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Final

Site Inspection Report for Former Cat Island Bomb Target BT-2 and Surface Danger Zone

Marine Corps Air Station Cherry Point
Havelock, North Carolina

Prepared for

Department of the Navy

Naval Facilities Engineering Command
Mid-Atlantic Division

Contract No.
N62470-08-D-1000
CTO-0026

July 2010

Prepared by

CH2MHILL

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Under the

NAVFAC CLEAN 1000 Program
Contract No. N62470-08-D-1000

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Executive Summary

This document presents data, results, and conclusions for the Site Inspection (SI) conducted at the Former Cat Island Bomb Target BT-2 and Surface Danger Zone (SDZ) (referred to hereafter as BT-2) associated with Marine Corps Air Station (MCAS) Cherry Point, North Carolina. The SI was conducted to evaluate the presence of munitions and explosives of concern (MEC) and to characterize potential impacts to soil, surface water, and sediment related to historical activities at BT-2. The SI was performed in accordance with the *Site Inspection Work Plan for Former Cat Island Bomb Target (BT-2) and Surface Danger Zone* (CH2M HILL, 2008).

BT-2 is a closed range located in Bogue Sound in Western Carteret County, between Emerald Isle and the North Carolina mainland at Latitude 34º 41′ 12″N and Longitude 76º 57′ 06″ W as shown on **Figure 2-1**. The coordinates of BT-2 were modified several times during operation of the target location, but all target coordinates were located in the immediate vicinity of Wood Island. The site includes Former Cat Island Bomb Target BT-2 and associated historical SDZs. SDZs associated with this site extend up to three miles from the target location as shown on **Figure 2-2**. The site consists of an approximately 12-acre island primarily covered with marsh grasses and other vegetation and the associated three-mile radius SDZ.

Field activities included airborne digital geophysical mapping (ADGM) and environmental sampling of surface soil, surface water, and sediment. Environmental samples included surface soil samples collected from Wood Island, surface water samples collected from Bogue Sound and water-filled depressions on Wood Island, and sediment samples collected from Bogue Sound. In addition to the samples collected within the site boundary, background surface water and sediment samples were collected outside the SDZ boundary in Bogue Sound. All samples were analyzed for explosives residues, perchlorate, and target analyte list (TAL) metals.

Explosives residues and perchlorate were not detected in any of the surface soil samples; however, arsenic, chromium and iron exceeded screening criteria in surface soil samples. Perchlorate was detected in three of the twelve sediment samples, but concentrations did not exceed screening criteria. Arsenic and chromium concentrations exceeded the screening criteria in sediment; however, these detections were consistent with concentrations detected in the background samples.

Explosives residues were detected at four of the six surface water sampling locations, including the background sampling location, while perchlorate was not detected in surface water samples. There are no applicable screening criteria for explosives residues or perchlorate in a tidal water body such as this. Arsenic, cadmium, and silver exceeded screening criteria in surface water samples onsite. Silver concentrations were consistent with concentrations detected in the background sample.

A total of 10,400 magnetic anomalies were detected during the ADGM of 6,600 acres of Bogue Sound within the BT-2 SDZ. The largest concentration of anomalies is located within

a radius of approximately 650 feet around Wood Island. The remaining detected anomalies are sporadically distributed throughout the survey area, punctuated by smaller clusters of low-amplitude anomalies. The clusters of low-amplitude anomalies do not resemble typical munitions target patterns observed at bomb target sites. The geophysical survey results do not differentiate between munitions items and other metallic debris; however, the high concentration of anomalies observed around Wood Island is consistent with typically observed munitions target patterns. According to the ADGM survey results, the density of metallic objects decreases with increased distance from Wood Island.

A human health risk screening (HHRS) including a risk ratio evaluation was performed for surface soil, sediment, and surface water at BT-2. Results of the HHRS indicate that there are no unacceptable risks identified for current or likely future receptors exposed to surface soil, sediment, and surface.

An ecological risk screening was performed for surface soil, sediment, and surface water at BT-2. Results of the ecological risk screening indicate that there are no unacceptable risks identified for ecological receptors exposed to BT-2 surface soil, sediment, or surface water.

Based on the results of the HHRS and ecological risk screening, no further evaluation of surface soil, surface water, and sediment is currently recommended at BT-2. However, due to the presence of MEC on Wood Island and the high concentration of anomalies identified in the waters around Wood Island, it is recommended that additional investigation be performed to assess the nature of the identified anomalies. Further evaluation of the site may be conducted, as necessary, following future actions that could result in changes to site conditions.

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Acronyms and Abbreviations

ADGM	airborne digital geophysical mapping
ARSR	Archival Records Search Report
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-term Environmental Action—Navy
CMC	criterion maximum concentration
COPC	chemical of potential concern
CR	carcinogenic risk
CSM	conceptual site model
CTO	Contract Task Order
°F	degrees Fahrenheit
DO	dissolved oxygen
DoD	Department of Defense
DoN	Department of the Navy
DOT	Department of Transportation
DRMO	Defense Reutilization and Marketing Office
EcoSSL	Ecological Soil Screening Level
EOD	Explosive Ordnance Disposal
EPC	exposure point concentration
ESS	explosives safety submission
ESV	ecological screening value
FRCE	Fleet Readiness Center – East
GIP	Geophysical Investigation Plan
GIS	geographic information system
GPO	geophysical prove-out
GPS	global positioning system
HHRS	Human Health Risk Screening
HI	hazard index
HQ	hazard quotient
IDW	investigation-derived waste
LOEC	lowest observed effect concentration
µg/L	microgram per liter
µg/kg	microgram per kilogram
MC	munitions constituent
MCAS	Marine Corps Air Station
MCB	Marine Corps Base

MEC	munitions and explosives of concern
mg/kg	milligram per kilogram
mm	millimeter
MPPEH	material potentially presenting an explosive hazard
MRP	Munitions Response Program
MS/MSD	matrix spike/matrix spike duplicate
msl	mean sea level
NAVFAC	Naval Facilities Engineering Command
NCDENR	North Carolina Department of Environment and Natural Resources
NC 2B	North Carolina Tidal 2B
NC HWS SSL	North Carolina Hazardous Waste Site Soil Screening Level
NRWQC	National Recommended Water Quality Criteria
nT/m	nanoteslas per meter
NTR	Navy Technical Representative
ORNL	Oakridge National Laboratory
ORP	oxidation-reduction potential
PPE	personal protective equipment
QA	quality assurance
QC	quality control
QCP	Quality Control Plan
RDX	cyclotrimethylenetrinitramine
RMUS	Range and Munitions Use Subcommittee
RSL	regional screening level
SI	Site Inspection
SDZ	Surface Danger Zone
TAL	target analyte list
TCLP	Toxicity Characteristic Leaching Procedure
TOC	total organic carbon
UCL	upper confidence limit
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USMC	United States Marine Corps
UXO	unexploded ordnance

SECTION 1

Introduction

Marine Corps Air Station (MCAS) Cherry Point is in the process of investigating closed ranges in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) investigation process. Due to historical activities at the Former Cat Island Bomb Target BT-2 and the associated surface danger zone (SDZ) (collectively referred to hereafter as BT-2), a Munitions Response Program (MRP) Site Inspection (SI) has been conducted. The SI was conducted by CH2M HILL under the Naval Facilities Engineering Command (NAVFAC) Atlantic, Comprehensive Long-term Environmental Action—Navy (CLEAN) Contract N62470-02-D-3052, Contract Task Order (CTO) 201 and Contract N62470-08-D-1000, CTO-026.

This document presents data, results, and conclusions for the SI conducted at BT-2. The SI was conducted to evaluate the extent and density of geophysical anomalies and to characterize potential impacts to surface water, soil, and sediment related to historical activities at BT-2. The SI study area included Wood Island and approximately 6,600 acres of the approximately 18,100 acre BT-2 SDZ located within and adjacent to Bogue Sound. The SI was performed in accordance with the *Site Inspection Work Plan for Former Cat Island Bomb Target (BT-2) and Surface Danger Zone* (CH2M HILL, 2008), referred to herein as the Work Plan.

1.1 Objectives

The objectives of the SI were to:

Identify historical activities conducted at BT-2 that may have resulted in environmental contamination associated with munitions and explosives of concern (MEC)

Evaluate the presence and nature of any munitions constituents (MC) contamination that may exist at BT-2 in the vicinity of the former bomb target locations

Assess the potential risk to ecological and human receptors at BT-2 in the vicinity of the former bomb target locations

Identify and evaluate the extent and density of geophysical anomalies in the BT-2 SDZ within Bogue Sound that could represent subsurface MEC related to the former military use of BT-2

1.2 Report Organization

This SI Report is composed of the following sections:

Section 1 – Introduction, provides the project scope and objectives of the SI and the format for report organization.

Section 2 – Site Background, provides general description of BT-2 and the surrounding SDZ, summarizes the history of the site.

Section 3 – Field Investigation Activities, identifies the technical approach, methods, and operational procedures that were used to execute the field investigation activities, including sampling of environmental media and the airborne digital geophysical mapping (ADGM).

Section 4 – Investigation Results, summarizes the results of the environmental sampling and the ADGM investigation.

Section 5 – Human Health Risk Screening, evaluates the potential for human health risks associated with exposure to surface soil, sediment, and surface water at BT-2.

Section 6 – Ecological Risk Screening, evaluates the potential for ecological risks associated with exposure to surface soil, sediment, and surface water at BT-2.

Section 7 – Conclusions and Recommendations, summarizes the findings of the investigation and provides recommendations for further actions to be taken based on these findings.

Section 8 – References, lists the references cited in the preceding sections.

SECTION 2

Site Background

This section presents a summary of regional and site-specific information, including location, site setting, physical characteristics, and site history.

2.1 MCAS Cherry Point Location and Description

MCAS Cherry Point is a 13,164-acre military reservation located north of the town of Havelock, in southeastern Craven County, North Carolina (**Figure 2-1**). Commissioned in 1942, MCAS Cherry Point currently provides support facilities and services for the Second Marine Aircraft Wing, the Fleet Readiness Center – East (FRCE), Service Support Detachment 21 of the Second Force Service Support Group, the Naval Air Maintenance Training Group Detachment, and the Defense Reutilization and Marketing Office (DRMO). MCAS Cherry Point maintains facilities for training and supporting the Atlantic Fleet Marine Force aviation units and is designated as a primary aviation supply point. BT-2 is located approximately 14 miles south of MCAS Cherry Point.

2.2 BT-2 Site Description

The Former BT-2 is a closed range located in Bogue Sound in Western Carteret County, between Emerald Isle and the North Carolina mainland centered at Latitude 34º 41′ 12″N and Longitude 76º 57′ 06″ W, as shown on **Figure 2-1**. The site includes Former Cat Island Bomb Target BT-2 and associated historical SDZs. BT-2 is composed of three bomb target locations used from 1945 to 1955 and a 3-mile SDZ around the targets, as shown on **Figure 2-2**. The former bomb target coordinates, which were modified several times during operation of this target, were located in the immediate vicinity of Wood Island in Bogue Sound. Wood Island is an approximately 12-acre island primarily covered with marsh grasses and other vegetation. The SDZ includes Wood Island and portions of Bogue Sound, mainland North Carolina, the Bogue Banks barrier island, and the Intracoastal Waterway. The conceptual site model for BT-2 is presented in **Figure 2-3**.

