyses will be notified in writing prior to beginning work at the project that samples could possibly contain chemical agent contamination. This notification shall explain the measures taken to ensure, to the extent possible, that the non-surety laboratory will not receive samples that are contaminated by chemical agent (USACE, 2004). **Figure 4-2** illustrates the environmental sampling characterization process discussed above (DA, 2004).

Example text for this letter follows:

> "This letter is to inform you of the nature of the operations that will be taking place at the above project. The objective for sampling at this site includes an assessment for chemical warfare agent and agent breakdown products, as well as the hazardous and toxic wastes (HTW) for which your laboratory will be performing analyses. Prior being sent to your laboratory, the disposal characterization samples will be cleared for agent by [state name of ECBC laboratory or contractor facility with current Bailment agreement to handle surety materiel for analysis]. A copy of the clearance report for these samples will be sent to your laboratory along with the HTW samples." (USACE, 2004)

Sample preservation details are presented in the Master Project Plans. The type of container used for each sampling effort, as well as a summary of preservation requirements is described in the Master QAPP.

Proper COC documentation will be maintained for all samples from the time of collection until they are shipped to the analytical laboratory. The COC forms will contain the following information: project number (CTO), sampler names, sample numbers, number of containers, methods of preservation, date and time of sample collection, analysis requested, date and time of transportation to the laboratory, method of transportation, and any other information pertinent to the samples. Specific COC procedures are presented in the Master Project Plans.

Samples will be hand delivered to the surety laboratory for CA analysis. After confirmation from the surety laboratory that CA is not present in a sample. The sample will be shipped via overnight courier to the non-surety laboratory with a note describing samples as having no detectable concentrations of chemical agent.

4.6 Investigation-derived Waste Management

IDW will be managed in accordance with Section 4.20 of the Master Project Plans. IDW will consist of health and safety disposables, potentially contaminated soil, decontamination fluids, and groundwater. Health and safety disposables, such as sampling gloves, and soil IDW generated as part of the field activities will be separately containerized in Department of Transportation (DOT) approved 55-gallon drums or in roll-off containers. Water IDW will be placed in poly tanks or 55-gallon drums. The IDW containers will be transported to and staged at a designated 90-day storage area pending final disposition.

4.7 Data Management and Validation

It is anticipated that data management activities will consist primarily of entering field and laboratory data onto computerized spreadsheets using database software and tabulating field and analytical results for preparation of the report.

An independent data validator will be subcontracted for data validation. The laboratory analytical results will be evaluated to assess the technical adequacy and usability of the data. The data will be technically reviewed based on specifications set forth in the Naval Energy and Environmental Support Activity (NEESA) and USEPA guidance documents.

4.8 Data Evaluation

This task involves efforts related to the data once it is received from the laboratory and is validated. In addition, this task involves the evaluation of field-generated data including laboratory analytical data, water level measurements, Test Boring and Well Construction Records, water quality measurements, and other field notes. Efforts under this task will include the tabulation of validated analytical data and field data; generation of Test Boring and Well Construction Records; and generation of groundwater contour maps and other diagrams/figures/tables associated with field notes or data received from the laboratory (e.g., sampling location maps).

The laboratory analytical results will be compared to the North Carolina 2L standards (NCAC, 2006), NC SRGs (NCDENR, 2009), and/or USEPA Residential and Industrial RSLs for Chemical Contaminants at Superfund Sites (USEPA, April 2009) and the established base background/secondary criteria.

4.9 Risk Assessment

The Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (ERA) will be re-evaluated with the addition of samples collected during this Supplemental Investigation at Site 69. The HHRA and ERA will identify existing or potential risks that

may be posed to human health and/or the environment and will serve to support the evaluation of the threats posed by a site with respect to current and future potential exposure scenarios. In addition, the HHRA and ERA will be used to support development and evaluation of remedial alternatives during the Feasibility Study (FS). The general approach for conducting the HHRA and ERA is presented in the Master Project Plans and summarized in the following subsections.

4.9.1 Human Health Assessment

The re-evaluated HHRA will be conducted in accordance with the *National Oil and Hazardous Substances Pollution Contingency Plan (NCP)* (USEPA, 1990). The primary guidance document for the HHRA will be the *Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual (Part A) Interim Final* (USEPA, 1989). USEPA Region IV will be consulted for Federal guidance and the NCDENR will be consulted for guidance in the State of North Carolina.

The technical components of the HHRA will include contaminant identification, exposure assessment, toxicity assessment, and risk characterization. The objectives of the risk assessment process are as follows:

- Characterize the toxicity and levels of COPCs in relevant media (e.g., soil, groundwater, surface water, sediment, air, and biota).
- Characterize the environmental fate and transport mechanisms within specific environmental media.
- Identify potential current and future human receptors.
- Identify potential exposure routes and the extent of the actual or expected exposure.
- Define the extent of the expected impact or threat.
- Identify the levels of uncertainty associated with the above items.

The HHRA will utilize all available data to date that has been properly validated in accordance with USEPA guidelines plus data that is collected and validated from additional sampling during the Supplemental Investigation.

4.9.2 Ecological Assessment

The ERA will be conducted to evaluate the likelihood that adverse ecological effects would occur or are occurring as a result of exposure to one or more physical or chemical stressors. The assessment will evaluate the potential effects of chemicals on terrestrial and aquatic receptors (e.g., flora and fauna) and their habitats, including the consideration of protected species and sensitive or critical habitats and will identify particular chemical stressors that may cause adverse effects.

The ERA will be conducted according to guidance provided by the USEPA and NCDENR.

4.10 Report Preparation

A Supplemental Investigation Report will be prepared following the general format as presented in USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final* (USEPA, 1998) and will include, but not be limited to, the following:

- Information to supplement and/or verify the environmental setting of the site including geology and hydrogeology
- A summary of the investigation/sampling activities
- Characterization of the source(s)
- Evaluation of the nature and extent of contamination
- Human health and ecological risk assessments
- Conclusions and recommendations

A draft report will be submitted to the USEPA and NCDENR for comments and approval. Response to comments and necessary revisions will be made to the revised draft report before issuing a final report.

4.11 Meetings

This task includes participation in project meetings to be held between members of the project team. Meetings will be held before and after completion of the field activities; one meeting will be held after submission of the draft report. The purpose of the meetings will be to discuss the field activities and sampling results/findings.

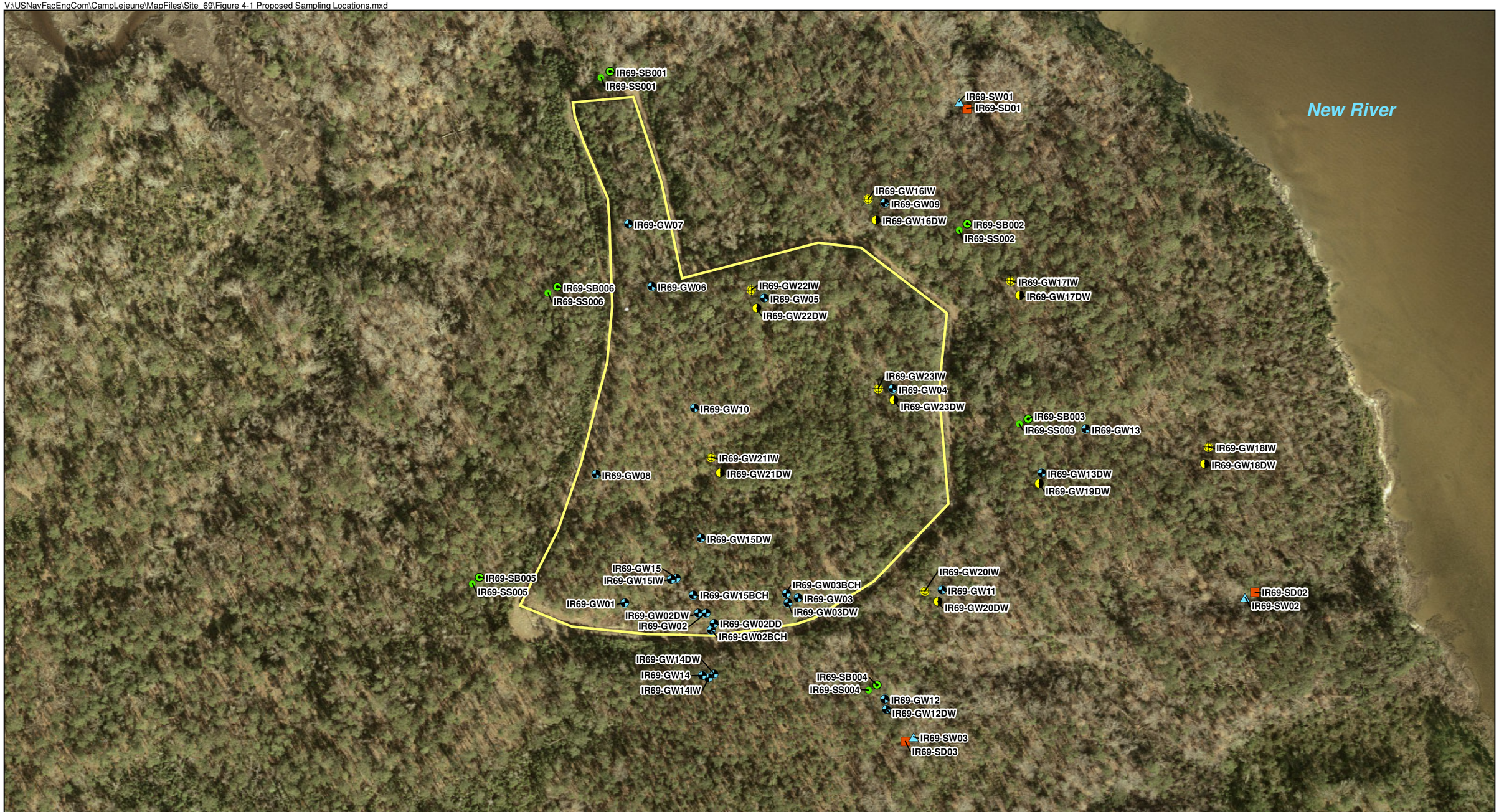
TABLE 4-1
Sample Analysis Summary - OU-14, Site 69
Supplemental Investigation, CTO - 0105
MCB, Camp Lejeune, North Carolina

Sample Type	Sample Designation	Soil Samples	Water Samples	
			Schedule A	Schedule B
Surface Water	IR69-SW01 through IR69-SW03		3	
	SUBTOTAL	**0**	**3**	**0**
Sediment	IR69-SD01 through IR69-SD03	3		
	SUBTOTAL	**3**		
Surface and Subsurface Soil	IR69-SS001 through IR69-SS006	6		
	IR69-SB001 through IR69-SB006	6		
	SUBTOTAL	**6**	**0**	**0**
Groundwater	28 existing + 14 newly installed wells		42	42
	SUBTOTAL		**42**	**42**
Total Environmental Samples		**9**	**45**	**42**
Trip Blanks		0	6	0
Field duplicate samples		1	5	5
Matrix Spike Samples (MS)		1	2	0
Matrix Spike Duplicate Samples (MSD)		1	2	0
Field Blanks		1	6	6
Equipment Rinsate Blanks		1	6	6
	TOTAL SAMPLES	**14**	**72**	**59**

Schedule A VOCs, SVOCs, Pesticides, PCBs, CWM degradation products

Schedule B Natural attenuation indicator parameters

V:\USNavFacEngCom\CampLejeune\MapFiles\Site_69\Figure 4-1 Proposed Sampling Locations.mxd



Legend

Proposed Sampling Locations:
- Surface Soil
- Subsurface Soil
- Surface Water
- Sediment