2.3 Site History

From 1943 to 1952, BT-2 was used for bombing practice using inert, target-practice munitions. In 1952, the use of live ammunition was initiated at the site (Department of the Navy [DoN], 1957a). The *Range Identification and Preliminary Range Assessment* report (United States Army Corps of Engineers [USACE], 2001) indicates that general purpose bombs, armor piercing bombs, semi-armor piercing bombs, depth bombs, rockets and machine guns (.30 caliber to 20 millimeter [mm]) were used for training activities at BT-2. The estimated subsurface depth of munitions varies according to the type of munitions that were used (USACE, 2001). Air-delivered ordnance, including up to 2,000-pound bombs, were reportedly used on the island. A memorandum dated April 5, 1956, indicated that the Navy and/or Marines had discontinued the use of Cat Island for bombing purposes in approximately 1955 (DoN, 1956).

The DoN leased the Wood Island property from 1943 to 1955 (Lease Agreement, 1943). In 1955, the DoN proposed to acquire the land because it was economically impractical to restore the property to its original condition (DoN, 1957a). On April 24, 1956, the Navy acquired the land by condemnation proceedings and a Declaration of Taking (DoN, 1957b).

In 1972, the DoN concluded that Cat Island could not be released from Department of Defense (DoD) control as the high cost of complete unexploded ordnance (UXO) removal made disposal of the property infeasible (DoN, 1972). Although the land is no longer being used for military training, ownership of Wood Island is still retained by the Navy. Detailed site historical information is provided in the Archival Records Search Report (ARSR) presented in **Appendix A**.

2.4 Previous Investigations

The Navy performed UXO clearance, referred to as surface decontamination, of Wood Island in 1957. The details and extent of the level of UXO clearance is unknown. At that time the DoN concluded that there was a high probability that UXO was present below the surface of the island that could not be detected by probing and that UXO may continue to be exposed through tidal action and storms. The DoN stated that Wood Island remained a potentially dangerous area (DoN, 1957c).

On November 21 and 27, 1963, the MCAS Cherry Point Explosive Ordnance Disposal (EOD) team conducted a surface sweep of Wood Island for UXO. No UXO was found; however, items of inert and expended ordnance were found. At that time, no responsible officer would certify that Wood Island had been decontaminated with respect to UXO due to the potential for ordnance to be buried to a depth of 30 feet or more and due to the potential for buried ordnance to be brought to the surface through tidal action and storms (USMC, 1963).

MCAS Cherry Point EOD performed a site visit in August 2007. Miniature practice bombs and rocket components were identified on the island surface and were destroyed by EOD personnel.

Site reconnaissance visits were made to Wood Island in February 2008 and January 2009 by CH2M HILL, NAVFAC, and MCAS Cherry Point personnel. During the site reconnaissance visits, surface and partially buried material potentially presenting an explosive hazard (MPPEH) was observed on the island. A higher concentration of surface MPPEH was observed on the beaches located on the western portion of Wood Island.

2.5 Regional Climate

Proximity to the Atlantic Ocean significantly influences the climate of BT-2. The climate is warm and humid with short, mild winters and long, hot summers. Winter temperatures average 46 degrees Fahrenheit (°F), and summer temperatures average 77°F. Precipitation is not evenly distributed, with the greatest monthly precipitation occurring during July, August, and September (6 to 8 inches per month). In the other months, monthly rainfall averages 3 to 4 inches. Average precipitation for the Coastal Plain is approximately 50 inches per year (Giese, Eimers, and Coble, 1997).

2.6 Regional Geology

The regional geologic and hydrogeologic framework for North Carolina presented here is based principally on information compiled and developed as part of the United States Geological Survey's (USGS) Regional Aquifer-System Analysis. The Coastal Plain Province of North Carolina is underlain by an eastward-thickening wedge of unconsolidated gravel, sand, silt, and clay with scattered beds of shells and loosely consolidated beds of limestone, sandy limestone, and shell limestone (Winner and Coble, 1996). The sedimentary sequence ranges in age from Quaternary to Cretaceous and reaches a thickness of 10,000 feet (ft) at the Atlantic coast. Near MCAS Cherry Point, the Coastal Plain Province sediments are estimated to be approximately 2,500 ft thick (Lloyd and Daniel, 1988). The lower sedimentary sequence is predominantly nonmarine deltaic in origin and consists of discontinuous and heterogeneous sand-and-clay sequences. The upper sequences are predominantly marine in origin and include near-shore and estuarine deposits. The sedimentary deposits overlie pre-Cretaceous crystalline basement rock. Historical Coastal Plain Province sedimentation and deposition were controlled by fluctuations in sea level on a subsiding continental margin.

2.7 Site Geology

The marshland soils at Wood Island are level and very poorly-drained mucks. The dominant soil is classified as the Newham-Corolla complex and is composed of marine sediment deposits and organic mucks. The northern one-third (4 acres) of the island is a vegetated dune including trees and bushes with an elevation of 9 feet above mean sea level (msl); the elevation of the southern two-thirds of the island is less than 3 feet above msl. Except for the higher elevation dune habitat, the land is subject to tidal flooding. Some marshlands are present on the island, and have semi-permanently saturated and flooded soils. Strong storm tides may flood the terrestrial dune habitat (USMC, 2001). The sediments surrounding the island are predominantly poorly-graded fine sands with trace to minor clay and silt components.

Legend

- Surface Danger Zone (3-mile radius)
- Wood Island
- MCAS Cherry Point Boundary

N
W E
S

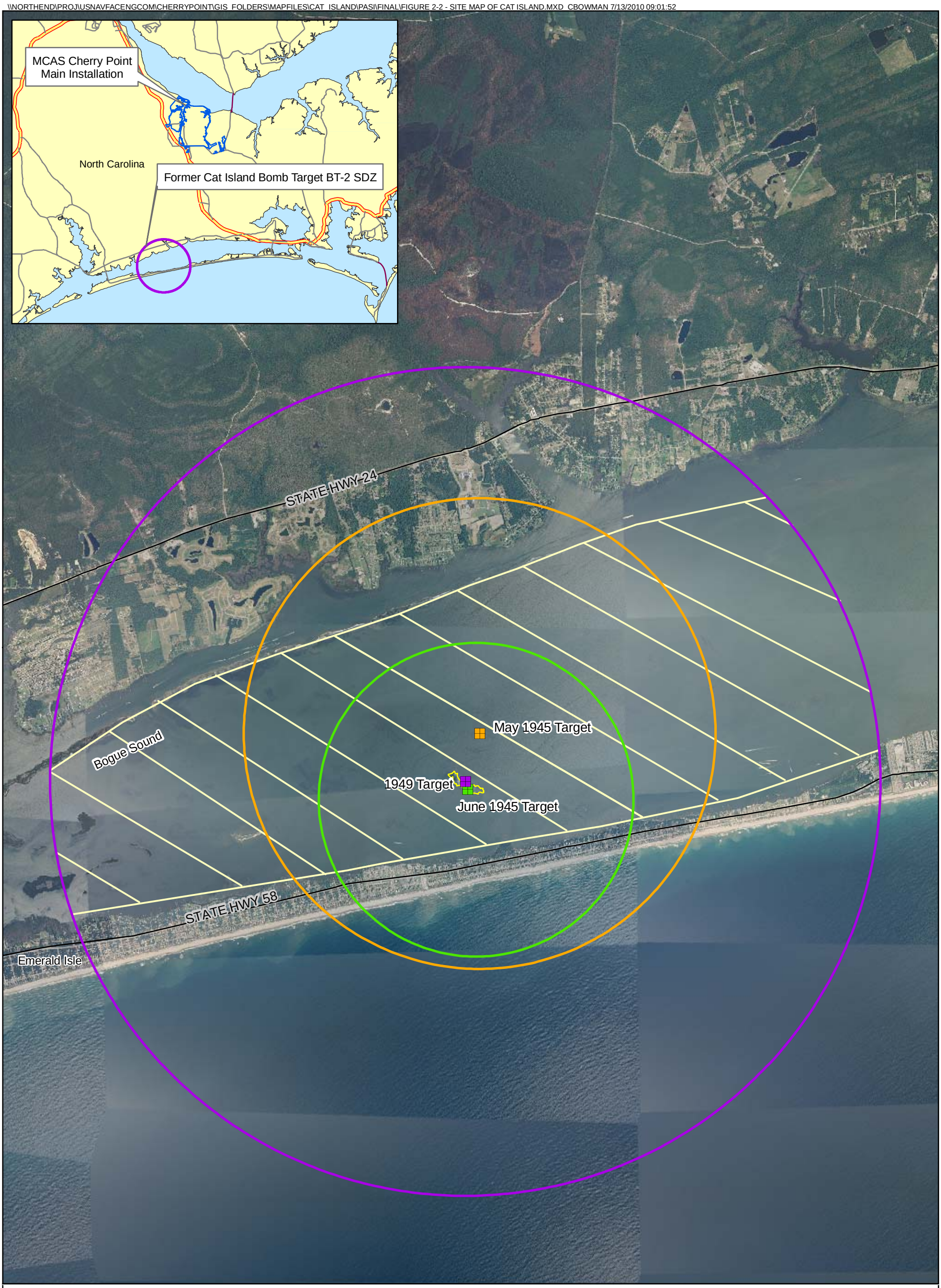
0 8,500 17,000
Feet

Figure 2-1
Regional Site Map
Former Cat Island Bomb Target BT-2
and Surface Danger Zone
MCAS Cherry Point
North Carolina

CH2MHILL

Generated by: *Jeremy Diner* Checked by: *Renee Clore*

\\NORTHEND\PROJ\USNAVFACENGCOM\CHERRYPOINT\GIS_FOLDERS\MAPFILES\CAT_ISLAND\PASI\FINAL\FIGURE 2-2 - SITE MAP OF CAT ISLAND.MXD CBOWMAN 7/13/2010 09:01:52



Legend

- May 1945 Target
- June 1945 Target
- 1949 Target
- May 1945 SDZ- 3000 yards
- June 1945 SDZ - 2000 yards
- 1949 SDZ - 3 miles
- Investigation Area

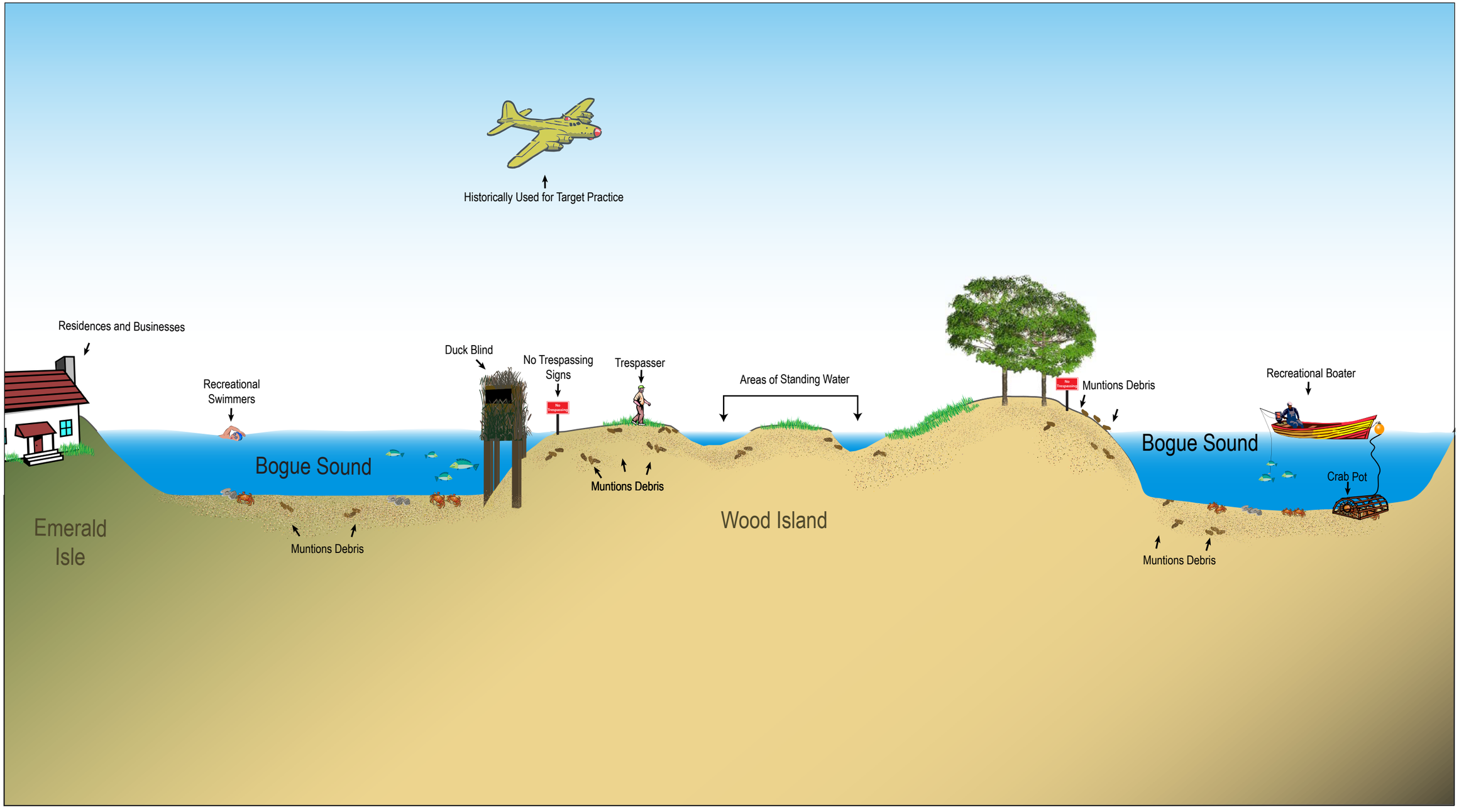
N
W E
S

0 1,750 3,500
Feet

Figure 2-2
Site Map
Former Cat Island Bomb Target BT-2
and Surface Danger Zone
MCAS Cherry Point
North Carolina

CH2MHILL

Generated by: *Jeremy Diner* Checked by: *Renee Clore*



Note: Not to Scale

Figure 2-3
Conceptual Site Model
Former Cat Island Bomb Target (BT-2)
MCAS Cherry Point
North Carolina

SECTION 3

Field Investigation Activities

Field investigation activities were performed in accordance with the Work Plan (CH2M HILL, 2008). Surface soil samples on Wood Island and surface water samples from the water-filled depressions on Wood Island were collected in March 2009. ADGM activities were conducted during March and April 2009. Surface water and sediment samples were collected from Bogue Sound in May 2009. Details of the field activities conducted at BT-2 are provided below.

3.1 Site Preparation and Support

3.1.1 MEC Avoidance

During the field mobilization, MEC avoidance was conducted as necessary in accordance with the approved Explosives Safety Submission (ESS) Determination (USMC, 2008). A qualified UXO Technician escorted all on-site personnel and provided MEC avoidance services during all investigation activities performed on Wood Island and within the SDZ. Specific project duties for the UXO Technician included the following:

Trained field personnel in appropriate MEC safety procedures prior to initiation of field activities

Escorted field personnel while conducting onsite activities in areas of potential MEC contamination

Provided subsurface MEC avoidance for intrusive environmental investigation activities (e.g., soil and sediment sampling)

3.1.2 Site Surveying

During survey operations, the spatial coordinates of each surface soil, sediment, and surface water sampling location were digitally recorded using a handheld global positioning system (GPS) unit for entry into a geographical information system (GIS) database.

3.2 Geophysical Investigation

3.2.1 Airborne Digital Geophysical Mapping Survey

The ADGM survey was performed by Battelle Memorial Institute to identify anomalies that represent potential subsurface MEC. The ADGM survey was conducted over the 6,600-acre portion of the SDZ located within Bogue Sound, as this area could be effectively investigated using ADGM technology. The results of this field investigation will be evaluated to help determine if portions of the mainland and/or barrier island located within the surface danger zone (SDZ) should be included in a potential future phase of investigation.

All ADGM activities were conducted in accordance with the Geophysical Prove-Out (GPO) Plan and the Geophysical Investigation Plan (GIP), which are included in Appendices B and C, respectively, of the Work Plan (CH2M HILL, 2008). Quality control (QC) was performed by both Battelle and CH2M HILL, in accordance with the QC plan, which is included in Appendix H of the Work Plan.

The ADGM survey was performed over approximately 6,600 acres of Bogue Sound located within the 3-mile SDZ. The survey was conducted using a helicopter equipped with a low-altitude magnetic gradient (VG-16) system composed of eight vertical gradiometers spaced 1.7 meters apart. Each gradiometer consisted of a pair of cesium magnetometers vertically offset 50 cm from one another. ADGM helicopter operations were flown out of Michael J. Smith Field in Beaufort, North Carolina from March 3 to April 22, 2009. A support boat was present in Bogue Sound during all ADGM flights.

High winds, precipitation, and foggy conditions caused delays throughout the ADGM event. Flight directions were varied throughout the survey to accommodate changing wind direction. A summary of the ADGM results is provided in **Section 4-2**. A detailed discussion of the ADGM survey and results is provided in Battelle's ADGM report in **Appendix B**.

3.2.2 Geophysical Prove-Out

The airborne GPO was performed at Michael J. Smith Field in Beaufort, North Carolina. A line of test items were placed on the ground surface after a pre-seed ground-based geophysical survey using the VG-16. The test items consisted of six inert ordnance items and a seventh item identical to the CH2M HILL QC seeds placed in Bogue Sound. The inert ordnance items were chosen to be representative of the size of items that could be encountered in the survey area. The QC seed item consisted of two 3-foot-long steel pipes and a 15-pound boat anchor. Identical QC seed items were placed at various locations within Bogue Sound during the ADGM event.

The GPO consisted of ADGM surveys flown over the test strip at heights of 1, 2, 3, 5, 7, and 10 meters above the ground surface to demonstrate the functionality of the system and to determine the optimum survey elevation. The GPO is discussed in the ADGM QC Final Report, included in **Appendix B.** During the remainder of the survey, the GPO plot was flown twice daily to ensure the proper and consistent operation of the VG-16 system.

3.2.3 Data Processing and Quality Control

Data processing of the BT-2 survey data occurred in several stages, including correction for time lags, removal of sensor dropouts, correction for sensor heading error, array balancing, and removal of helicopter rotor noise. A full description is provided in the ADGM report (**Appendix B**).

Comprehensive QC processes (as described in the Quality Control Plan [QCP] provided in the Work Plan [CH2M HILL, 2008]) were applied across all aspects of the operations and a final QC validation was performed by the CH2M HILL QC Geophysicist before data delivery. Data was examined in the field by the project team geophysicists to ensure sufficient quality for final processing. The adequacy of the geophysical corrections was confirmed during data processing. During survey operations, the ADGM operator monitored flight line locations to verify full coverage of the area. Data were examined for

high noise levels, data drop outs, unacceptable diurnal activity, excessive survey elevations, and other unacceptable conditions. Lines deemed to be unacceptable were re-flown. Missing lines or areas where data were not captured were reacquired.

3.3 Environmental Investigation Activities

3.3.1 Surface Soil Sampling

Surface soil samples were collected from Wood Island in March 2009. Six composite surface soil samples were collected (three sample increments for each composite sample) and were analyzed for explosives residues, perchlorate, and target analyte list (TAL) metals. Sample increment locations and the composite sample boundaries for each surface soil composite sample are shown on **Figure 3-1**. Surface soil sample increments were collected from 0 to 1 foot below ground surface (bgs). Due to the low elevation of Wood Island and the close proximity of groundwater, the collection of soil samples deeper than those collected likely would have resulted in saturated samples.

Surface soil samples were collected using hand trowels, stainless steel bowls, and spoons for homogenization. Surface soil sample locations were adjusted from those presented in the Work Plan based on site features. The collection of composite samples based on site features, including soil type and surrounding vegetation, was performed to allow possible correlations to be drawn between constituent concentrations and site conditions during evaluation of the analytical data. The coordinates of each sampling location were recorded by the sampling team using a handheld GPS.

3.3.2 Sediment Sampling

Vibracore sediment sampling was conducted in Bogue Sound by Athena Technologies Inc. of Columbia, South Carolina. Nine sediment samples were collected around the perimeter of Wood Island; one sediment sample was collected near the bomb target location north of Wood Island; and two background sediment samples were collected from outside of the 3-mile SDZ. The background sediment samples were collected immediately outside of the 3-mile SDZ and are considered representative of background conditions because they were located outside of the site boundaries, in areas not likely to have been affected by historical actions conducted at the site, yet within Bogue Sound and in close enough proximity to the site for sediment conditions to be consistent with those within the site. Sediment sampling locations are presented on **Figure 3-1.** Sediment boring logs are presented in **Appendix C**.

Sediment cores were collected using a vibratory coring head constructed from an electric concrete vibrator attached to a metal coring barrel. A polycarbonate core liner was inserted into an aluminum coring barrel and the apparatus was lowered to the sediment surface. At which point the vibratory head was engaged, and the sediment core was collected from the target depth of 0 to 1 foot. The core was brought onboard and the bottom was immediately capped to prevent sample loss. The polycarbonate liner was then removed from the outer barrel and holes were drilled to allow drainage of any overlying water. The core liner was then cut to the length of the core, the top end capped, and each core secured on deck for transport to shore. All cores were collected in a single day and processed the following morning. Cores were stored on ice in a secured field vehicle overnight.

Sediment samples were collected from 0 to 1 foot below the floor surface, although a penetration of approximately two feet was necessary to ensure that the top foot of sediment was recovered. During core processing the top 1 foot of each core was separated from the rest of the core using a hand saw. The sediment was extruded into a pre-cleaned, dedicated aluminum pan for characterization and photo documentation. The material was described with respect to gross grain size, sediment type, color, odor and any other distinguishing characteristics. After the material was characterized and photographed, the sediment was homogenized until a uniform color and texture was achieved and a sample of the sediment was containerized for shipment to the laboratory. Samples were placed on ice immediately after collection.

Sediment samples were analyzed for explosives residues, perchlorate, and TAL metals. Sediment samples were also analyzed for grain size and total organic carbon (TOC) in order to better assess the transport characteristics of potential contaminants across the site.

3.3.3 Surface Water Sampling

Three surface water samples were collected from Bogue Sound around the perimeter of Wood Island; two samples were collected from the water-filled depressions located on Wood Island; and one background sample was collected from Bogue Sound from a location outside the 3-mile SDZ. The background surface water sample was collected immediately outside the SDZ to be outside of the 3-mile SDZ and is considered representative of background conditions because it was located outside of the site boundaries, in an area not likely to have been affected by historical actions conducted at the site, yet within Bogue Sound and in close proximity to the site for surface water conditions to be consistent with BT-2 conditions. Surface water sampling locations are presented on **Figure 3-1**.