Proposed Monitoring Wells:
- Deep
- Intermediate

- Phase I Remedial Investigation Well
- Site 69

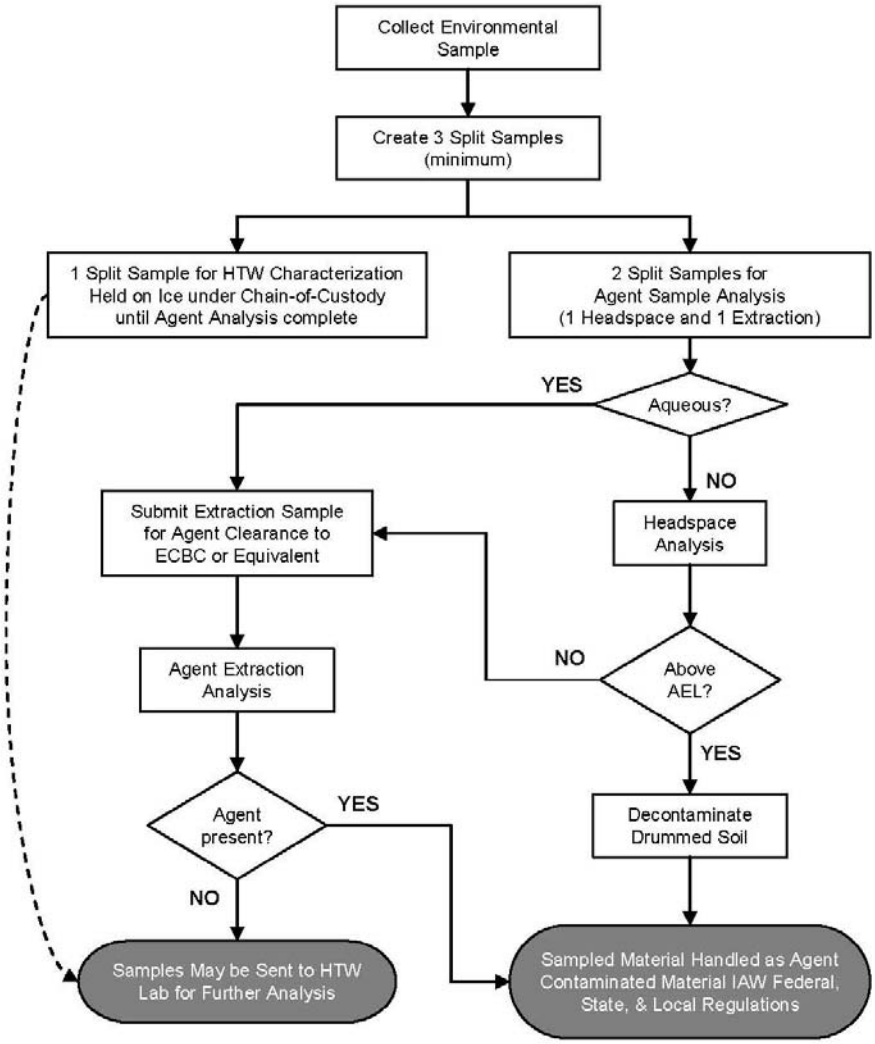
N

0 100 200 400 Feet

1 inch = 200 feet

Figure 4-1
Proposed Sampling Locations
Operable Unit 14 (Site 69)
MCB Camp Lejeune, North Carolina

CH2MHILL



Source: Department of the Army, 2004

Figure 4-2
Environmental Sample Characterization
Operable Unit 14 (Site 69)
MCB Camp Lejeune, North Carolina

SECTION 5

Project Management and Staffing

CH2M Hill's primary participants for this project (CTO-0223) are as follows:

- Mr. Matt Louth – Activity Coordinator
- Mr. Theron Grim – Project Manager
- Task Managers

Mr. Grim and the Task Managers will have the overall responsibility for conducting the field activities and completing the reports associated with this CTO. They will be supported by geologists, engineers, scientists, biologists, and clerical personnel, as needed. The Task Managers will report to Mr. Grim and Mr. Louth who will then relay pertinent issues and maintain close contact with NAVFAC and the Base.

SECTION 6

Project Schedule

The project schedule is presented in **Figure 6-1**. The schedule presents the anticipated completion and/or submittal dates for specific tasks or documents.

FIGURE 6-1
Proposed Project Schedule - OU14, Site 69

Task Name	Duration (days)
Supplemental Investigation Field Work	26
Laboratory Analysis/Data Validation	45
Draft Supplemental Investigation Report	90
Agency Review	40
Final Supplemental Investigation Report	30

SECTION 7

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Appendix A
Health and Safety Plan

Appendix B
Low Probability Contingency Plan

Final

Low Probability Contingency Plan
Site 69, Operable Unit Number No. 14
Former Rifle Range Chemical Dump

Marine Corps Base Camp Lejeune
Jacksonville, North Carolina

Contract Task Order 0223

January 2010

Prepared for

Department of the Navy
Naval Facilities Engineering Command
Mid-Atlantic

Under the

NAVFAC CLEAN III Program
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Prepared by

CH2MHILL

Charlotte, North Carolina

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Acronyms and Abbreviations

ATNAA	Antidote Treatment—Nerve Agent, Auto-Injector
CA	chemical agent
CARA	CBRNE Analytical and Remediation Activity
CBRN	chemical, biological, radiological, and nuclear
CBRNE	chemical, biological, radiological, nuclear, and high-yield explosives
CRZ	contamination reduction zone
CWM	chemical warfare materiel
DAAMS	Depot Area Air Monitoring System
DPT	direct push technology
ECBC	Edgewood Chemical Biological Center
EOD	Explosive Ordnance Disposal
EPDS	emergency personnel decontamination station
EZ	exclusion zone
HSM	Health and Safety Manager
HSP	Health and Safety Plan
MCB CamLej	Marine Corps Base Camp Lejeune
MEC	munitions and explosives of concern
mg/m^3	milligrams per square meter
MPPEH	material potentially presenting an explosive hazard
MRP	Munitions Response Program
NAVFAC	Naval Facilities Engineering Command
PCB	polychlorinated biphenyl
PID	photoionization detector
PM	Project Manager
PPE	personal protective equipment
RPM	Remedial Project Manager
SSC	Site Safety Coordinator
SVOC	semivolatile organic compound
SUXOS	Senior Unexploded Ordnance Supervisor
UXO	unexploded ordnance
VOC	volatile organic compound

SECTION 1

Introduction

1.1 Purpose

The purpose of this contingency plan is to define the procedures that will be followed in the unlikely event that items potentially related to chemical agents (CAs) or their degradation products are encountered during investigation activities at the Site 69 Former Rifle Range Chemical Dump, Marine Corps Base Camp Lejeune (MCB CamLej), North Carolina. In addition to being a former waste disposal site, Site 69 lies within United States Marine Corps Munitions Response Program (MRP) Site UXO-02; therefore, the presence of munitions and explosives of concern (MEC) including material potentially presenting an explosive hazard (MPPEH) is possible at the site. This MEC/MPPEH is not anticipated to contain chemical agent. A 1982 memorandum (USMC, 1982) from the Office of the Staff Judge Advocate at MCB CamLej documents an interview with a former Base employee who stated that he buried approximately fifty 55-gallon drums in two trenches at the site in 1953. He stated that at the time of disposal he was told that the drums contained "either mustard gas or G-class nerve gas". No other documentation of CA use, disposal, or storage at MCB CamLej has been identified.

1.2 Proposed Investigation Activities

Proposed investigation activities include the installation of groundwater monitoring wells utilizing sonic drilling methods, subsurface soil sampling utilizing direct push technology (DPT), and the collection of groundwater, surface soil, sediment, and surface water samples. The purpose of the supplemental investigation activities is to define the nature and extent of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), pesticides, and metals-impacted media and verify the presence or absence of CA or CA degradation products in the vicinity of Site 69. MEC avoidance will be performed during all sampling activities (monitoring well installation and soil, sediment, surface water, and groundwater sampling) to prevent contact with metallic items, including MEC and buried containers. Previously identified disposal areas and/or areas that contain subsurface anomalies will be avoided during this field investigation. Should a subsurface anomaly be detected during intrusive activities, the Site Manager will be notified, all intrusive work will cease at that location and an alternate location will be selected.

1.3 Emergency Response

Prior to the start of field activities, CH2M HILL (project organizational chart provided as **Figure 1-1**) will coordinate with Base emergency services personnel to ensure adequate emergency response capabilities in the event of a positive agent detection or a suspected employee exposure to agent. At a minimum, project personnel will have two forms of communications available at all times for emergency communications. Project personnel

will request a base radio for communication with Base emergency services. The Senior Unexploded Ordnance Supervisor (SUXOS) will inform the MCB CamLej Naval Hospital (100 Brewster Boulevard, [910] 450-4300) prior to the initiation of field activities. Emergencies involving CA exposure will be handled at the MCB CamLej Naval Hospital. All other emergencies requiring medical care will be handled at the Onslow County Memorial Hospital. Site activities will also be coordinated with the United States Army Edgewood Chemical and Biological Center (ECBC) to perform CA air monitoring and sampling.

1.4 Exclusion Zone

At each drilling or subsurface sampling location, an exclusion zone (EZ) will be set up and demarcated. Flags will be placed at the corners of the EZ to monitor wind direction. A decontamination station will be constructed upwind as indicated by wind flags posted at the four corners of the EZ.

1.5 Intrusive Activities

Intrusive activities (i.e., drilling) inside the fence line will be performed in Level C personal protective equipment (PPE) as indicated in the Health and Safety Plan (HSP), including an MSA Millennium® CBRN (chemical, biological, radiological, and nuclear) gas mask, or equivalent.

Intrusive activities (i.e., drilling) outside the fence line will be performed in Modified Level D as indicated in the HSP. All intrusive activities conducted at the site will require continuous air monitoring using the MINICAMS® near-real-time continuous air monitoring system (portable flame photometric detector) and Depot Area Air Monitoring System (DAAMS) tubes operated by personnel from the ECBC. In addition to the DAAMS tube sampler deployed to confirm the MINICAMS readings, DAAMS tubes will also be deployed at the perimeter of the work area by ECBC to ensure CA Airborne Exposure Limits (Table 2-4 of Health and Safety Plan) or Worker Population Limits have not been exceeded.

No continuous air monitoring will be required for non-intrusive sampling activities, including surface water, sediment, surface soil, and groundwater sampling. However, initial headspace screening of monitoring wells inside and outside the fence line will be performed in Level C as indicated in the HSP. The MINICAMS® system will be used for collecting initial headspace screening data from all monitoring wells. Personnel may downgrade to Level D if the MINICAMS® system is negative for CA and the photoionization detector (PID) used to monitor VOCs indicates concentrations are below the appropriate action levels specified in the HSP.

PPE may be upgraded or downgraded during site activities with the approval of the CH2M HILL Project Manager (PM) and Health and Safety Manager (HSM).

The following circumstances may require initiation of the procedures described in this Low Probability Contingency Plan:

- Alarm for CA on air monitoring equipment (**Section 3**)
- Potential CA item observed (**Section 4**)
- Personnel exhibiting symptoms of exposure (**Section 5**)

In the event that the Low Probability Contingency Plan is initiated for any reason, activities being conducted at other areas of Site 69 or Unexploded Ordnance (UXO)-02 as part of this project will be halted immediately.