Surface water samples outside the perimeter of the island were collected from 1 foot above the sediment surface if the water depth was 2 feet or greater; if the water depth was less than 2 feet the sample was collected from the midpoint of the water column. Water samples were collected using a peristaltic pump equipped with Teflon-lined tubing; the tubing was lowered through the water column until the target depth was reached. Dedicated tubing was used at each sampling location and tubing was purged for approximately 1 minute with site water prior to collecting aliquots for chemical analysis.

Surface water samples were submitted for the analysis of explosives residues, perchlorate, and total and dissolved TAL metals. Water quality parameters including specific conductivity, oxidation-reduction potential (ORP), pH, temperature, dissolved oxygen (DO), and turbidity were also measured at each sampling location.

3.3.4 Quality Assurance/Quality Control Sampling

Appropriate quality assurance (QA)/QC sampling was performed in accordance with the Work Plan (CH2M HILL, 2008), including the collection of temperature blanks, field blanks, equipment blanks, duplicates, and matrix spike/matrix spike duplicates (MS/MSDs).

3.4 Data Tracking and Validation

Sample identification numbers and the required analytical tests were recorded on chain-of-custody forms, which accompanied the samples to the laboratory. Chain-of-custody entries

were checked against the project instructions to verify that all designated samples were collected and submitted for the appropriate analyses. Upon receipt of the samples by the laboratory, a comparison to the field information was made to verify that each sample was analyzed for the correct parameters. In addition, a check was made to ensure that the appropriate number and types of QA/QC samples were collected.

Analytical data reports, in hard copy and electronic format, were submitted to Environmental Data Services for third-party validation. The procedures used for the validation process included *National Functional Guidelines for Organic Data Review* (USEPA, 1999) and *National Functional Guidelines for Inorganic Data Review* (USEPA, 2004).

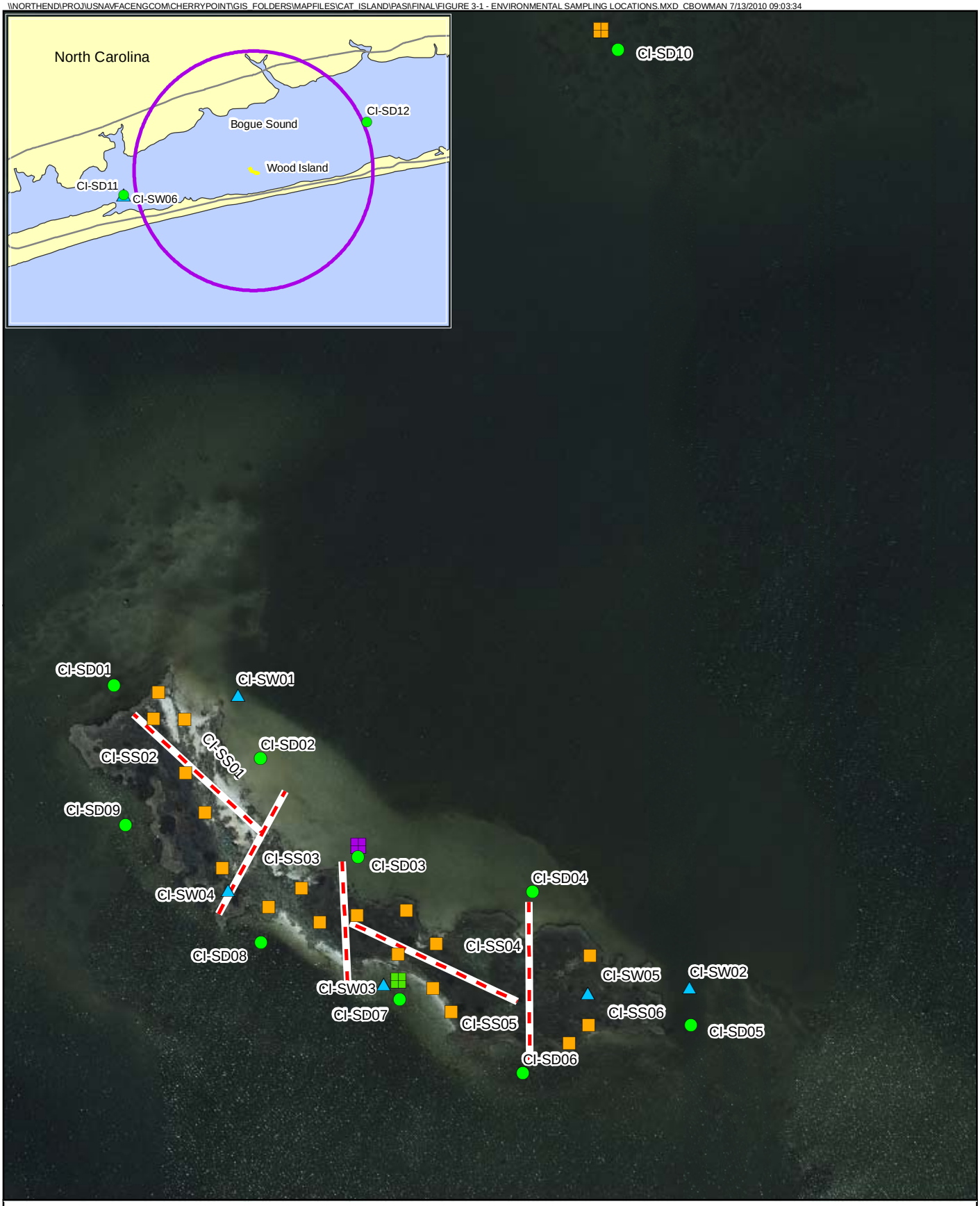
The validation process focuses on the usability of the data to support the project decision-making process.

Sample results may include a qualifying flag, such as:

> **U—Undetected.** Samples were analyzed for this analyte, but it was not detected above the method detection limit (MDL) or instrument detection limit.
>
> **UJ—Detection limit estimated.** Samples were analyzed for this analyte, but the results were qualified as not detected. The results are estimated.
>
> **J—Estimated.** The analyte was present, but the reported value may not be accurate or precise.

3.5 Investigation-derived Waste Management

Investigation-derived waste (IDW) generated during the investigation was managed in accordance with the Work Plan (CH2M HILL, 2008). IDW consisted of sediment cuttings from the vibracore borings. Sediment cuttings generated during sampling were containerized in a labeled, Department of Transportation (DOT)-approved 55-gallon drum. CH2M HILL collected representative samples of the IDW in order to determine disposal requirements and the method of transport to the proper disposal facility. The IDW was removed from MCAS Cherry Point by Capitol Environmental and disposed of at the Environmental Quality Florida facility within 90 days of generation, based on the results of the Toxicity Characteristic Leaching Procedure (TCLP) analysis. IDW analytical results are presented in **Appendix D**. Personal protective equipment (PPE) and other trash generated during field activities were placed in heavy plastic garbage bags, tied securely, and disposed of as municipal trash.



Legend

- Sediment Sample Location
- Surface Water Sample Location
- Surface Soil Composite Increment Location
- Surface Soil Composite Sample Boundary
- May 1945 Target
- June 1945 Target
- 1949 Target
- 1949 SDZ - 3 miles

N
W E
S

0 150 300 Feet

Figure 3-1
Environmental Sampling Locations
Former Cat Island Bomb Target BT-2
and Surface Danger Zone
MCAS Cherry Point
North Carolina

CH2MHILL

Generated by: *Jeremy Diner* Checked by: *Renee Clore*

SECTION 4

Investigation Results

4.1 Environmental Investigation

A discussion of the surface soil, sediment, and surface water analytical results is presented below. Analytical services were provided by Empirical Laboratories in Nashville, Tennessee, a North Carolina-certified, Navy-approved laboratory. Raw analytical data are presented in **Appendix D**.

4.1.1 Surface Soil Analytical Results

Surface soil analytical data were screened against the North Carolina Hazardous Waste Site Soil Screening Levels (NC HWS SSLs) (NCDENR, 2010) and the United States Environmental Protection Agency (USEPA) Adjusted Residential Soil Regional Screening Level (RSLs) (USEPA, 2010). The NC HWS SSLs represent soil concentration thresholds deemed to be protective of groundwater based on a conservative analytical model of leaching from overlying soil into underlying groundwater. The USEPA RSLs represent screening levels for potential human health risk from direct exposure to soil. Detected analytes exceeding these regulatory screening criteria are presented in **Table 4-1** and on **Figure 4-1**. A summary of the surface soil analytical results is provided below.

- Neither explosives residues nor perchlorate were detected in any of the surface soil samples.
- Arsenic was detected at four of the six surface soil sample locations at concentrations ranging from 1 J milligrams per kilogram [mg/kg] to 3.1 mg/kg, which exceeded the adjusted residential soil RSL (0.39 mg/kg) but did not exceed the NC HWS SSL (5.8 mg/kg).
- Chromium was detected at all of the six surface soil sample locations at concentrations ranging from 0.78 J mg/kg to 12.6 mg/kg, which exceeded the adjusted residential soil RSL (0.29 mg/kg). There is no NC HWS SSL for chromium.
- Iron was detected at all surface soil sample locations at concentrations ranging from 247 mg/kg to 5,850 mg/kg, which exceeded the NC HWS SSL (150 mg/kg). Only one sample CI-SS06-0309 exceeded the adjusted residential soil RSL (5,500 mg/kg).

As MCAS Cherry Point and Marine Corps Base (MCB) Camp Lejeune are located within a 14-mile radius of BT-2 with surface soils belonging to the same geologic formation as those at BT-2, it is reasonable to use MCAS Cherry Point and MCB Camp Lejeune background concentrations for comparison purposes since no local BT-2 background data are available. Two times the average background concentration for inorganic constituents is often used for an initial screening to determine if site concentrations of naturally-occurring constituents (such as arsenic, chromium, and iron) are indicative of a contaminant release or represent natural conditions. At MCAS Cherry Point, for example, two times the average background concentrations of arsenic, chromium, and iron in soil are 3.9, 16.96 and 5,958.76 mg/kg,

respectively. All of the detected concentrations of arsenic, chromium and iron in soil at Wood Island are less than the two times average background concentration for each constituent in the MCAS Cherry Point background data set. Similarly, the arsenic, chromium, and iron concentrations are also generally consistent with the background data set for soil at MCB Camp Lejeune (Baker Environmental, 2001), which is also located in the Coastal Plain of North Carolina. BT-2 metals concentrations are consistent with surface soil background concentrations observed at both MCAS Cherry Point and MCB Camp Lejeune. The arsenic, chromium, and iron results in Wood Island surface soil from the BT-2 SI do not provide significant evidence of a contaminant release of these constituents and likely represent natural background conditions.

4.1.2 Sediment Analytical Results

Sediment analytical data were screened against the USEPA Adjusted Residential Soil RSLs (USEPA, 2009a). Analytes exceeding regulatory screening criteria are presented in **Table 4-2** and on **Figure 4-2**. A summary of the sediment analytical results is provided below.