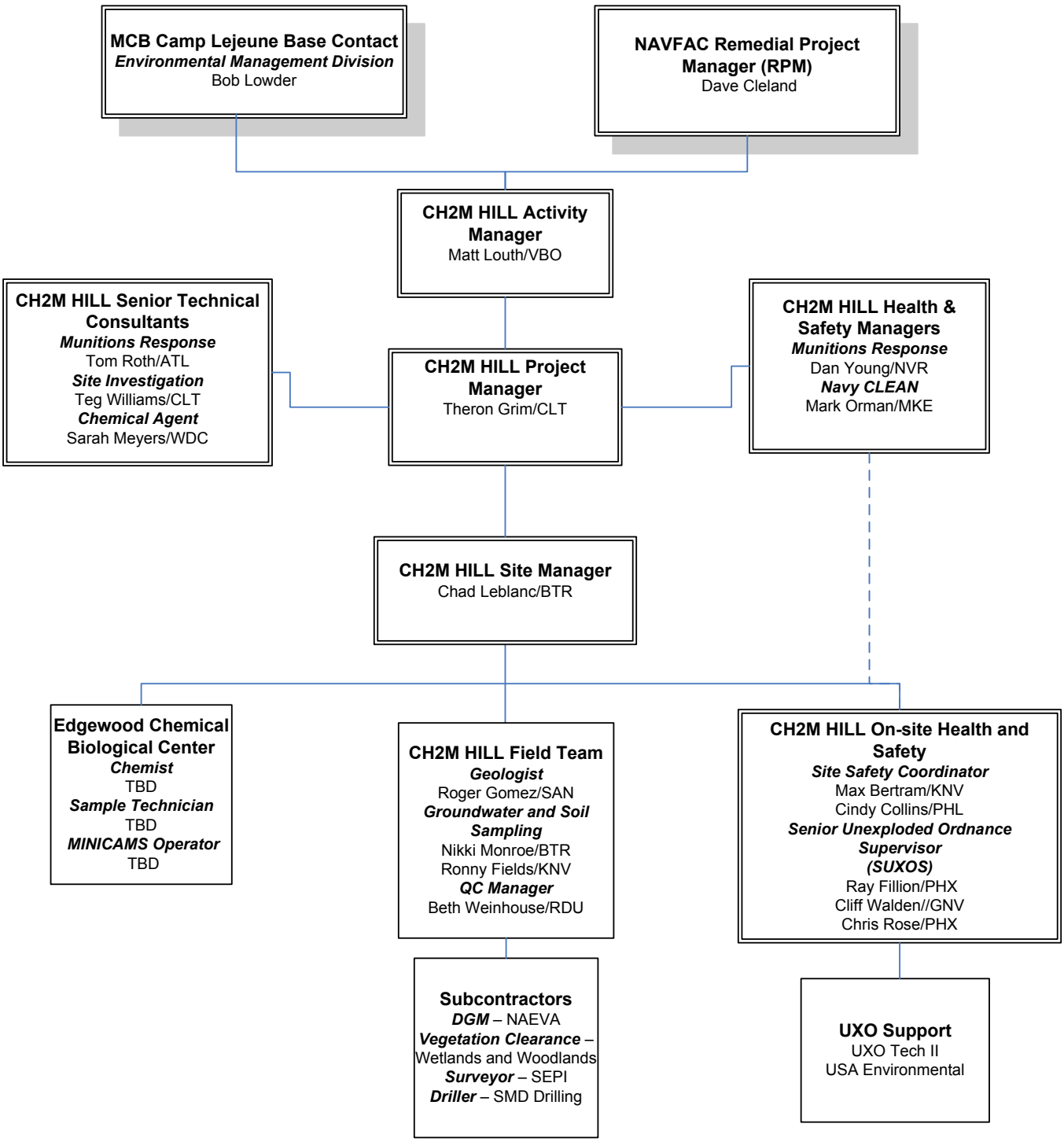

Figure 1-1
Site 69 Project Organization Chart
Low Probability Contingency Plan
Marine Corps Base, Camp Lejeune
North Carolina

SECTION 2

Definitions

2.1 Potential CA Items

Items that are potentially related to CA at Site 69 will be defined as "potential CA items" for the purposes of this Low Probability Contingency Plan. These include but are not limited to the following items:

- Groundwater, soil, sediment, or surface water that appears to be contaminated with CA or its degradation products.
- Any item that site personnel observe to be, or monitoring activities identify as, potentially related to CA disposal at the site, including partial or intact containers.

2.2 Intrusive Activities

In the context of the Site 69 supplemental investigation, intrusive activities include the installation of groundwater monitoring wells and soil borings.

2.3 Air Monitoring Alarm

Individual air monitoring alarm levels have been determined for CA constituents of concern for monitoring scenarios using the MINICAMS® system.

Alarm levels for the MINICAMS® system are as follows:

- Mustard (H/HD) 0.00016 milligrams per square meter (mg/m^3)
- Lewisite (L) 0.00016 mg/m^3
- Tabun (GA) 0.000021 mg/m^3
- Sarin (GB) 0.000021 mg/m^3
- Soman (GD) 0.000021 mg/m^3

2.4 MINICAMS® System

The MINICAMS® system is a near-real-time air monitoring system which uses a capillary column gas chromatograph with the capability of detecting chemical agent constituents and their degradation products. The MINICAMS® system consists of a monitor (sample collection, analysis, detection, and alarm equipment), vacuum pump, heated sample transfer lines, compressed gases, and computer. In the sampling cycle, a vacuum pump draws air into the MINICAMS® system through a heated sample transfer line. The transfer line is heated to prevent condensation of any CWM material on the walls of the transfer line. The transfer line can be up to 150-feet long, which allows ECBC technicians to operate the system from a distance, thereby helping to minimize the number of personnel within the EZ. The air sample is drawn through an automated gas chromatograph that first collects

agent on a solid sorbent, or in a specific volume sample loop, and then thermally desorbs the agent into a separation column for analysis. A direct readout, in units of the hazard level, is provided. A permanent trace of the chromatogram is stored in the computer. If chemical warfare materiel (CWM) is detected at the hazard level preprogrammed by the operator, the MINICAMS® system alarm will activate and the workers will take immediate actions. The MINICAMS® system is considered a near-real-time monitor because it does not sample continuously, air sampling is stopped during the thermal-desorption step.

2.5 DAAMS Tubes

The DAAMS tubes are sorbent tubes in which samples are collected using battery operated sampling pumps. DAAMS tubes may be used to confirm chemical agent alarms with the MINICAMS® system.

SECTION 3

Initiation Procedures for Air Monitoring Alarms

3.1 Air Monitoring

Air monitoring will be conducted using MINICAMS® system (used for near real-time air monitoring during intrusive activities such as drilling) and DAAMS tubes (used for confirmation of MINICAMS® system readings). The MINICAMS® system and DAAMS tubes will be calibrated, operated, and maintained by ECBC. The MINICAMS® system sample line will be positioned at the location of the intrusive activities by ECBC prior to initiating the intrusive work. The DAAMS tubes will also be deployed at the work area and at the perimeter of the work area by ECBC prior to initiating the intrusive work.

3.2 MINICAMS® System Alarm

If the MINICAMS® system sounds an alarm, all work at that location shall stop and the step-by-step procedures detailed in **Figures 3-1, 3-2, and 3-3** will be implemented. **Figures 3-1 and 3-2** detail the procedures to be implemented by the Site Safety Coordinator (SSC), Site Manager, and SUXOS after a MINICAMS® system alarm has occurred. **Figure 3-3** details the procedures to be implemented by the field personnel within the EZ performing the intrusive work. The step-by-step procedures provided in **Figures 3-1, 3-2, and 3-3** are summarized below:

- If personnel are working in Level C with respiratory protection for CA (i.e., drilling inside the fence line), personnel will attempt to secure the source area by capping or covering with polyethylene sheeting and sand bags to the greatest extent possible. Personnel will collect the DAAMS tube sampler and then proceed to an area within the contamination reduction zone (CRZ) that is upwind of the potential source area.
- If personnel are NOT working in Level C with respiratory protection for CA, personnel will don the MSA Millennium® respirator being carried on their person, and attempt to secure the source area, as described above. Personnel will then collect the DAAMS tube sampler and then proceed to an area within the CRZ that is upwind of the potential source area.
- The onsite CH2M HILL UXO Technician/SUXOS, SSC, and Site Manager will be informed of the alarm status.
- The MINICAMS® system will be cycled one additional time, with each cycle taking approximately 10 minutes.
- The CH2M HILL Site Manager, SSC, and SUXOS will initiate the Tier I Phone Chain as shown in **Figure 3-2**.

- If the ECBC MINICAMS operator informs the SUXOS that an alarm has not occurred on the next cycle of the MINICAMS, work may resume at that location at the discretion of the SUXOS.
- If the MINICAMS® system sounds an alarm on the next cycle (i.e., a second consecutive alarm), it will be considered to be an indication of agent detection and the following procedures will be implemented:
  - Upon notification of a potential positive detection and prior to exiting the CRZ, personnel shall undergo decontamination as described in the HSP (liquid soap will be used for skin decontamination, and bleach will be used for decontamination of other surfaces).
  - Confirmation of agent detection will be accomplished with DAAMS tubes. ECBC personnel will coordinate subsequent analysis of the DAAMS tube samples following the second consecutive MINICAMS® system alarm.
  - Equipment will be left in place with sources secured, and work will not restart until the location is confirmed free of CA contamination by DAAMS tube analysis. The DAAMS tube, retrieved by the CH2M HILL field personnel while exiting the EZ, will be analyzed by ECBC in their onsite laboratory.
  - Site activities may be conducted in other areas of Site 69 while waiting for DAAMS tube results with the approval of the SUXOS.
  - If DAAMS tube results are positive for CA or their degradation products, the Tier II Phone chain shown in **Figure 3** will be initiated and a project stand down will occur. If warranted, the Naval Facilities Engineering Command (NAVFAC) Remedial Project Manager (RPM) may contact the Chemical, Biological, Radiological, Nuclear, and Explosive (CBRNE) Analytical and Remediation Activity (CARA) of the U.S. Army 20th Support Command for support in addressing the CA detections.
  - If DAAMS tube results are negative for CA and their degradation products, site work may continue at the same location after authorization to continue is received from the SUXOS. CH2M HILL employees will not re-enter the area until cleared by the SUXOS.

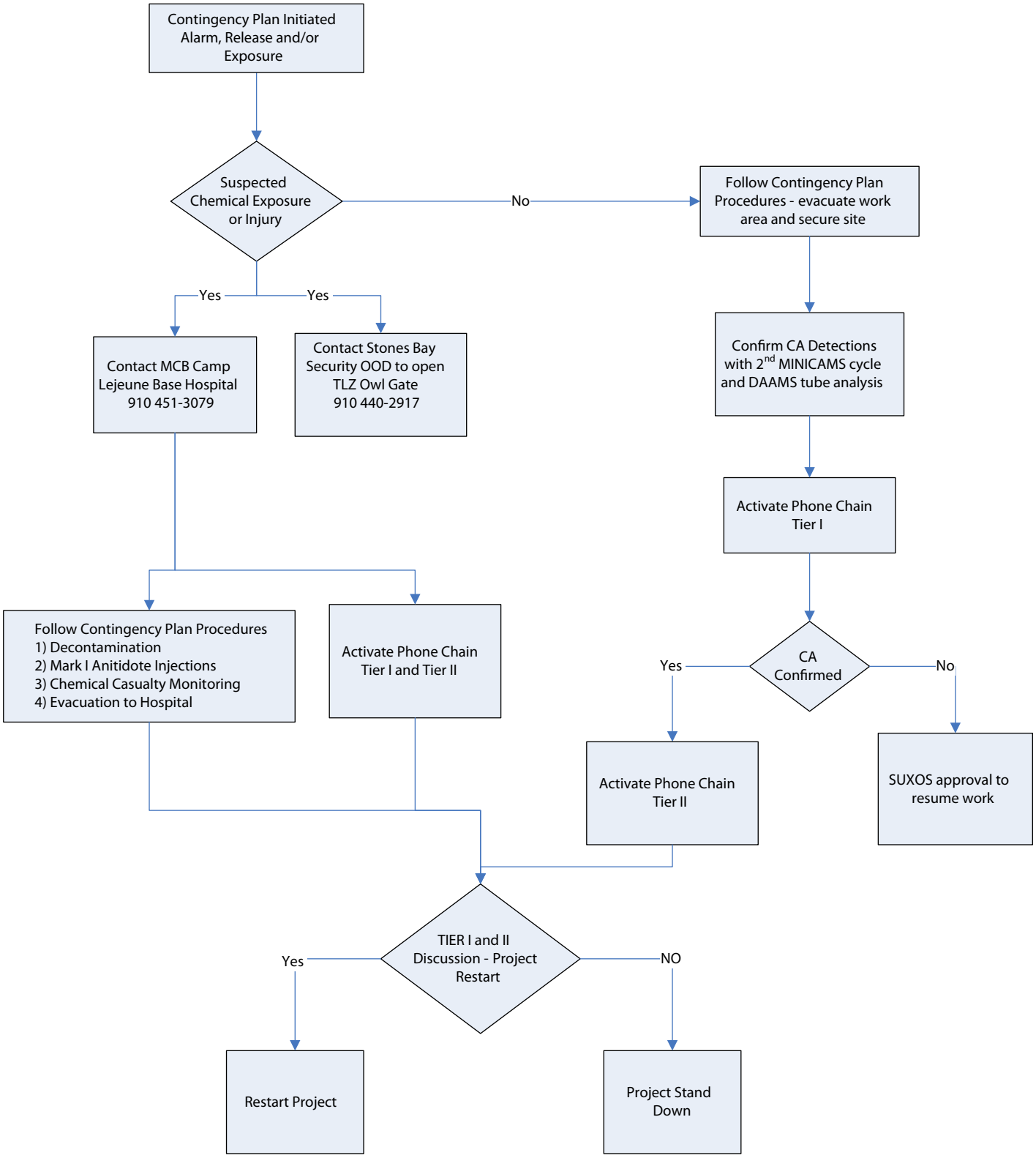

Figure 3-1
Contingency Plan Flow Chart
Low Probability Contingency Plan
Marine Corps Base, Camp Lejeune
North Carolina