- Explosives residues were not detected in sediment.
- Perchlorate was detected at three of the twelve sediment sample locations at concentrations ranging from 0.48 J micrograms per kilogram [µg/kg] to 1.8 J µg/kg. No samples exceeded the adjusted residential soil RSL (5,500 µg/kg). No perchlorate was detected in the background samples.
- Arsenic was detected at seven of the twelve sediment sample locations, two of which were background sample locations CI-SD11 and CI-SD12. Arsenic concentrations within the SDZ ranged from 0.92 J mg/kg to 1.7 J mg/kg; the background samples ranged from 1.7 J mg/kg to 3.2 J mg/kg. Arsenic exceeded the adjusted residential soil RSL (0.39 mg/kg) at each of these locations. The two highest detections of arsenic were observed in the background samples.
- Chromium was detected at all of the twelve sediment sample locations, two of which were background sample locations CI-SD11 and CI-SD12. Chromium concentrations within the SDZ ranged from 1.9 J mg/kg to 10 mg/kg; the background samples ranged from 5.3 mg/kg to 12.2 J mg/kg. Chromium exceeded the adjusted residential soil RSL (0.29 mg/kg) at each of these locations. The highest detection of chromium was observed in a background sample.

Based on the comparison of detected arsenic and chromium concentrations in the site samples to the background samples, the results indicate that the detected arsenic and chromium concentrations in sediment are consistent with natural background conditions and are not indicative of a contaminant release.

4.1.3 Surface Water

Surface water analytical data were screened against North Carolina Tidal 2B (NC 2B) standards (NCDENR, 2007) and the National Recommended Water Quality Criteria (NRWQC) (USEPA, 2009a). Detected analytes exceeding regulatory screening criteria are presented in **Table 4-3** and on **Figure 4-3**. A summary of the surface water analytical results is provided below.

- One or more explosives residues (1,3,5-trinitrobenzene, 2,6-dinitrotoluene, 2-nitrotoluene, 4-nitrotoluene, and RDX) were detected at three of the five surface water sampling locations within the SDZ at concentrations ranging from 0.062 J micrograms per liter (µg/L) to 2.3 µg/L. 2,6-Dinitrotoluene is the only explosive residue detected in the background sampling location CI-SW06 at a concentration of 0.073 J µg/L. There are no regulatory screening criteria for these analytes.
- Perchlorate was not detected in surface water.
- Total arsenic was detected twice (once in the parent sample and once in a duplicate sample) in one of five sample locations within the SDZ at concentrations ranging from 3.5 J µg/L to 5.5 J µg/L. Detected arsenic concentrations exceeded the NRWQC standard (0.14 µg/L) but did not exceed the NC 2B standard (50 µg/L). Total arsenic was not detected in the background sample.
- Dissolved arsenic was detected twice (once in the parent sample and once in a duplicate sample) in one of five sample locations within the SDZ at concentrations ranging from 3.4 J µg/L to 9.8 J µg/L. Detected arsenic concentrations exceeded the NRWQC standard (0.14 µg/L) but did not exceed the NC 2B standard (50 µg/L). Dissolved arsenic was not detected in the background sample.
- Total cadmium was detected at all sample locations at concentrations ranging from 2.1 J µg/L to 10.6 J µg/L. Total cadmium exceeded the NC 2B standard (5 µg/L) in one of five samples within the SDZ at a concentration of 10.6 J µg/L. Total cadmium did not exceed screening criteria in the background sample.
- Total silver was detected at four of five sample locations within the SDZ at concentrations ranging from 1.1 J µg/L to 1.6 J µg/L. Total silver was detected in the background sample at a concentration of 1.7 J µg/L. Total silver concentrations exceeded the NC 2B standard (0.1 µg/L) in all samples where it was detected.
- Dissolved silver was detected at all sample locations within the SDZ at concentrations ranging from 1.1 J µg/L to 1.5 J µg/L. Dissolved silver was detected in the background sample at a concentration of 1.3 J µg/L. Dissolved silver concentrations exceeded the NC 2B standard (0.1 µg/L) in all samples where it was detected.

In similar fashion as the sediment results, the surface water results for metals do not provide significant evidence that releases of these constituents have occurred. With the exception of arsenic, the surface water sampling results are consistent with the background concentrations. While arsenic was not detected in the single background sample, arsenic was detected at relatively low concentrations of 5.5 J µg/L and 3.5 J µg/L (duplicate sample) at one sample location.

4.2 Geophysical Survey

A threshold level of 0.331 nanoteslas per meter (nT/m) was established to identify target anomalies representative of potential MEC items in BT-2. A total of 10,400 magnetic anomalies greater than the cutoff level were detected during the 6,600-acre ADGM (**Figure 4-4**). Anomalies were generally sporadically and evenly distributed throughout the survey area, with the notable exception of the area immediately surrounding Wood Island. A

radius of approximately 650 feet around Wood Island contained the largest concentration of high-amplitude magnetic anomalies (F**igure 4-5**). The density of anomalies in this area did not allow discrimination of individual targets but rather indicated a mass of closely-spaced metallic objects.

No other large clusters of anomalies appear in the data, but several small clusters and patterns of anomalies are visible in the ADGM data. One such concentration of anomalies occurs approximately 2,500 feet southwest of Wood Island. Two additional clusters of anomalies can be seen in the southeastern portion of the ADGM survey area, approximately 2.5 miles east of the former BT-2 target area. The first anomaly cluster is located directly off the northern shore of Bogue Banks in the vicinity of docks and piers that extend into Bogue Sound from Bogue Banks. The second anomaly cluster is located approximately 3,000 feet north of Bogue Banks and corresponds with the location of Dog Island. These clusters of low-amplitude anomalies do not resemble typical munitions target patterns seen at other sites. Several linear chains of anomalies can be seen across the survey area, which do not appear to be patterns typical of bombing activities. Bogue Sound is known to contain crab pots, which are deployed in regular, linear arrays that would cause anomaly patterns similar to those seen in the data.

The geophysical survey results do not differentiate between munitions items and other metallic debris; however, the high concentration of anomalies observed around Wood Island is consistent with typically observed munitions target patterns. According to the ADGM survey results, the density of metallic objects decreases with increased distance from Wood Island.

The ADGM report, including all information regarding survey procedures, data processing, QC, figures, and data interpretation, is provided in **Appendix B.**

TABLE 4-1
Surface Soil Analytical Results
Former Cat Island Bomb Target BT-2 and Surface Danger Zone
MCAS Cherry Point, North Carolina

Station ID	**CLEAN NC HWS SSL (January 2010)**	**Adjusted Residential Soil RSLs**	CI-SS01	CI-SS02	CI-SS03		CI-SS04	CI-SS05	CI-SS06
Sample ID			CI-SS01-0309	CI-SS02-0309	CI-SS03-0309	CI-SS03-D-0309	CI-SS04-0309	CI-SS05-0309	CI-SS06-0309
Sample Date			03/03/09	03/03/09	03/03/09	03/03/09	03/03/09	03/03/09	03/03/09
Chemical Name									
Explosives (µg/kg)									
No Detections									
Total Metals (mg/kg)									
Aluminum	--	7,700	**425**	**3,670**	**1,150**	**1,080**	**4,320**	**186**	**4,060**
Arsenic	5.8	0.39	2.2 U	**3**	**1 J**	**1.3 J**	**3.1 J**	2.3 U	**3.1**
Barium	580	1,500	**1.6 J**	**6.3 J**	**6.5 J**	**5.6 J**	**6.9 J**	9 U	**6.6 J**
Cadmium	3	7	1.1 U	1.4 U	**0.24 J**	1.3 U	1.6 U	1.1 U	1.3 U
Calcium	--	--	**278 J**	**1,040 J**	**16,500**	**14,400**	**811 J**	1,130 U	**620 J**
Chromium	--	0.29	**2.7**	**11.3**	**3.2**	**3.4**	**12.6**	**0.78 J**	**11.1**
Copper	700	310	2.2 U	**3.2**	**7.6**	**5.4**	**3.1 J**	2.3 U	**3.2**
Iron	150	5,500	**1,020**	**3,970**	**1,510**	**1,440**	**4,940**	**247**	**5,850**
Lead	270	400	**1.4**	**9**	**5.5**	**5**	**16.4**	**2.5**	**5.5**
Magnesium	--	--	**272 J**	**1,540**	**1,090 J**	**958 J**	**1,810**	1,130 U	**1,890**
Manganese	65	180	**2 J**	**19.2**	**22.6**	**21.3**	**24.4**	**2 J**	**20.8**
Mercury	1	2.3	0.037 U	0.053 U	**0.026 J**	0.041 U	0.055 U	0.036 U	0.042 U
Nickel	130	150	2.2 U	**2.9**	**0.88 J**	**0.84 J**	**3.2**	2.3 U	**3**
Potassium	--	--	1,100 U	**720 J**	**245 J**	1,280 U	**901**	1,130 U	**849 J**
Selenium	2.1	39	1.1 U	1.4 U	**1.3**	**1.3**	**1.1**	1.1 U	**0.99 J**
Sodium	--	--	**967 J**	**2,220**	**1,600**	**1,410**	**3,230**	**636 J**	**4,280**
Vanadium	--	39	**1.2 J**	**11.9**	**4.4**	**3.7 J**	**14.1**	3.4 U	**13**
Zinc	1,200	2,300	**2.2 J**	**14.7**	**61.7**	**55.2**	**15**	4.5 U	**13.8**

Notes:

Red text indicates exceedance of NC HWS SSL

Blue text indicates exceedance of Residential RSL

Green text indicates of both NC SSL and Residential RSL

Bold indicates detections

J - Analyte present, value may or may not be accurate or precise

U - The material was analyzed for, but not detected

mg/kg - Milligrams per kilogram

µg/kg - Micrograms per kilogram

NC HWS SSL - North Carolina Hazardous Waste Site Soil Screening Levels

RSL - Regional Screening Level

TABLE 4-2
Sediment Analytical Results
Former Cat Island Bomb Target BT-2 and Surface Danger Zone
MCAS Cherry Point, North Carolina