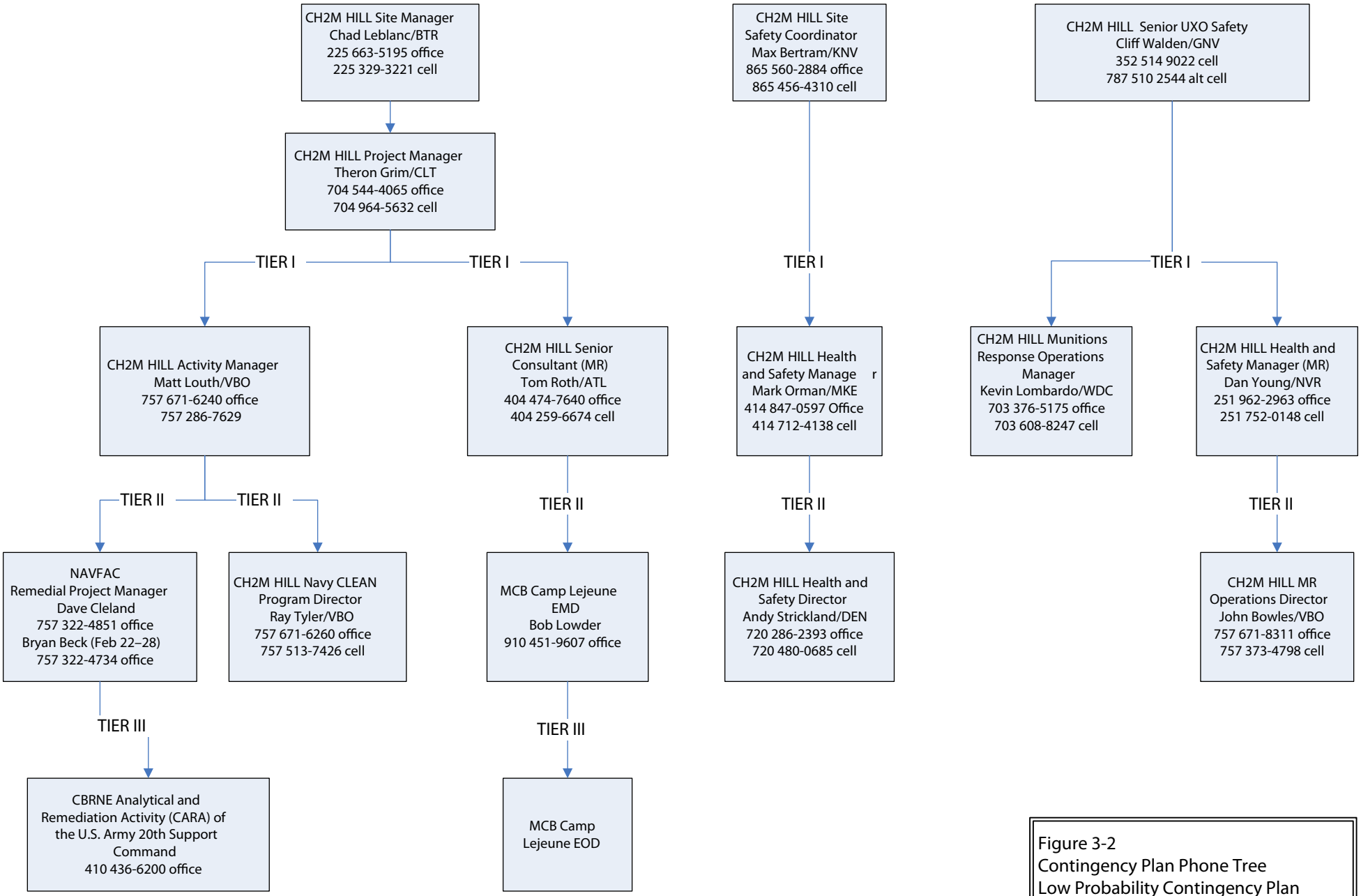

Figure 3-2
Contingency Plan Phone Tree
Low Probability Contingency Plan
Marine Corps Base, Camp Lejeune
North Carolina

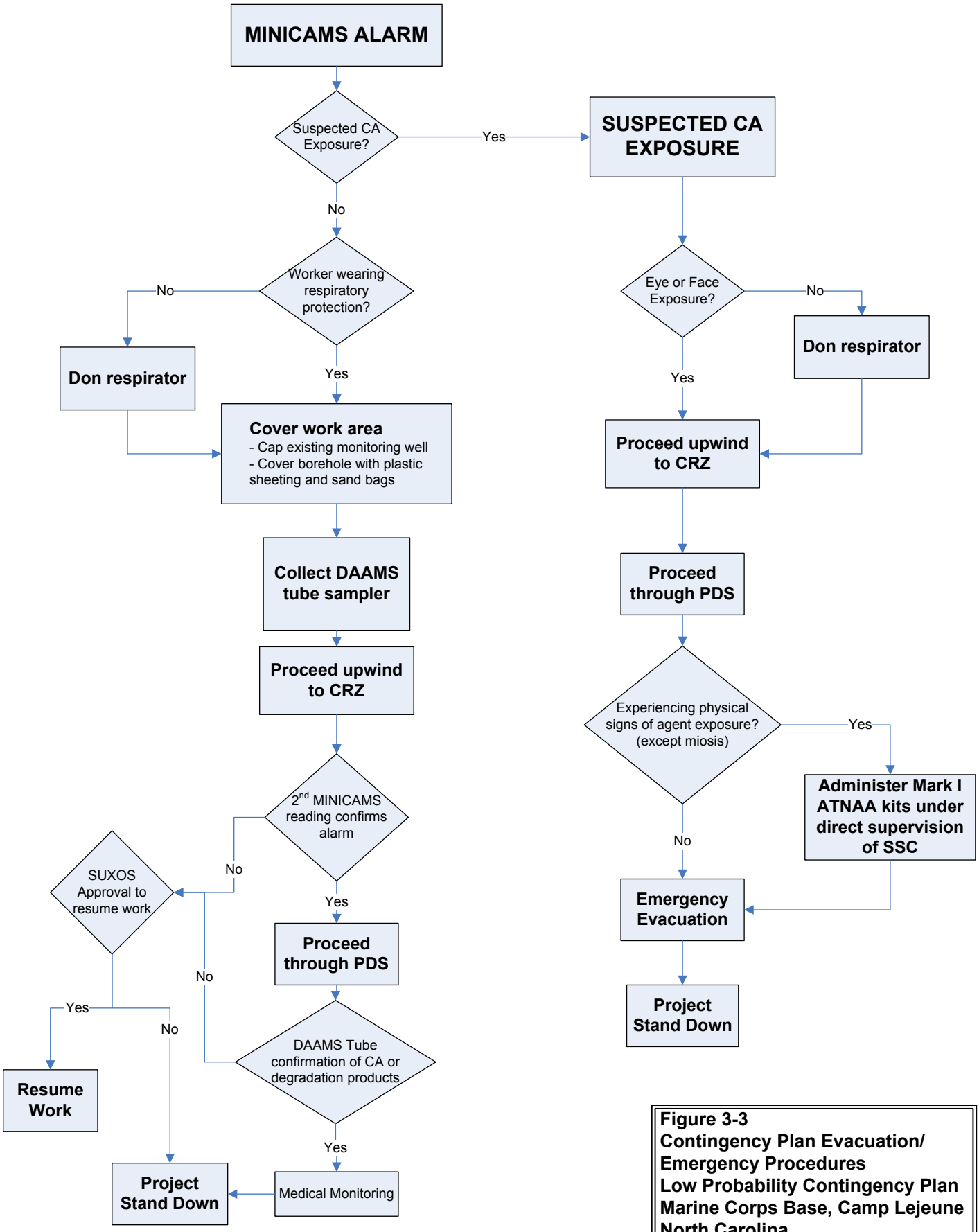

Figure 3-3
Contingency Plan Evacuation/ Emergency Procedures
Low Probability Contingency Plan
Marine Corps Base, Camp Lejeune
North Carolina

SECTION 4

Initiation Procedures for Potential CA Items

Available reports indicate that the potential CA present at Site 69 is buried in 55-gallon drums. All intrusive activities will be conducted using anomaly avoidance procedures. Consequently it is not anticipated that any items containing CA will be encountered during the completion of the field investigation. However, if the team observes a potential CA item all work in the area shall stop and the step-by-step procedures summarized below will be implemented. Potential MEC encountered during the field investigations will not be investigated. All MEC contacts and suspected MEC anomalies will be reported to the CH2M HILL Site Manager who will in turn notify the CH2M HILL PM. The discovery of MEC will not require the initiation of the Low Probability Contingency Plan.

- Potential CA items will not be moved and the area surrounding the item will be secured by the CH2M HILL UXO Technician.
- The CH2M HILL Site Manager, SSC, and SUXOS will initiate the Tier I Phone Chain as shown in **Figure 3-2**.
- The CH2M HILL Activity Manager and Senior Technical Consultant will coordinate with the NAVFAC RPM and MCB CamLej Base representative to contact the Base Explosive Ordnance Disposal (EOD) and/or CARA so that the items can be further assessed. Intrusive activities will not resume at the site until authorization to continue is received from the MCB CamLej base contact and the NAVFAC RPM. CH2M HILL employees will not re-enter the area until cleared by the CH2M HILL SUXOS.

SECTION 5

Initiation Procedures for Possible Agent Exposure

5.1 G-class Nerve Agent Exposure Symptoms

Symptoms of potential nerve agent exposure include:

- Coughing/breathing difficulty
- Salivation and sweating
- Vomiting
- Diarrhea and stomach cramps
- Involuntary urination/defecation
- Generalized muscle twitching/muscle cramps
- Headache
- Drowsiness
- Difficulty concentrating/confusion

5.2 Mustard Agent Exposure Symptoms

Symptoms of potential mustard agent exposure include:

- Hoarseness or hacking cough
- Itching and tearing in eyes
- Nausea and vomiting
- Diarrhea and abdominal pain
- Runny/bloody nose, sneezing and sinus pain
- Red and itchy skin followed by blisters

Refer to Section 2.5.1 of the HSP for a thorough description of potential CA exposure symptoms and project specific action limits.

5.3 Chemical Exposure Procedures

5.3.1 Emergency Notification, Evacuation, and Decontamination Procedures

In the event that this Low Probability Contingency Plan is initiated because site personnel exhibit symptoms of chemical exposure, the step-by-step procedure detailed in **Figures 3-1, 3-2, and 3-3** will be implemented. **Figure 3-1** details the procedures to be implemented by the SSC, Site Manager, and SUXOS after suspected exposure has occurred. **Figure 3-3** details the procedures to be implemented by the field personnel within the EZ. The step by step procedures provided in **Figures 3-1, 3-2, and 3-3** are summarized below:

- Personnel, showing signs of exposure will don respirator, if eye or face exposure has not occurred. Personnel will then move upwind of the intrusive investigation area or other potential source of exposure. If eye or face exposure is suspected, personnel will move directly upwind to the emergency personnel decontamination station (EPDS).
- Field personnel, within the EZ, not suspected to have been exposed to CA will follow the step-by-step procedures for a MINICAMS® system alarm detailed in **Figure 3-3** and **Section 3.2** (don respirator, cover work area, collect DAAMS tube**)**, proceed upwind and then assist with the decontamination of the exposed individual.
- The SSC will call the MCB CamLej Naval Hospital ([910] 450-4300) and inform them of the exposure and site location. The SSC will have an ambulance dispatched from the MCB CamLej Naval Hospital to the predetermined meeting point (described below).
- If indications of exposure are observed on site personnel skin or clothing, the potentially exposed personnel will be processed through the EPDS, established and maintained by the SSC in the CRZ. Decontamination of personnel exposed to CA will be performed as quickly as possible in accordance with the procedures described in Section 6.0 of the HSP. A summary of these procedures is provided below:
  - After removal from the contaminated area, the exposed individual(s) will be decontaminated by washing of skin with liquid soap and clothing and PPE with bleach, followed by flushing with potable water. **Direct skin (dermal) contact must be addressed via decontamination within 1 minute of exposure via liquid soap**. **Because of the potential rapid effects of CA, it is extremely important that decontamination of personnel not be delayed by attempting to blot off excessive agent prior to decontamination.**
  - The respirator mask, if donned, is left on the exposed individual until decontamination has been completed unless it has been determined that areas of the face were contaminated and the mask must be removed to decontaminate.
  - **ONLY** potable water will be used when flushing the eyes or mouth.
- The CH2M HILL SSC. Site Manager, and SUXOS will initiate the Tier I and II phone chains, as shown in **Figure 3-2**.
- After decontamination, ECBC will perform chemical casualty monitoring (screening of decontaminated individual for CA with the MINICAMS® system). The exposed individual will then be transported by the CH2M HILL person, designated by the SSC, to the predetermined meeting point with the MCB CamLej Naval Hospital ambulance. The ambulance will then transport the exposed individual the MCB CamLej Naval Hospital for treatment.
- All site activities will stop and a project stand down will occur.

5.3.2 Emergency Treatment

"Mark I" Antidote Treatment—Nerve Agent, Auto-Injector (ATNAA) kits will be supplied by ECBC and self-administered as described below. If the exposed individual is unable to self administer the auto-injector, the injection will be administered by the SSC at the support

zone after decontamination or by a second individual within the EZ/CRZ, designated by and directed by the SSC. All field personnel will be trained on how to properly administer the Mark I ATNAA kits prior to initiation of field work by ECBC. **ALL MARK I ATNAA INJECTIONS, INCLUDING SELF ADMINISTERED INJECTIONS, WILL BE COMPLETED AT THE DIRECTION OF THE SSC.**

Inhalation

Hold breath until respiratory protective mask is donned. Self-administered injections using the Mark I ATNAA kits may be repeated at 5 to 20 minute intervals, at the direction of the SSC, if signs and symptoms are progressing until three series of injections have been administered. In addition, a record will be maintained by the SSC of all injections given. If breathing has stopped, the SSC will remove the exposed individual's respirator and give artificial respiration (after decontamination). Approved mask-bag or oxygen delivery systems will be provided and maintained by the properly trained SSC during all site activities. Seek medical attention IMMEDIATELY.

Eye Contact

IMMEDIATELY flush eyes with water for 10 to 15 minutes, eyewash station will be located in the Support Zone. Although miosis (pinpointing of the pupils) may be an early sign of agent exposure, an injection will not be administered when miosis is the only sign present. Instead, the individual will be taken IMMEDIATELY to the medical treatment facility for observation.

Skin Contact

Don respiratory protective mask and remove contaminated clothing. Immediately wash contaminated skin with a solution of soapy water followed by copious water wash. If local sweating and muscular twitching symptoms are present, self-administer Mark I ATNAA kit. Seek medical attention IMMEDIATELY. Injections using the Mark I ATNAA kits may be repeated at 5 to 20 minute intervals if signs and symptoms are progressing until three series of injections have been administered.

Ingestion

Do not induce vomiting. First symptoms are likely to be gastrointestinal. IMMEDIATELY administer Mark I ATNAA kit. Seek medical attention IMMEDIATELY. Self-administered injections using the Mark I ATNAA kits may be repeated at 5 to 20 minute intervals if signs and symptoms are progressing until three series of injections have been administered.

Severe Exposure (Inhalation, Eye Contact, Skin Contact and Ingestion)

If severe signs of agent exposure appear (e.g., tightening of the chest, pupil constriction, lack of coordination), the SSC may direct the exposed individual to immediately self-administer, in rapid succession, three Mark I/ATNAA kits instead of at 5 to 20 minute intervals as directed above. No more injections will be given unless directed by medical personnel.

SECTION 6

Onsite Tracking for Contingency Plan

The Site Manager will enter descriptions of all events that trigger the Low Probability Contingency Plan into the field log book.

On any day that the Low Probability Contingency Plan is initiated, the Site Manager will complete a Contingency Plan Initiation Summary and include it with the daily report. The CH2M HILL Site Manager will sign each Contingency Plan Initiation Summary.

SECTION 7

References

United States Marine Corps (USMC). 1982. *Memorandum Subject: Hazardous Wastes.* Office of the Staff Judge Advocate, Marine Corps Base Camp Lejeune, North Carolina 28542. From: Environmental Law Counsel. To: Assistant Chief of Staff, Facilities. October 6.

Appendix C
Geophysical Prove Out Work Plan

Final

Geophysical Investigation Plan
Rifle Range Chemical Dump
(Operable Unit 14, Site 69)

Marine Corps Base Camp Lejeune
Jacksonville, North Carolina

January 2010

Prepared for

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Prepared by

CH2MHILL

Charlotte, North Carolina

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2 DGM Instruments Standardization Tests and Acceptance Criteria

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2 Proposed Site 69 Geophysical Investigation Area
3 Overview of DGM Process QC
4 QC of DGM Data – Process Flowpath

Acronyms and Abbreviations

AMSL	Above Mean Sea Level
CAIS	Chemical Agent Identification Sets
CLEAN	Comprehensive Long-Term Environmental Action Navy
cm	Centimeters
CWM	Chemical Warfare Materiel
DGM	Digital Geophysical Mapping
DGPS	Differential Global Positioning System
DQO	Data Quality Objective
ft	Feet
FTP	File Transfer Protocol
GPO	Geophysical Prove-Out
GPS	Global Positioning System
HASP	Health and Safety Plan
IST	Industry Standard Target
MEC	Munitions and Explosives of Concern
MCB	Marine Corps Base
MPPEH	Material Potentially Presenting an Explosive Hazard
MRSIMS	Munitions Response Site Information System
nT	NanoTeslas
OU	Operable Unit
OSHA	Occupational Safety and Health Administration
PCBs	Polychlorinated Biphenyls
QAPP	Quality Assurance Project Plan
QC	Quality Control
RF	Radio-Frequency
RTK	Real-Time Kinematic
SOP	Standard Operating Procedure
SUXOS	Senior UXO Supervisor
UXO	Unexploded Ordnance

1.0 Geophysical Operations Overview

This Geophysical Investigation Plan (GIP) provides details of the equipment, approach, methods, operational procedures and quality control to be used in performing the geophysical investigation for the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Supplemental Investigation under the Installation Restoration Program at Operable Unit (OU) 14, Site 69 – Rifle Range Chemical Dump at Marine Corps Base (MCB) Camp Lejeune, North Carolina.

This Site-Specific GIP was prepared by CH2M HILL under Contract Task Order (CTO) 0223 of the Department of the Navy's Comprehensive Long-Term Environmental Action Navy (CLEAN) Program. CH2M HILL is responsible for implementation of this project. It should be noted that this Site-Specific GIP is to be used in conjunction with the Master Project Plans, which include the Master Work Plan, Master Quality Assurance Project Plan (QAPP), and Master Health and Safety Plan (HASP) (CH2M HILL, 2005). The Master Project Plans will be referenced to the greatest extent possible.

MCB Camp Lejeune is located within the Atlantic Coastal Plain Physiographic Province in Onslow County, North Carolina, approximately 45 miles south of New Bern and 47 miles north of Wilmington. The Base covers approximately 236 square miles. The Base is bisected by the New River, which flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean (Figure 1). The Base is bordered by the City of Jacksonville, North Carolina (NC) and State Route 24 to the north; the Atlantic shoreline to the south and east; and United States (U.S.) Route 17 to the west (not including the Greater Sandy Run Area of the Base west of U.S. Route 17.) Site 69, the Rifle Range Chemical Dump, is an approximately 14-acre site located west of the New River.

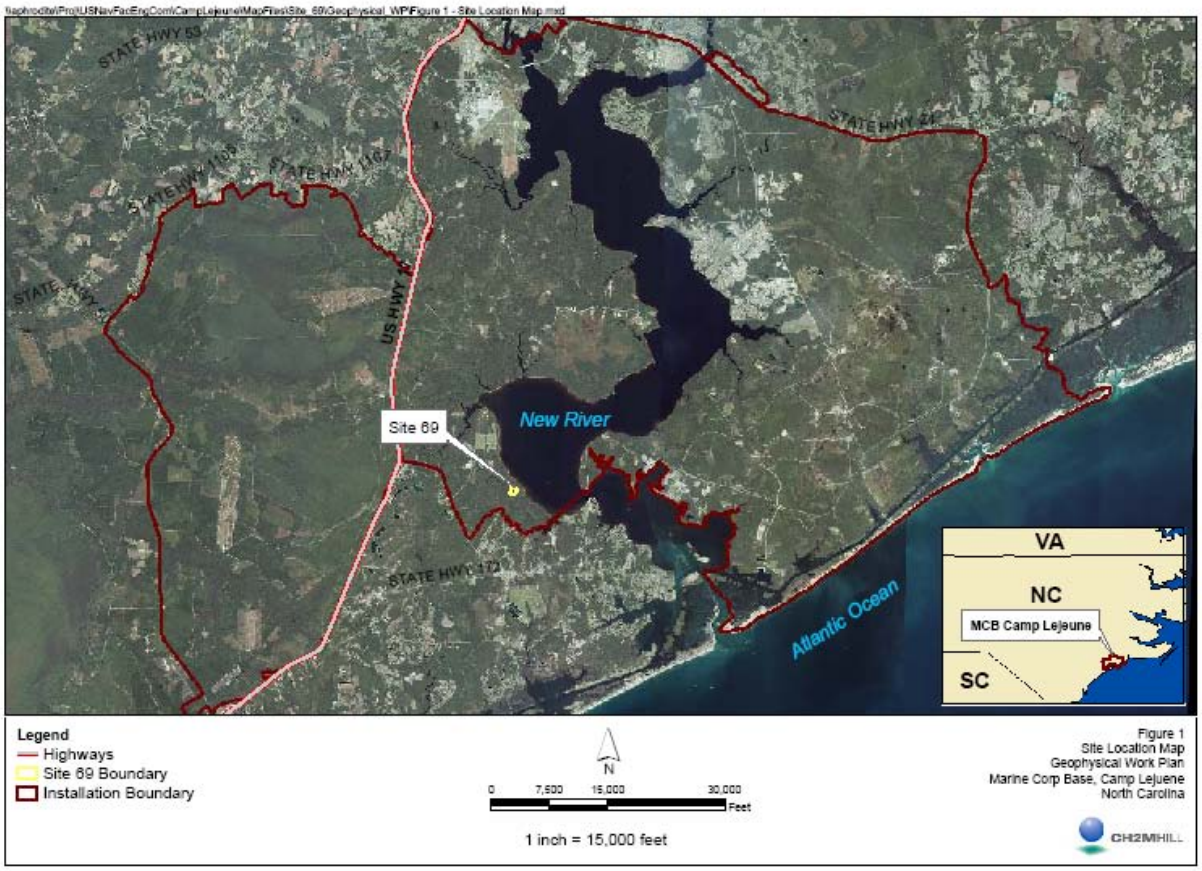
The purpose of the geophysical investigation is to identify subsurface anomalies within the focus area. This information will be used by CH2M HILL to identify potential targets of interest including buried drums of chlorinated solvents and pesticides and buried drums potentially containing chemical warfare materiel (CWM) at Site 69. The DGM survey will also assist in identifying safe locations for groundwater monitoring wells and environmental sampling points.

The following topics are covered in the GIP subsections: safety issues; geophysical data quality objectives (DQOs); description of the site; site physical conditions (e.g., geology and topography); adverse geophysical conditions; site utilities and manmade features that may affect the geophysical operation; data acquisition and reporting; and geophysical program Quality Control (QC) requirements.

Geophysical instruments will be used during digital geophysical mapping (DGM) survey operations. DGM operations use instruments that record instrument response digitally, allowing for the subsequent download and interpretation of the data. DGM instruments will be operated by the DGM subcontractor. Geophysical instruments used during operations such as clearance of locations for emplacement of survey stakes will be analog, meaning these instruments will be used to detect metallic items in the subsurface on a real-time basis, and the instrument response will not be recorded. Generally, analog instruments indicate

the presence of metallic anomalies through sound or visual display. The analog instruments will be operated by unexploded ordnance (UXO) technicians.

FIGURE 1
Base Map with Site 69



2.0 Safety Issues

Because munitions and explosives of concern (MEC) and material potentially presenting an explosive hazard (MPPEH) items may be present in the survey area, DGM survey personnel are prohibited from touching, handling, moving, or investigating any item that resembles MEC or MPPEH. Upon encountering such an item, survey personnel will immediately inform the Senior UXO Supervisor (SUXOS) or a UXO technician. In the event that such an item is discovered, either inside or outside the controlled project boundaries, and no UXO-qualified personnel are present, survey personnel will conspicuously mark and secure a perimeter around the item and immediately contact the SUXOS. DGM survey personnel should not remain within 200 feet of any suspected MEC or MPPEH item.