Station ID	**Adjusted Residential Soil RSLs**	CI-SD01	CI-SD02	CI-SD03		CI-SD04	CI-SD05		CI-SD06	CI-SD07	CI-SD08	CI-SD09	CI-SD10	CI-SD11	CI-SD12
Sample ID		CI-SD01-0509	CI-SD02-0509	CI-SD03-0509	CI-SD03-P-0509	CI-SD04-0509	CI-SD05-0509	CI-SD05-P-0509	CI-SD06-0509	CI-SD07-0509	CI-SD08-0509	CI-SD09-0509	CI-SD10-0509	CI-SD11-0509	CI-SD12-0509
Sample Depth		0-1 feet	0-1 feet	0-1 feet	0-1 feet	0-1 feet	0-1 feet	0-1 feet	0-1 feet	0-1 feet	0-1 feet	0-1 feet	0-1 feet	0-1 feet	0-1 feet
Sample Date		05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09
Chemical Name															
Explosives (µg/kg)															
Perchlorate	5,500	2.7 U	**0.48 J**	2.6 U	2.4 U	2.5 U	2.8 U	2.7 U	2.5 U	3.6 U	**1.8 J**	**0.74 J**	2.6 U	2.7 U	2.5 U
Total Metals (mg/kg)															
Aluminum	7,700	**1,030 J**	**484 J**	**490 J**	**741 J**	**649 J**	**2,690 J**	**1,720 J**	**747 J**	**688 J**	**986 J**	**620 J**	**1,410 J**	**3,650 J**	**1,100 J**
Arsenic	0.39	**1.2 J**	2.4 U	2.3 U	2.5 U	2.3 U	**1.4 J**	**0.97 J**	**0.92 J**	2.4 U	**1.1 J**	2.5 U	**1.7 J**	**3.2**	**1.7 J**
Barium	1,500	**2 J**	9.4 U	9.1 U	**1.5 J**	**1.4 J**	**4.4 J**	**3 J**	**1.6 J**	**1.6 J**	**1.9 J**	**1.4 J**	**2.6 J**	**5.7 J**	**2.5 J**
Calcium	--	**448 J**	**290 J**	**524 J**	**460 J**	**494 J**	**1,360**	**678 J**	**835 J**	**488 J**	**624 J**	**474 J**	**1,080 J**	**10,800**	**842 J**
Chromium	0.29	**4.3**	**1.9 J**	**2.6**	**3**	**3.4**	**10**	**7**	**4**	**3.9**	**4.1**	**3.2**	**6**	**12.2**	**5.3**
Copper	310	2.6 U	2.4 U	2.3 U	2.5 U	2.3 U	2.4 U	2.5 U	2.6 U	2.4 U	2.4 U	2.5 U	2.5 U	**1.9 J**	2.3 U
Iron	5,500	**1,270 J**	**734 J**	**734 J**	**1,130 J**	**917 J**	**2,540 J**	**1,780 J**	**1,370 J**	**1,020 J**	**1,300 J**	**761 J**	**2,160 J**	**5,180 J**	**1,900 J**
Lead	400	**1.7**	**2.8**	**1.1**	**1.6**	**0.78**	**2.2**	**1.8**	**1.4**	**3.8**	**1.8**	**1.7**	**1.5**	**4.2**	**1.4**
Magnesium	--	**726 J**	**468 J**	**499 J**	**616 J**	**558 J**	**1,170 J**	**903 J**	**495 J**	**683 J**	**777 J**	**498 J**	**1,160 J**	**2,040**	**1,110 J**
Manganese	180	**6.4**	**3.5 J**	**3.3 J**	**5.5**	**4**	**13.4**	**9**	**6.2**	**3.9**	**7.2**	**3.9**	**11.8**	**27.2**	**10.1**
Nickel	150	**0.92 J**	2.4 U	2.3 U	2.5 U	**0.73 J**	**1.9 J**	**1.4 J**	**0.82 J**	**0.79 J**	**0.96 J**	2.5 U	**1.4 J**	**2.9**	**1.1 J**
Vanadium	39	**4.4**	**2.5 J**	**2 J**	**2.4 J**	**2.9 J**	**7.9**	**5.8**	**2.7 J**	**3.1 J**	**4**	**2.3 J**	**5.9**	**10.9**	**4.6**
Zinc	2,300	5.2 U	4.7 U	4.6 U	4.9 U	4.6 U	**8.9**	5 U	5.3 U	4.9 U	4.9 U	5 U	5.5 U	**13**	4.8 U

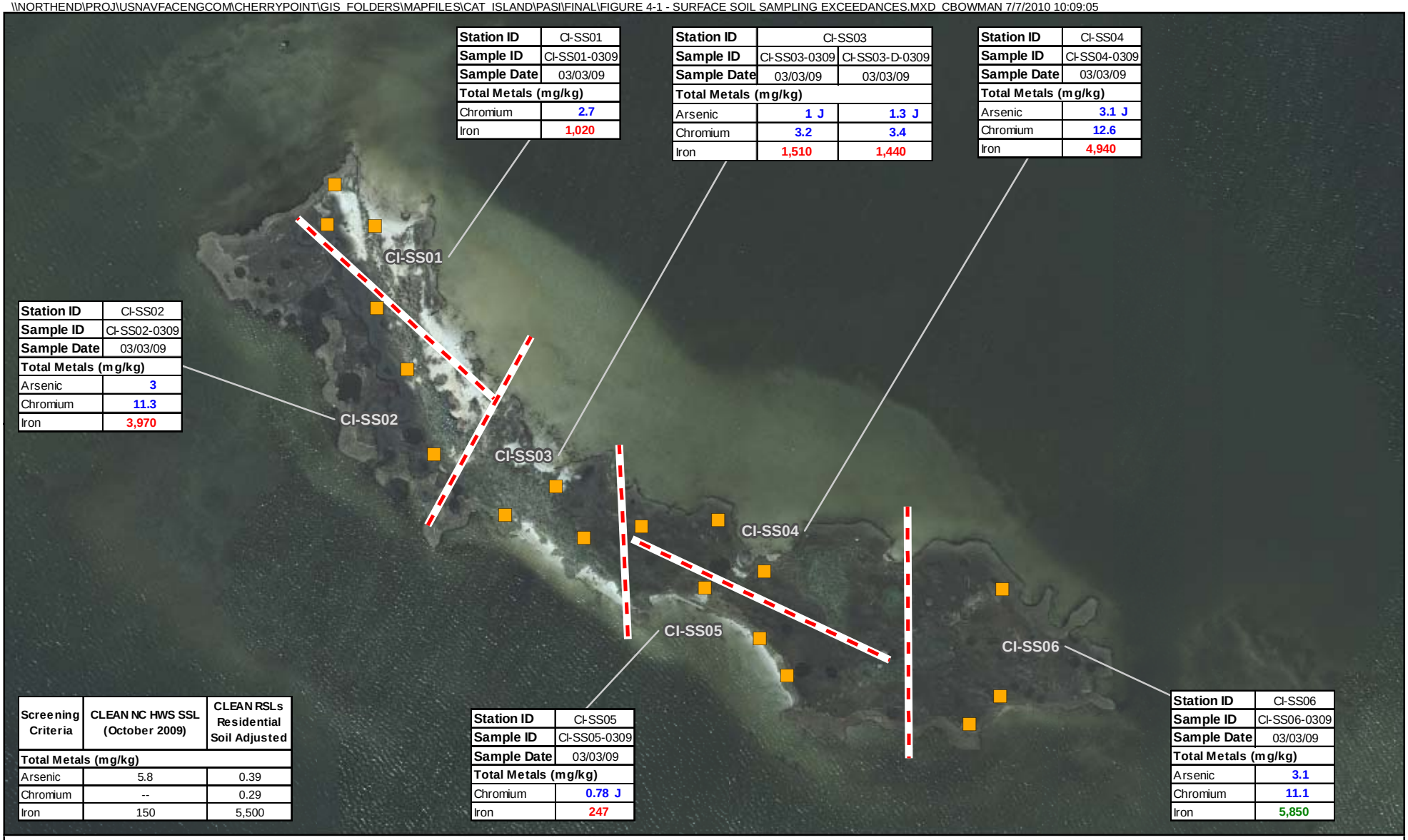
Notes:
Blue text indicates exceedance of Adjusted Residential Soil RSL
Bold indicates detections
NA - Not analyzed
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
mg/kg - Milligrams per kilogram
µg/kg - Micrograms per kilogram
RSL - Regional Screening Level

TABLE 4-3
Surface Water Sampling Results
Former Cat Island Bomb Target BT-2 and Surface Danger Zone
MCAS Cherry Point, North Carolina

Station ID	**NC2B Tidal Waters**	**NRWQC - Human Health - Organism**	CI-SW01	CI-SW02		CI-SW03	CI-SW04	CI-SW05		CI-SW06
Sample ID			CI-SW01-0509	CI-SW02-0509	CI-SW02-P-0509	CI-SW03-0509	CI-SW04-0309	CI-SW05-0309	CI-SW05-D-0309	CI-SW06-0509
Sample Date			05/28/09	05/28/09	05/28/09	05/28/09	03/03/09	03/04/09	03/04/09	05/28/09
Chemical Name										
Explosives (µg/L)										
1,3,5-Trinitrobenzene	--	--	0.2 U	**0.062 J**	**0.078 J**	0.18 U	0.2 U	0.2 U	0.2 U	0.18 U
2,6-Dinitrotoluene	--	--	0.2 U	0.19 U	0.2 U	0.18 U	0.2 U	**0.12 J**	0.2 U	**0.073 J**
2-Nitrotoluene	--	--	0.2 U	**0.073 J**	0.2 U	0.18 U	0.2 U	0.2 U	0.2 U	0.18 U
4-Nitrotoluene	--	--	0.2 U	**0.19 J**	**0.2 J**	0.18 U	0.2 U	0.2 U	0.2 U	0.18 U
RDX	--	--	0.2 U	**0.076 J**	0.2 U	0.18 U	**2.3**	0.2 U	0.2 U	0.18 U
Total Metals (µg/L)										
Aluminum	--	--	**332 J**	**394 J**	**436 J**	**608 J**	200 U	200 U	**1,040**	**669 J**
Arsenic	50	0.14	10 U	10 U	10 U	10 U	50 U	**5.5 J**	**3.5 J**	10 U
Barium	--	--	**14.4 J**	**14.8 J**	**14.3 J**	**15.2 J**	**14 J**	**16.8 J**	**19.5 J**	**15.3 J**
Cadmium	5	--	**2.2 J**	**2.1 J**	**2.3 J**	**2.4 J**	**10.6 J**	**2.4 J**	**2.6 J**	**2.4 J**
Calcium	--	--	**399,000**	**397,000**	**385,000**	**409,000**	**358,000**	**358,000**	**347,000**	**406,000**
Iron	--	--	**230 J**	**290 J**	**302 J**	**500 J**	**60.6 J**	**141 J**	**1,500 J**	**491 J**
Magnesium	--	--	**1,150,000**	**1,130,000**	**1,110,000**	**1,150,000**	**1,190,000**	**1,050,000**	**1,020,000**	**1,160,000**
Manganese	--	100	75 U	75 U	75 U	**17.7 J**	**7.2 J**	**16.9**	**23.6**	75 U
Nickel	8.3	4,600	**5.2 J**	**5.5 J**	**5.2 J**	**4.9 J**	10 U	10 U	10 U	**4.7 J**
Potassium	--	--	NA	NA	NA	NA	**463,000**	**420,000**	**403,000**	NA
Selenium	71	4,200	**3.3 J**	**3.4 J**	**5.8 J**	**6.5 J**	**17.5 J**	**5.3**	**8.4**	**4.4 J**
Silver	0.1	--	**1.5 J**	**1.3 J**	**1.1 J**	**1.6 J**	50 U	**1.2 J**	**1.2 J**	**1.7 J**
Sodium	--	--	**9,490,000**	**9,440,000**	**9,110,000**	**9,780,000**	**10,400,000**	**8,590,000**	**8,120,000**	**9,760,000**
Vanadium	--	--	15 U	**5.3 J**	**5.3 J**	**5.7 J**	15 U	15 U	**5.6 J**	**5.4 J**
Dissolved Metals (µg/L)										
Aluminum, Dissolved	--	--	200 U	200 U	200 U	200 U	**511 J**	**391 J**	**415 J**	200 U
Arsenic, Dissolved	50	0.14	10 U	10 U	10 U	10 U	10 U	**9.8 J**	**3.4 J**	10 U
Barium, Dissolved	--	--	**14.2 J**	**13.8 J**	**13.9 J**	**13.8 J**	**13.6 J**	**15.5 J**	**15.1 J**	**14 J**
Cadmium, Dissolved	5	--	**2.5 J**	**2.5 J**	**2.4 J**	**2.1 J**	**2.3 J**	**2.3 J**	**2.6 J**	**2.4 J**
Calcium, Dissolved	--	--	**393,000**	**387,000**	**392,000**	**392,000**	**376,000**	**362,000**	**348,000**	**402,000**
Lead, Dissolved	--	--	15 U	15 U	15 U	15 U	15 U	15 U	**13.5 J**	15 U
Magnesium, Dissolved	--	--	**1,310,000**	**1,310,000**	**1,300,000**	**1,310,000**	**1,250,000**	**1,060,000**	**1,020,000**	**1,310,000**
Manganese, Dissolved	--	100	75 U	75 U	75 U	75 U	**6.7 J**	**15.7**	**15.8**	75 U
Potassium, Dissolved	--	--	**443,000**	**442,000**	**438,000**	**445,000**	**470,000**	**419,000**	**408,000**	**445,000**
Selenium, Dissolved	71	4,200	**6.4 J**	**4.7 J**	**5 J**	5 U	5 U	5 U	**5.3 J**	**5.1 J**
Silver, Dissolved	0.1	--	**1.1 J**	**1.2 J**	**1.3 J**	**1.4 J**	**1.4 J**	**1.5 J**	**1.1 J**	**1.3 J**
Sodium, Dissolved	--	--	**10,100,000**	**9,890,000**	**10,100,000**	**10,300,000**	**10,800,000**	**8,570,000**	**8,280,000**	**10,300,000**
Zinc, Dissolved	86	--	100 U	100 U	100 U	**29.6 J**	20 U	20 U	20 U	100 U