DGM survey personnel will not access areas that have not been previously surface cleared by a UXO technician. Personnel will also be required to adhere to the project Health and Safety Plan.

3.0 DGM Personnel Qualifications

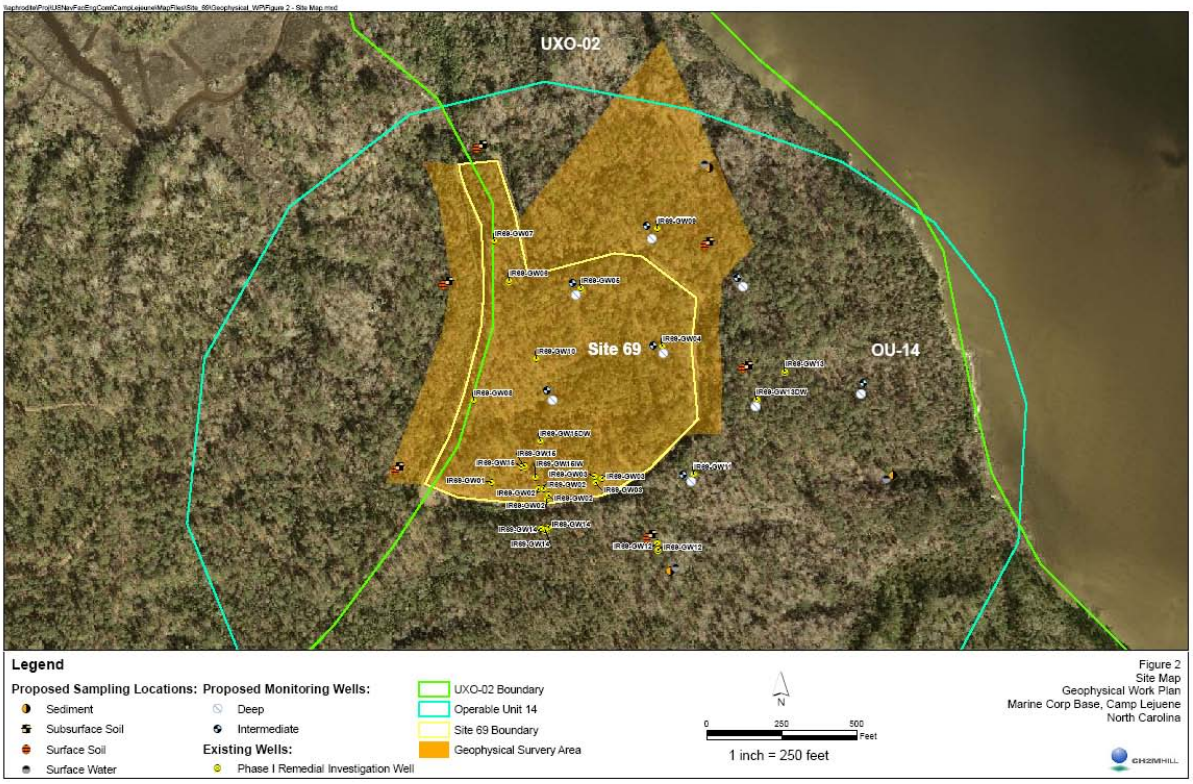
DGM operations will be conducted by personnel experienced in MEC geophysical operations and led by a qualified MEC geophysicist. All DGM support personnel onsite will have documentation of 40-hour Occupational Safety and Health Administration (OSHA) certification, any necessary re-certification (8-hour refresher), and OSHA-compliant medical monitoring physical exams. Throughout DGM operations, DGM support personnel will strictly adhere to the general practices given in this Work Plan and specifically in the project HASP.

4.0 Area to be Investigated

Site 69, the Rifle Range Chemical Dump, is an approximately 14-acre site located west of the New River. The area to be investigated is shown in Figure 2.

A series of linear transects, spaced 10 feet (ft) apart, will be established across the survey area to provide sufficient DGM coverage to confidently locate chemical drum burial locations. Control points will be placed on the ground using either real-time kinematic (RTK) Differential Global Positioning Systems (DGPS) or conventional survey equipment as required to use the DGM systems validated through the Geophysical Prove-Out (GPO) process (see Attachment 1).

FIGURE 2
Proposed Site 69 Geophysical Investigation Area



5.0 Past, Current, and Future Site Uses

From 1950 to 1976, Site 69 was used for the trench disposal of chemical wastes, including polychlorinated biphenyls (PCBs), solvents, and pesticides. The Site also has a reported history of CWM disposal in the form of 50 to 60 drums containing mustard or nerve agent. Chemical Agent Detector Kits, similar to the M18A2, have been observed at the site leading to speculation of potential presence of Chemical Agent Identification Sets (CAIS), e.g. K941 or K951. However no physical evidence to support the presence of CAIS has been discovered. In 1990, a chain link fence was erected to restrict access to the disposal area. However, review of historical aerial photography, specifically from 1964, suggests that an area of disposal may lie to the north of the fenced area.

The site is rather secluded; however, training exercises are conducted throughout the surrounding area. Site 69 is currently vacant and unused and no change to site use is anticipated. Following the geophysical survey and clearance of MEC and non-MEC metallic items (if needed), groundwater monitoring wells and sample locations will be established to monitor subsurface contaminants and remediation efforts.

6.0 Vegetation and Topography

The topography of the Base is generally flat and typical of the NC Coastal Plain. Elevations on the Base range from sea level to approximately 72 feet (ft) above mean sea level (amsl). However, elevations on the majority of the base range from approximately 20 to 40 ft amsl. Site 69 is situated in a topographically high area. The area is overgrown to the point that the boundary of the former dump is not easily discernable. Three surface water bodies are located within a quarter mile of the site: the New River to the east, an unnamed tributary of the New River to the north, and Everett Creek to the south.

Drainage at the Base generally is toward the New River, except in areas near the coast, which drain through the Intracoastal Waterway. In developed areas, the natural drainage has been altered by asphalt cover, storm sewers, and drainage ditches. Approximately 70 percent of the Base is situated in broad, flat interstream areas. Drainage is poor in these areas and the soils are often wet. The U.S. Army Corps of Engineers has mapped the limits of the 100-year floodplain at the Base at 7 ft amsl in the upper reaches of the New River increasing downstream to 11 ft amsl near the coastal area (WAR, 1983).

7.0 Geologic Conditions

According to Cardinell, Berg, and Lloyd (1993), the uppermost undifferentiated formation of Holocene and Pleistocene age sediments consist of mostly fine, loose to medium dense sands, with a lesser amount of silt and clay and is present from land surface to depths of 20 to 30 ft below ground surface (bgs). Thin, discontinuous lenses of silt and clay may be regionally associated with the Belgrade formation. The Belgrade formation generally consists of mostly fine sands, silts and clays, with lesser amounts of shell fragments.

The upper portion of the River Bend Formation, which underlies the Quaternary age sediments is composed of sands, silts, shell and fossil fragments, and trace amounts of clay. The River Bend Formation overlies the Eocene Castle Hayne Formation. The Castle Hayne formation consists of both poorly indurated and well indurated biomicrite and biomicrudite limestone (Harris and Zullo, 1991). Thickness of the Castle Hayne Formation ranges between 150 ft and over 450 ft locally at MCB Camp Lejeune (Cardinell, Berg, and Lloyd, 1993).

8.0 Shallow Groundwater Conditions

Based on previous investigations and site knowledge, the groundwater table is located approximately 5 – 15 ft below ground surface (bgs) in the area to be investigated.

9.0 Adverse Geophysical Conditions

There are no known adverse geophysical conditions that might affect DGM operations.

10.0 Site Utilities

No site utilities are expected in the areas where DGM will be performed.

11.0 Manmade Features Potentially Affecting Geophysical Operations

A fence runs around the perimeter of area to be investigated. Interference from the fence is therefore anticipated to be seen in the DGM data in close proximity to the site boundaries.

12.0 Site-Specific Dynamic Events

No site-specific dynamic events (e.g., unusually strong winds, harsh weather conditions) that might affect the DGM survey operations at the site are anticipated. Although it is possible that weather conditions may impede operations at some time during the project, no significant delays or effects on geophysical instruments resulting from weather are expected.

13.0 Overall Site Accessibility and Impediments

The survey areas are readily accessible via dirt roads and access impediments are not anticipated.

14.0 Potential Worker Hazards

No potential worker hazards are apparent at the site other than those associated with conducting project fieldwork, which are addressed in the project Health and Safety Plan.

15.0 Geophysical Prove-Out

A site-specific geophysical GPO will be compared to project DQOs (discussed in Attachment 1, the GPO Work Plan) to validate the geophysical systems selected for the DGM surveys.

16.0 DGM Data Quality Objectives

The primary objective of DGM activities at the site is to identify metallic anomalies that may be related to drums of buried chemical waste and CWM. DQOs specific to the DGM surveys at the site are in the GPO Work Plan (Attachment 1).

17.0 Geophysical Instrumentation

17.1 Analog Geophysical Instruments

The analog geophysical instrument to be used during non-DGM operation where a geophysical instrument is needed to detect metallic items will be the Schonstedt GA-52/Cx magnetometer.

17.2 DGM Instruments

The DGM instruments that have been presumptively selected based on site conditions and project objectives are the Geonics EM31 Terrain Conductivity Meter, the Geometrics G-858 Magnetometer, and the Geometrics G-856 Magnetometer. Positioning will be accomplished using RTK DGPS or odometer and fiducial methods. The DGM systems to be used for DGM operations at the site will be configured in a man-portable mode. Detailed descriptions of each DGM instrument and positioning technique are included in Section B.9.1 of Appendix B (Geophysical Investigation Plan) of the Master Project Plan.

18.0 DGM Methodology

DGM surveys at Site 69 will be conducted along parallel transects spaced at 10 ft intervals using the man-portable instruments described in Section 17.2. Prior to DGM surveys, vegetation will be removed from the proposed transects to allow safe passage of the geophysical systems. Positioning will be accomplished using RTK DGPS, if site conditions allow, or odometer and fiducial methods if environmental conditions such as excessive tree canopy limit the effectiveness of RTK DGPS.

19.0 Data Acquisition, Processing and Reporting

19.1 Field Data Sheets

Field data sheets will be recorded in the Munitions Response Site Information Management System (MRSIMS) field devices (Trimble GeoXT) and will include:

- Site ID
- Grid ID (or other identifier of surveyed area)
- Field team leader name
- Field team members' names
- Date of data collection
- Instrument used
- Positioning method used
- Instrument serial numbers
- File names in data recorders
- Data collection sampling rate
- Line numbers, survey direction, fiducial locations, start and end points
- Weather conditions
- Grid conditions
- Terrain conditions
- Cultural conditions
- Survey area sketch
- Associated QC data file names
- Field notes (other)

19.2 Data Processing

Instrument-specific software will be used for initial data processing, and the output will be imported into Geosoft Oasis Montaj™ for additional processing, graphical display, anomaly selections and QA/QC. Types of processing will be system specific, but the general processing steps that may be performed on the data include the following:

- Positional offset correction
- Sensor bias, background leveling and/or standardization adjustment
- Sensor drift removal
- Diurnal magnetic field correction
- Latency or lag correction
- Geophysical noise identification and removal (spatial, temporal, motional, terrain induced)
- Contour level selection with background shading
- Digital filtering and enhancement (low pass, high pass, band pass, convolution, correlation, non-linear, etc.)

19.3Interpretation/Anomaly Selection

MEC-experienced data processing geophysicists will use the following criteria, supplemented by site- and system-specific criteria established during instrument validation, for selecting and locating anomalies:

- Maximum amplitude of the response with respect to local background conditions
- Decay curve characteristics
- Location of the response with respect to the edge of the grid, unsurveyable areas, land features, cultural features, or utilities within or adjacent to the grid
- Potential distortions in the response due to interference from nearby cultural features

19.4 Anomaly Locations

The target analysis process culminates in the identification of digital anomalies (a shape file imported into the MRSIMS field devices for use by the intrusive investigation team), which include anomaly information, location, and amplitude of geophysical anomalies that are potentially related to buried drums.

19.5 Anomaly Maps

The DGM subcontractor will also provide anomaly maps, which contains the following:

- Client
- Project

- Contractor
- Map creator
- Map approver
- Date map was created
- Map file name (full path and file extension)
- Scale
- Grid identification
- Grid corner locations
- Contoured data
- Anomaly locations with unique identification numbers
- North arrow, legend, title block, etc.

19.6 Records Management

All files will be made available for QC verification during the project to verify that the field and data processing procedures are properly implemented. All raw data files, final processed data files, hard copies, and field notes will be maintained for the duration of the project.

19.7 Final Reports, Maps, and Geophysical Mapping Data

No later than 3 work days after collection, the DGM subcontractor will provide each day's data for QC inspection via the Internet using a File Transfer Protocol (FTP) site, electronic mail (email) attachments for small files under 5 megabytes, or digital compact disk. Such data are considered to be in raw form. These data will be corrected for sensor offsets, diurnal variations, latency, heading error (if magnetometer is used), and drift. Also provided will be a digital planimetric map, in Geosoft format and coincident with the location of the geophysical survey, so that each day's geophysical data set can be registered within the original mission plan survey map.

All geophysical field data will be provided to CH2M HILL in delineated fields as x, y, z, v1, v2, and so on, where x and y are UTM Grid Plane Coordinates in Easting (meters) and Northing (meters) directions, z (elevation is an optional field in feet), and v1, v2, v3, and so on are the instrument readings. The last data field will be a time stamp. Each data field will be separated by a comma or tab. No individual file may be more than 100 megabytes in size and no more than 600,000 lines long. Each grid of data will be logically and sequentially named so that the file name can be easily correlated with the grid name used by other project personnel.

Within 45 days of data collection, the processed geophysical field data, all final maps, and supporting geophysical interpretations will be provided to CH2M HILL. All geophysical data will be accompanied by a report (standard report format out of MRSIMS) documenting the field activities associated with the data and the processing performed. Information provided by the MRSIMS report is summarized in Table 1.

TABLE 1
Processing Documentation Requirements

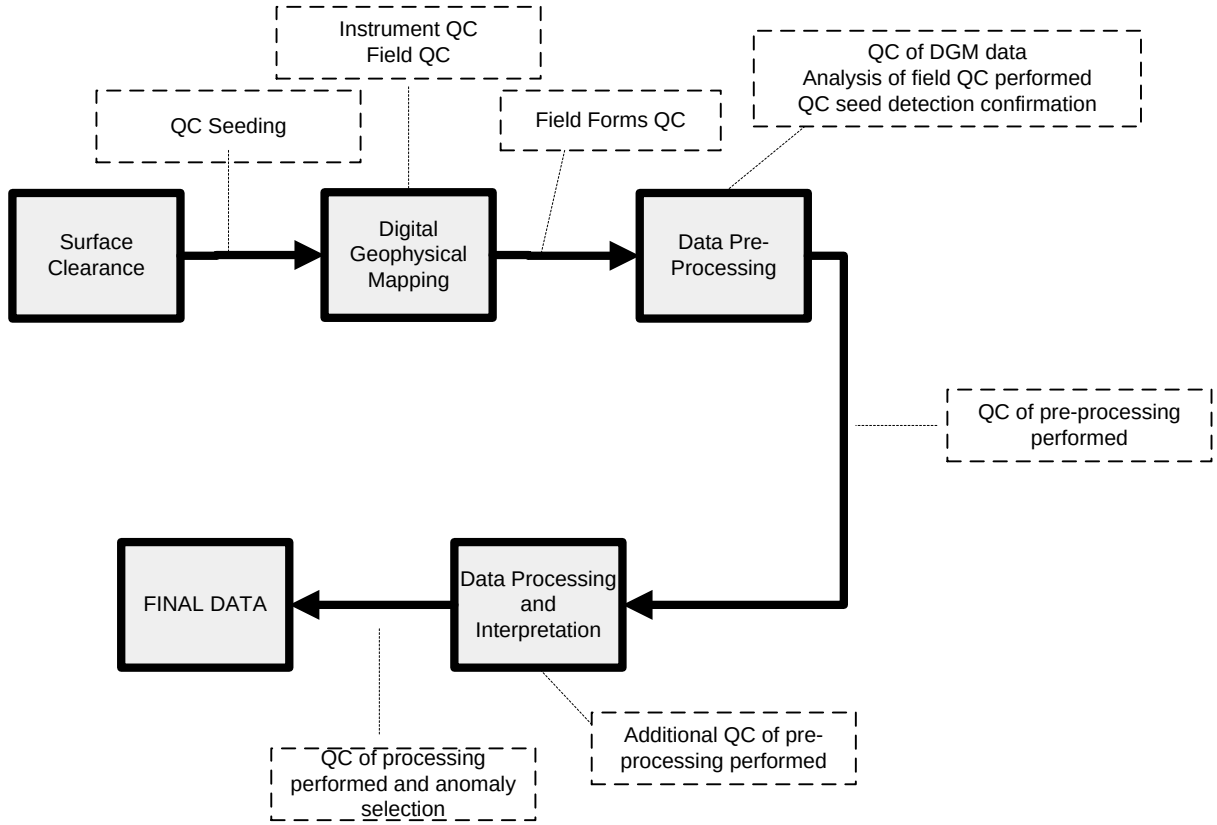
Information Type	"Raw" Data Delivery Report	Final Data Delivery Report	Must be in File Headers
Site ID	X	X	X
Geophysical instrument type used	X	X	
Positioning method used	X	X	
Instrument serial numbers (geophysical and positioning)	X	X	
Coordinate system and unit of measure	X	X	
Grid ID (or other identifier of surveyed area)	X	X	X
Date of data collection	X	X	X
Raw data file names associated with delivery	X	X	
Processed data file names associated with delivery	X	X	
Name of Project Geophysicist	X	X	
Name of Site Geophysicist	X	X	
Name of data processor	X	X	
Data processing software used	X	X	
Despiking method and details	X	X	
Sensor drift removal and details	X	X	
Latency/lag correction and details	X	X	
Sensor bias, background leveling and/or standardization adjustment		X	
method and details			
PDF document showing graphical results of each field quality control test	X	X	
Geophysical noise identification and removal (spatial, temporal, motional, terrain induced) and details		X	
Other filtering/processing performed and details		X	
Gridding method		X	
Anomaly selection and decision criteria details		X	
Geosoft ".xyz" file for unit of survey being delivered (e.g. grid or area agreed upon with MR Geophysicist)		X	
Geosoft ".grd" file for unit of survey being delivered		X	
Geosoft ".map" file for unit of survey being delivered		X	
PDF of Geosoft map for unit of survey being delivered		X	
Geosoft ".map" mosaic of all processed data to date		X	
PDF mosaic of Geosoft map of all processed data to date		X	
Other processing comments		X	
Date data processing is completed	X	X	
Data delivery date	X	X	
Scanned copy of field notes and field mobile data collection device notes (if applicable)	X		

All sensor data will be correlated with navigational data based upon a local "third order" (1:5,000) monument or survey marker. If a suitable point is not available, a land surveyor will establish a minimum of two new monuments or survey markers with a minimum of third-order accuracy.

20.0 DGM Systems Quality Control

An extensive QC program will be applied to the DGM operations at the site. Figure 3 shows an overall chart of the QC steps, and details for those steps are provided in the following subsections.

FIGURE 3
Overview of DGM Process QC



21.0 DGM Instruments Quality Control

Each of the geophysical systems will be field tested to confirm proper operating conditions. Several basic QC tests will be performed in addition to instrument-specific tests. A description of each basic QC test, its acceptance criteria, and its frequency is provided below and summarized in Table 2. Should an instrument fail a QC test, a root-cause analysis will be

performed and corrective actions determined. The DGM survey will not proceed until the geophysical instruments can successfully perform the QC tests within the acceptance criteria.

1. **Equipment Warm-up**. This is an instrument-specific activity, although standard warm-up time is 5 minutes. Some geophysical systems require more warm-up time than others. Each system-specific Standard Operating Procedure (SOP) defines the equipment-specific warm-up time. Equipment warm-up will be performed the first time an instrument is turned on for the day or has been turned off for a sufficient amount of time for the specific instrument to cool down.

2. **Record Sensor Positions**. Positioning accuracy of the final processed data will be demonstrated by operating the equipment over one or more known points. The accuracy of the data positioning will be assessed by calculating the difference between a known location over which a positioning instrument is held and the displayed position. The sensor position test will be conducted at the beginning of the survey operation for each work day.

3. **Personnel Test.** This test checks the response of instruments to personnel and their clothing/proximity to the system. On a daily basis, the instrument coils/sensors for those instruments being used that day will be checked for their response to the personnel operating the system. The response will be observed in the field for immediate corrective action and transmitted back to the processor, and analyzed and checked for spikes in the data that can possibly create false anomalies. The personnel test will be conducted at the beginning of the survey operation for each work day.

4. **Vibration Test (Cable Shake).** This test checks the response of instruments to vibration. On a daily basis, the instrument coils/sensors for those instruments being used that day will be checked for their response to vibrations in the cables. The response will be observed in the field for immediate corrective action and transmitted back to the processor and analyzed and checked for spikes in the data that can possibly create false anomalies. The vibration test will be conducted at the beginning of the survey operation for each work day.

5. **Magnetometer Static Background and Static Spike**. Magnetometer static tests will be performed by positioning the survey equipment within or near the survey boundaries in an area free of metallic contacts and collecting data for (minimally) a 1-minute period. During this time, the instrument will be held in a fixed position without a spike (known standard) and then with a spike. The purpose of the static test is to determine whether unusual levels of instrument or ambient noise exist. The static background and static spike test will be conducted at the beginning and end of each survey operation.

6. **EM31 Static Test**. EM31 static tests will be performed by positioning the survey equipment over an existing culvert or other known subsurface metallic object and collecting data for (minimally) a 1-minute period. During this time, the instrument will be held in a fixed position. The purpose of the static test is to determine whether unusual levels of instrument or ambient noise exist. The static test will be conducted at the same location at the beginning and end of each survey operation.

7. **Repeat Data.** This test is performed to verify repeatability of the data and will be performed after the initial survey over an area. At least 2% of the survey lines will be repeated.

TABLE 2
DGM Instruments Standardization Tests and Acceptance Criteria

Test	Test Description	Acceptance Criteria	Power On	Beginning of Day	Beginning and End of Day	First Time Instr. Used	2% of Total Area Surveyed
1	Equipment Warm-up	Equipment specific (typically 5 min)	X				
2	Record Sensor Positions	± 4 inch (2.54 cm)		X			
3	Personnel Test	Based on instrument used. Personnel, clothing, etc. should have no effect on instrument response		X			
4	Vibration Test (Cable Shake)	Data profile does not exhibit data spikes		X			
5	Static Background & Static Spike (Magnetometer)	± 20% of standard item response, after background correction			X		
6	Static Test (EM31)	± 20% of standard location response			X		
7	Repeat Data	Qualitative comparison of data.					X

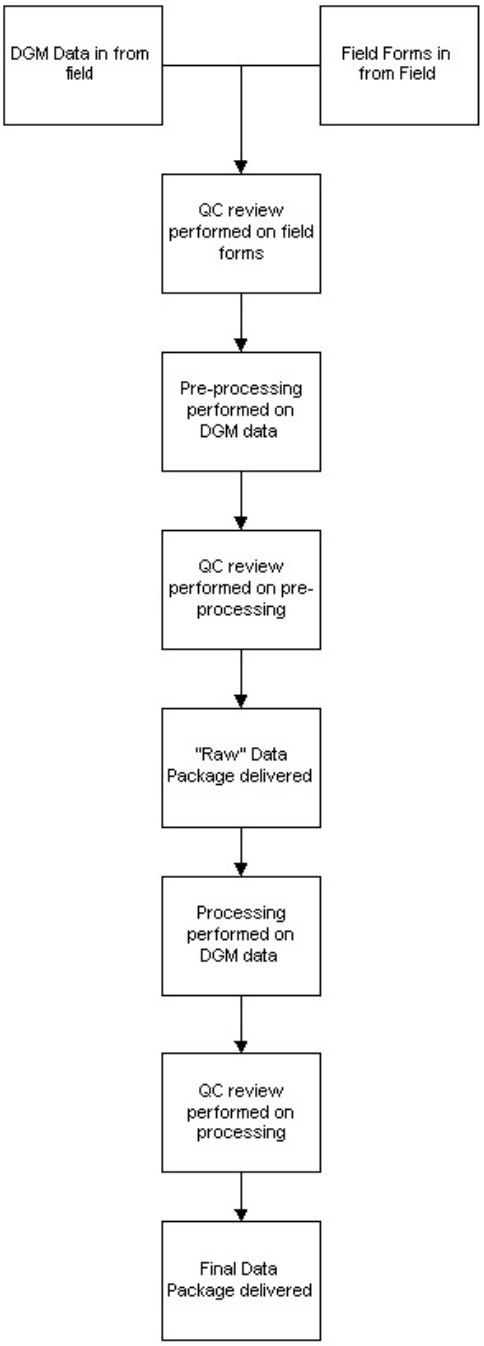
22.0 QC Seed Items

At least one QC seed item will be seeded per 14,500 ft of transects (i.e., at least one seed item for each acre of DGM survey) for continued validation of the G-858 surveys. (The EM31 surveys cannot be tested in the same way because the EM31 is designed to detect more general subsurface material differences by collecting an average conductivity over a very large area.) The seed items will be tagged with a non-biodegradable label identifying the items as inert and providing a contract reference, a point of contact address, phone number, and a target identifier. CH2M HILL personnel will perform seeding using hand tools. The seed locations will be checked using a hand-held analog geophysical instrument to confirm that no existing anomalies are present at the seed location. Once placed, the locations of all seeded items will be surveyed using an RTK DGPS or conventional survey equipment. The items will be placed at easily detectable depths in order to ensure detection (assuming the equipment is functioning appropriately.) Detection of the QC seed items will be monitored by CH2M HILL. Should an item not be detected, a root-cause analysis will be performed and corrective actions determined.