Notes:
Red text indicates exceedance of NRWQC
Blue text indicates exceedance of NC 2B standard
Bold indicates detections
NA - Not analyzed
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
UJ - Analyte not detected, quantitation limit may be inaccurate
µg/L - Micrograms per liter
NC2B - North Carolina Administrative Code 15A 2B Tidal Standard
NRWQC - National Recommended Water Quality Criteria
Generated by: Jeremy Diner
Checked by: Renee Clore

\\NORTHEND\PROJ\USNAVFACENGCOM\CHERRYPOINT\GIS_FOLDERS\MAPFILES\CAT_ISLAND\PASI\FINAL\FIGURE 4-1 - SURFACE SOIL SAMPLING EXCEEDANCES.MXD CBOWMAN 7/7/2010 10:09:05



Station ID	CI-SS01
Sample ID	CI-SS01-0309
Sample Date	03/03/09
Total Metals (mg/kg)	
Chromium	**2.7**
Iron	**1,020**

Station ID	CI-SS03	
Sample ID	CI-SS03-0309	CI-SS03-D-0309
Sample Date	03/03/09	03/03/09
Total Metals (mg/kg)		
Arsenic	**1 J**	**1.3 J**
Chromium	**3.2**	**3.4**
Iron	**1,510**	**1,440**

Station ID	CI-SS04
Sample ID	CI-SS04-0309
Sample Date	03/03/09
Total Metals (mg/kg)	
Arsenic	**3.1 J**
Chromium	**12.6**
Iron	**4,940**

Station ID	CI-SS02
Sample ID	CI-SS02-0309
Sample Date	03/03/09
Total Metals (mg/kg)	
Arsenic	**3**
Chromium	**11.3**
Iron	**3,970**

Screening Criteria	CLEAN NC HWS SSL (October 2009)	CLEAN RSLs Residential Soil Adjusted
Total Metals (mg/kg)		
Arsenic	5.8	0.39
Chromium	--	0.29
Iron	150	5,500

Station ID	CI-SS05
Sample ID	CI-SS05-0309
Sample Date	03/03/09
Total Metals (mg/kg)	
Chromium	**0.78 J**
Iron	**247**

Station ID	CI-SS06
Sample ID	CI-SS06-0309
Sample Date	03/03/09
Total Metals (mg/kg)	
Arsenic	**3.1**
Chromium	**11.1**
Iron	**5,850**

Legend

- Surface Soil Composite Increment Location
- Surface Soil Composite Sample Boundary

N
W E
S

0 100 200 Feet

Notes:
Red text indicates exceedance of NC HWS SSL
Blue text indicates exceedance of Residential RSL
Green text indicates exceedance of both the NC SSL and Residential RSL
Bold indicates detections
J - Analyte present, value may or may not be accurate or precise
mg/kg - Milligrams per kilogram
RSL - Regional Screening Level
NC HWS SSL - North Carolina Hazardous Waste Site Soil Screening Levels

Figure 4-1
Surface Soil Exceedances
Former Cat Island Bomb Target BT-2
and Surface Danger Zone
MCAS Cherry Point
North Carolina

CH2MHILL

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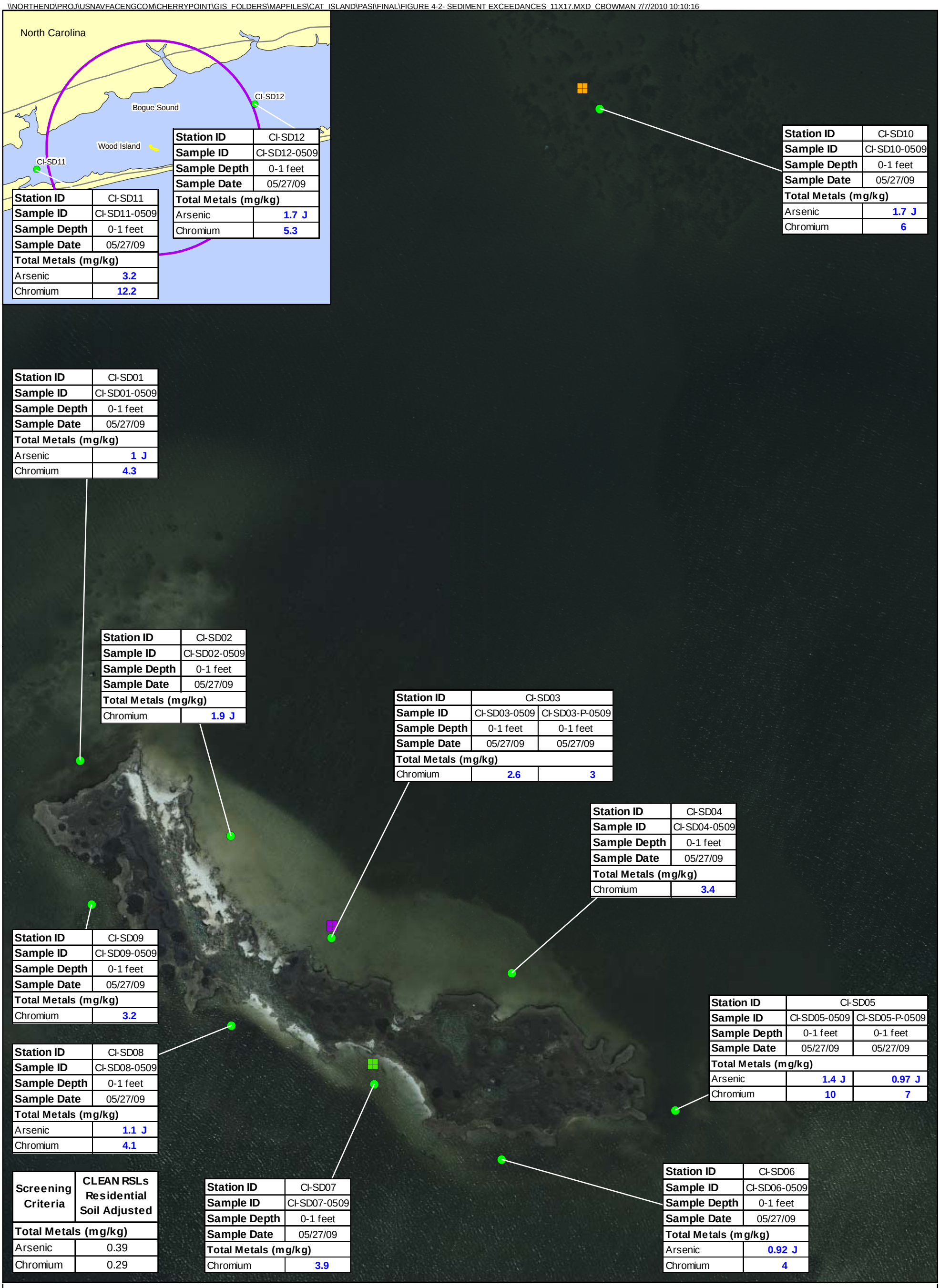

Station ID	CI-SD12
Sample ID	CI-SD12-0509
Sample Depth	0-1 feet
Sample Date	05/27/09
Total Metals (mg/kg)	
Arsenic	**1.7 J**
Chromium	**5.3**

Station ID	CI-SD11
Sample ID	CI-SD11-0509
Sample Depth	0-1 feet
Sample Date	05/27/09
Total Metals (mg/kg)	
Arsenic	**3.2**
Chromium	**12.2**

Station ID	CI-SD10
Sample ID	CI-SD10-0509
Sample Depth	0-1 feet
Sample Date	05/27/09
Total Metals (mg/kg)	
Arsenic	**1.7 J**
Chromium	**6**

Station ID	CI-SD01
Sample ID	CI-SD01-0509
Sample Depth	0-1 feet
Sample Date	05/27/09
Total Metals (mg/kg)	
Arsenic	**1 J**
Chromium	**4.3**

Station ID	CI-SD02
Sample ID	CI-SD02-0509
Sample Depth	0-1 feet
Sample Date	05/27/09
Total Metals (mg/kg)	
Chromium	**1.9 J**

Station ID	CI-SD03	
Sample ID	CI-SD03-0509	CI-SD03-P-0509
Sample Depth	0-1 feet	0-1 feet
Sample Date	05/27/09	05/27/09
Total Metals (mg/kg)		
Chromium	**2.6**	**3**

Station ID	CI-SD04
Sample ID	CI-SD04-0509
Sample Depth	0-1 feet
Sample Date	05/27/09
Total Metals (mg/kg)	
Chromium	**3.4**

Station ID	CI-SD09
Sample ID	CI-SD09-0509
Sample Depth	0-1 feet
Sample Date	05/27/09
Total Metals (mg/kg)	
Chromium	**3.2**

Station ID	CI-SD05	
Sample ID	CI-SD05-0509	CI-SD05-P-0509
Sample Depth	0-1 feet	0-1 feet
Sample Date	05/27/09	05/27/09
Total Metals (mg/kg)		
Arsenic	**1.4 J**	**0.97 J**
Chromium	**10**	**7**

Station ID	CI-SD08
Sample ID	CI-SD08-0509
Sample Depth	0-1 feet
Sample Date	05/27/09
Total Metals (mg/kg)	
Arsenic	**1.1 J**
Chromium	**4.1**

Screening Criteria	CLEAN RSLs Residential Soil Adjusted
Total Metals (mg/kg)	
Arsenic	0.39
Chromium	0.29

Station ID	CI-SD07
Sample ID	CI-SD07-0509
Sample Depth	0-1 feet
Sample Date	05/27/09
Total Metals (mg/kg)	
Chromium	**3.9**

Station ID	CI-SD06
Sample ID	CI-SD06-0509
Sample Depth	0-1 feet
Sample Date	05/27/09
Total Metals (mg/kg)	
Arsenic	**0.92 J**
Chromium	**4**