23.0 Quality Control of DGM Data and Deliverables

Both the DGM subcontractor and CH2M HILL will perform QC of geophysical data and data deliverables at each step of the processing path. Figure 4 shows the processing path and the QC steps performed. Data will not move to the next stage until they have passed the QC check.

FIGURE 4
QC of DGM Data – Process Flowpath



QC checks to be performed on field forms, pre-processed data and processed data can be found in Table 1.

24.0 Corrective Measures

Specific corrective measures are dependent on the type of geophysical equipment used; however, the following are the basic corrective measures to be followed in association with DGM surveying:

- Replacement of sensors if they fail to meet instrument check requirements.
- Resurvey of transects if seeded items are not identified (do not show in the DGM data) in the G-858 data. In a situation in which there is a failure to select a seed item from the data but the item is clearly present in the DGM data, a resurvey will not be performed, but instead a re-analysis of the DGM data.

25.0 Analog Geophysical Systems Quality Control

QC over the analog geophysical instruments will be accomplished through daily checks that the instruments are functioning prior to using them for field activities. Each instrument will be operated over a small metallic item buried close to the maximum detection depth determined for that item during instrument validation. If the instrument is not able to detect the item, it will be taken out of use until it is repaired.

Attachment 1
Geophysical Prove-Out (GPO) Work Plan

Geophysical Prove Out Work Plan
Rifle Range Chemical Dump
(Operable Unit 14, Site 69)

Marine Corps Base Camp Lejeune
Jacksonville, North Carolina

Contract Task Order 0223

January 2010

Prepared for

Department of the Navy
Naval Facilities Engineering Command
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Prepared by

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Table

1 Geophysical Surveys to be Performed During GPO

Figure

1 GPO Process

Acronyms and Abbreviations

ASR	Archive Search Report
DGM	digital geophysical mapping
DQO	data quality objectives
GIP	geophysical investigation plan
GPO	geophysical prove-out
GPS	global positioning system
MCB	Marine Corps Base
MRP	munitions response program
QC	quality control
TDEM	time domain electromagnetics
WP	work plan

ATTACHMENT 1

Geophysical Prove-Out Work Plan

This Geophysical Prove-Out (GPO) Plan is a supplement to the Master GPO Work Plan (WP) from the Marine Corps Base (MCB) Camp Lejeune Munitions Response Master Project Plan (CH2M HILL, 2007) (herein referred to as Munitions Response Program [MRP] Master Project Plan) and provides additional site specific details related to GPO activities for digital geophysical mapping (DGM) surveys at the Rifle Range Chemical Dump, Operable Unit (OU) 14, Archive Search Report (ASR) Site 69, MCB Camp Lejeune, North Carolina. Only additional detail, modifications or additions to the information provided in the Master GPO WP from the MRP Master Project Plan (CH2M HILL, 2007) are discussed herein.

1.0 Project Data Quality Objectives

All data quality objectives (DQOs) from the Master GPO WP, with the exception of survey coverage as described in this section, are applicable to the GPO for the subject site. The GPO will not be used to validate the EM31-MK2 system as the GPO is designed for detection of small items and the EM31-MK2 is designed to detect larger scale variations in the subsurface (such as pits, trenches, and very large metallic items.) The EM31-MK2 system will be validated as described in Section 3.2

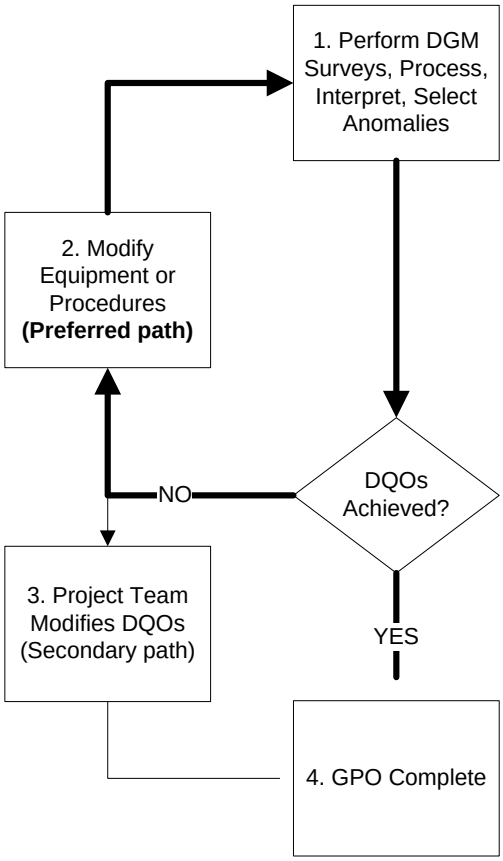
1.1 Survey Coverage (Lane Spacing)

The DQO for survey coverage (lane spacing) is to maintain appropriate lane spacing to provide 100 percent coverage of the survey area. *This DQO will not be applicable for the subject site surveys since 100% coverage will not be performed.*

2.0 Procedures

Because an existing GPO plot is to be used (discussed in Section 3.1) for the GPO activities, a modified Figure 1 is presented in this section that illustrates the GPO process and the procedures to be employed (numbered in accordance with the steps shown in this section).

FIGURE 1
GPO Process



DGM surveys will be performed in the GPO by the DGM subcontractor using the Geometrics G-858/G-856 Magnetometer system. Potential system configurations to be tested are shown in Table 1. (At a minimum, survey methods that will actually be employed will be demonstrated for validation. Selection of appropriate methodology for site surveys will be made on observation of actual field conditions.) The data will be processed and interpreted by the DGM subcontractor and anomaly selections made. Draft data will be provided to the CH2M HILL Project Geophysicist for evaluation within 4 hours of completing each GPO survey and final data packages, including subcontractor documentation demonstrating that DQOs were met, within one working day of GPO completion.

1. If the initial DQOs have not been met, the CH2M HILL Project Geophysicist will meet with the DGM subcontractor to discuss whether modifications or procedures can be made to the DGM systems in order to meet the DQOs.

2. If the DQOs cannot be met by the DGM subcontractor, the CH2M HILL Project Manager and Project Geophysicist will meet with the NAVFAC Project Manager to discuss a resolution (i.e., modification of a DQO) prior to completing the GPO.

TABLE 1
Geophysical Surveys to be Performed During GPO[1]

Test	Instrument	Platform/Positioning System	Approximate Sensor Height Above Ground Surface (m)	Design Lane Width[2] (m)	Data Collection Rate	Approximate Survey Speed (m/s)
1	G-858 with G-856 Base	Man-portable/Fiducial (time based) positioning	0.75	1	10 per second	1
2	G-858 with G-856 Base	Man-portable/RTK GPS	0.75	1	10 per second	1

Notes:
[1]Some data elements are subject to evaluation and modification in the field. At a minimum, survey methods that will actually be employed will be demonstrated for validation. Selection of appropriate methodology for site surveys will be made on observation of actual field conditions.
[2]The design lane width is applicable only if full coverage is being. In cases where transects are used, the design lane width is not relevant.
RTK GPS = Real-time Kinematic Global Positioning System; m = meter; m/s = meters per second

3. Once the surveys have been performed and at least one configuration of each system has been determined capable of meeting the initial (or modified) DQOs, the GPO will be complete.

3.0 Additional GPO Considerations

Additional topics taken into consideration for the design of the GPO include plot location, size, and shape; quantities of seeded items; and geophysical and positioning instruments and technologies.

3.1 GPO Plot Location

The location of the GPO was determined on the basis that a plot already exists at MCB Camp Lejeune in similar geologic conditions. Multiple surveys have been performed at MCB Camp Lejeune using time domain electromagnetics (TDEM) technology, and these systems have been demonstrated over this GPO plot. Although the current DGM survey does not utilize TDEM methods, the previous surveys have established this GPO location as a legitimate demonstration of DGM system performance that can be used to validate the magnetometer systems to be used during the current project.

3.2 Number and Types of Geophysical Instruments and Technologies Selected for Testing

Because of the primary objective of locating buried drums at the site, a pre-field analysis of geophysical techniques used in the industry, including magnetics, TDEM, and ground conductivity, CH2M HILL has selected magnetics and ground conductivity techniques for testing. This selection is based on the ferrous composition and anticipated sizes and depths of the items of interest. The design and function of each system requires that they be tested in different manners. The magnetometer system has the capability to detect individual ferrous items and will therefore be validated over the GPO plot to ensure that it is performing appropriately. The ground conductivity system is designed to detect more general subsurface material differences by collecting an average conductivity over a very large area, so the GPO plot will not be an effective demonstration of system performance. The ground conductivity system will therefore be demonstrated over an existing culvert or subsurface utility line. This demonstration will validate the performance of the EM31-MK2 system by correlating variations in ground conductivity with the location of the subsurface culvert or utility.

A complete description of the Geonics EM31-MK2 Terrain Conductivity Meter and the Geometrics G-858/G-856 Magnetometer system is provided in the Master Geophysical Investigation Plan (GIP) as part of the MRP Master Project Plan (CH2M HILL, 2007).

3.3 Number and Types of Positioning Instruments and Technologies Selected for Testing

Because the areas to be surveyed are transects through heavily vegetated woods, the positioning systems to be tested during the GPO for positioning of the geophysical data include a fiducial method and a Real-Time Kinematic (RTK) Global Positioning System (GPS). The fiducial method is referenced to survey stakes emplaced by a licensed surveyor at regular intervals along a transect which are used for the placement of fiducial marks within the recorded data. Data are collected on a regular interval (i.e. 10 per second) while the operator(s) walk a constant pace, and the total number of data points collected between fiducial points (stakes) are distributed evenly between the fiducial points. A full description of the positioning methods is provided in the Master GIP as part of the Master Work Plan (CH2M HILL, 2007).

4.0 Quality Control

4.1 DGM Instruments Quality Control

All systems will be field tested by the DGM subcontractor to ensure that they are operating properly. All quality control (QC) tests described in the Master GPO WP will be performed for the G-858/G-856 Magnetometer system. The EM31-MK2 system is designed to detect changes in electrical conductivity in the ground over a broader area, and will therefore be field tested in a different manner. A static test will be conducted at the beginning and end of each survey day by placing the EM31-MK2 over the location of a previously identified subsurface culvert or utility line.

4.2 QC Seed Items

At least one QC seed item will be seeded per 14,500 ft of transects (i.e., at least one seed item for each acre of DGM survey) for continued validation of the G-858 surveys. The EM31-MK2 surveys cannot be tested in the same way because the EM31-MK2 is designed to detect more general subsurface material differences by collecting an average conductivity over a very large area.

5.0 References

CH2M HILL, 2007. *Munitions Response Master Project Plan, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina.* July 2007.

Appendix D
Quality Assurance Project Plan