Legend

- Sediment Sample Location
- May 1945 Target
- June 1945 Target
- 1949 Target

Notes:
Blue text indicates exceedance of Adjusted Residential Soil RSL
Bold indicates detections
J - Analyte present, value may or may not be accurate or precise
mg/kg - Milligrams per kilogram
RSL - Regional Screening Level

N
W E
S

0 50 100 200
Feet

Figure 4-2
Sediment Exceedances
Former Cat Island Bomb Target BT-2
and Surface Danger Zone
MCAS Cherry Point
North Carolina

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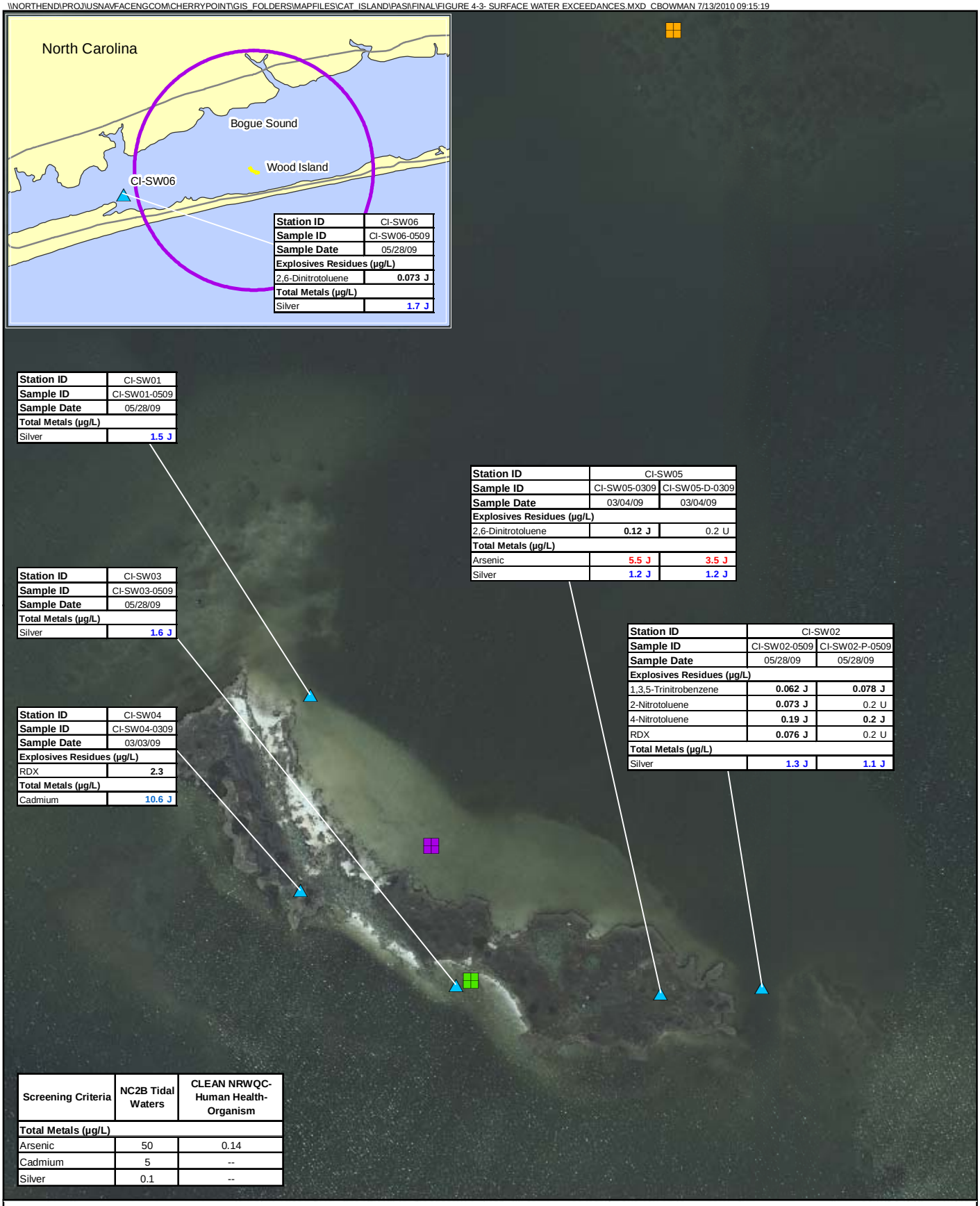

Station ID	CI-SW06
Sample ID	CI-SW06-0509
Sample Date	05/28/09
Explosives Residues (µg/L)	
2,6-Dinitrotoluene	**0.073 J**
Total Metals (µg/L)	
Silver	**1.7 J**

Station ID	CI-SW01
Sample ID	CI-SW01-0509
Sample Date	05/28/09
Total Metals (µg/L)	
Silver	**1.5 J**

Station ID	CI-SW05	
Sample ID	CI-SW05-0309	CI-SW05-D-0309
Sample Date	03/04/09	03/04/09
Explosives Residues (µg/L)		
2,6-Dinitrotoluene	**0.12 J**	0.2 U
Total Metals (µg/L)		
Arsenic	**5.5 J**	**3.5 J**
Silver	**1.2 J**	**1.2 J**

Station ID	CI-SW03
Sample ID	CI-SW03-0509
Sample Date	05/28/09
Total Metals (µg/L)	
Silver	**1.6 J**

Station ID	CI-SW02	
Sample ID	CI-SW02-0509	CI-SW02-P-0509
Sample Date	05/28/09	05/28/09
Explosives Residues (µg/L)		
1,3,5-Trinitrobenzene	**0.062 J**	**0.078 J**
2-Nitrotoluene	**0.073 J**	0.2 U
4-Nitrotoluene	**0.19 J**	**0.2 J**
RDX	**0.076 J**	0.2 U
Total Metals (µg/L)		
Silver	**1.3 J**	**1.1 J**

Station ID	CI-SW04
Sample ID	CI-SW04-0309
Sample Date	03/03/09
Explosives Residues (µg/L)	
RDX	**2.3**
Total Metals (µg/L)	
Cadmium	**10.6 J**

Screening Criteria	NC2B Tidal Waters	CLEAN NRWQC-Human Health-Organism
Total Metals (µg/L)		
Arsenic	50	0.14
Cadmium	5	--
Silver	0.1	--

Legend

- Surface Water Sample Location
- May 1945 Target
- June 1945 Target
- 1949 Target

N
W E
S

0 100 200 Feet

Notes:
Red text indicates exceedance of NRWQC
Blue text indicates exceedance of NC 2B standard
Bold indicates detections
J - Analyte present, value may or may not be accurate or precise
µg/L - Micrograms per liter
Dissolved metal exceedances are not shown
NRWQC - National Recommended Water Quality Criteria
NC2B - North Carolina Administrative Code 15A 2B Tidal Standard
No screening criteria were available for explosives residues

Figure 4-3
Surface Water Exceedances
Former Cat Island Bomb Target BT-2
and Surface Danger Zone
MCAS Cherry Point
North Carolina

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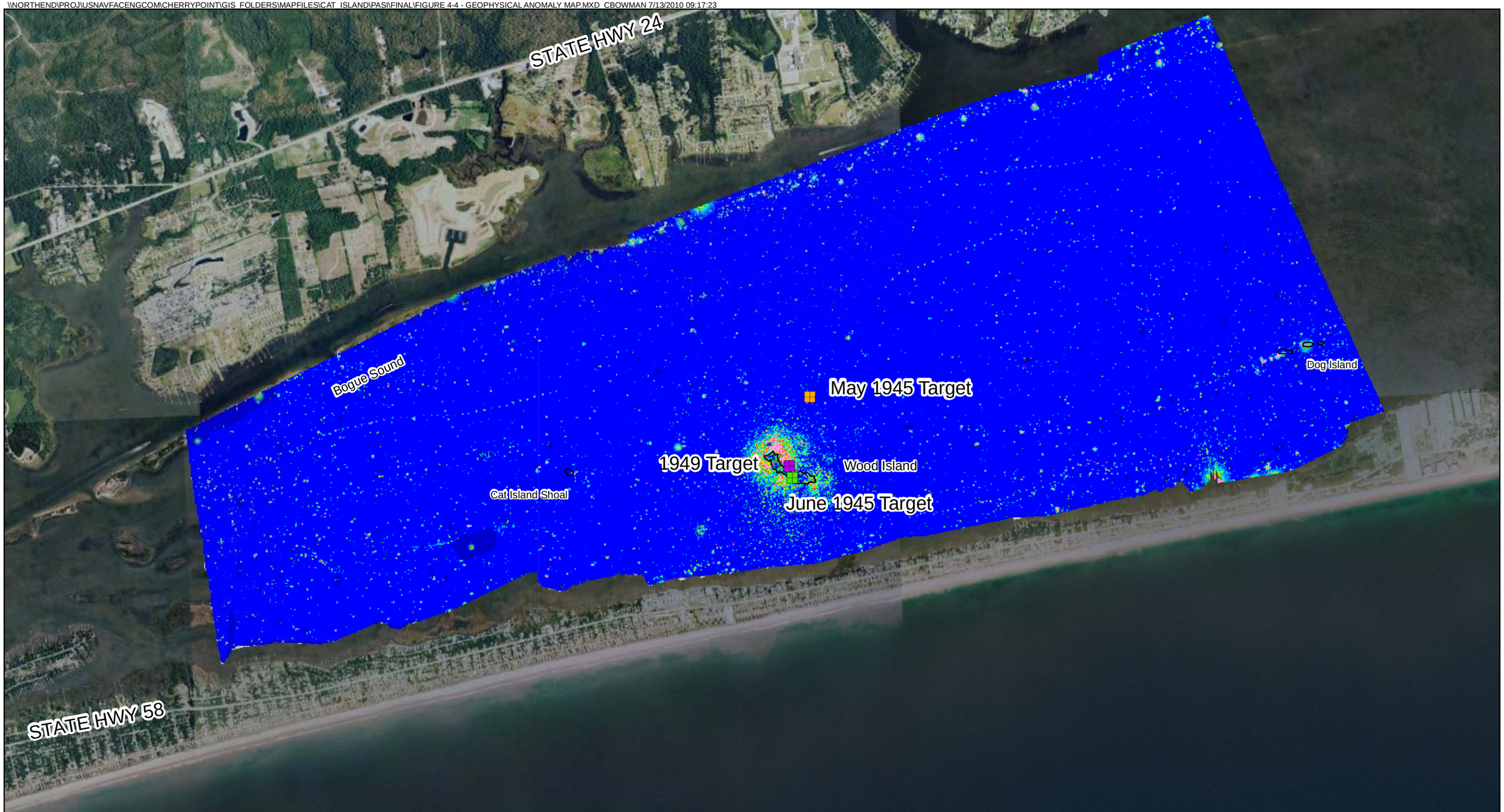

Legend

- May 1945 Target
- June 1945 Target
- 1949 Target
- Areas flown above 4 meters altitude
- Area covered by ADGM investigation

Anomaly Density

0.2 0.4 0.6 0.8 1.1 1.3 1.5 1.7 2.0 2.2 2.4 2.6 2.9 nT/m

nT/m = nanotesla per meter

N W E S

0 1,250 2,500 Feet

Figure 4-4
Geophysical Anomaly Map: BT-2
Former Cat Island Bomb Target BT-2
and Surface Danger Zone
MCAS Cherry Point
North Carolina

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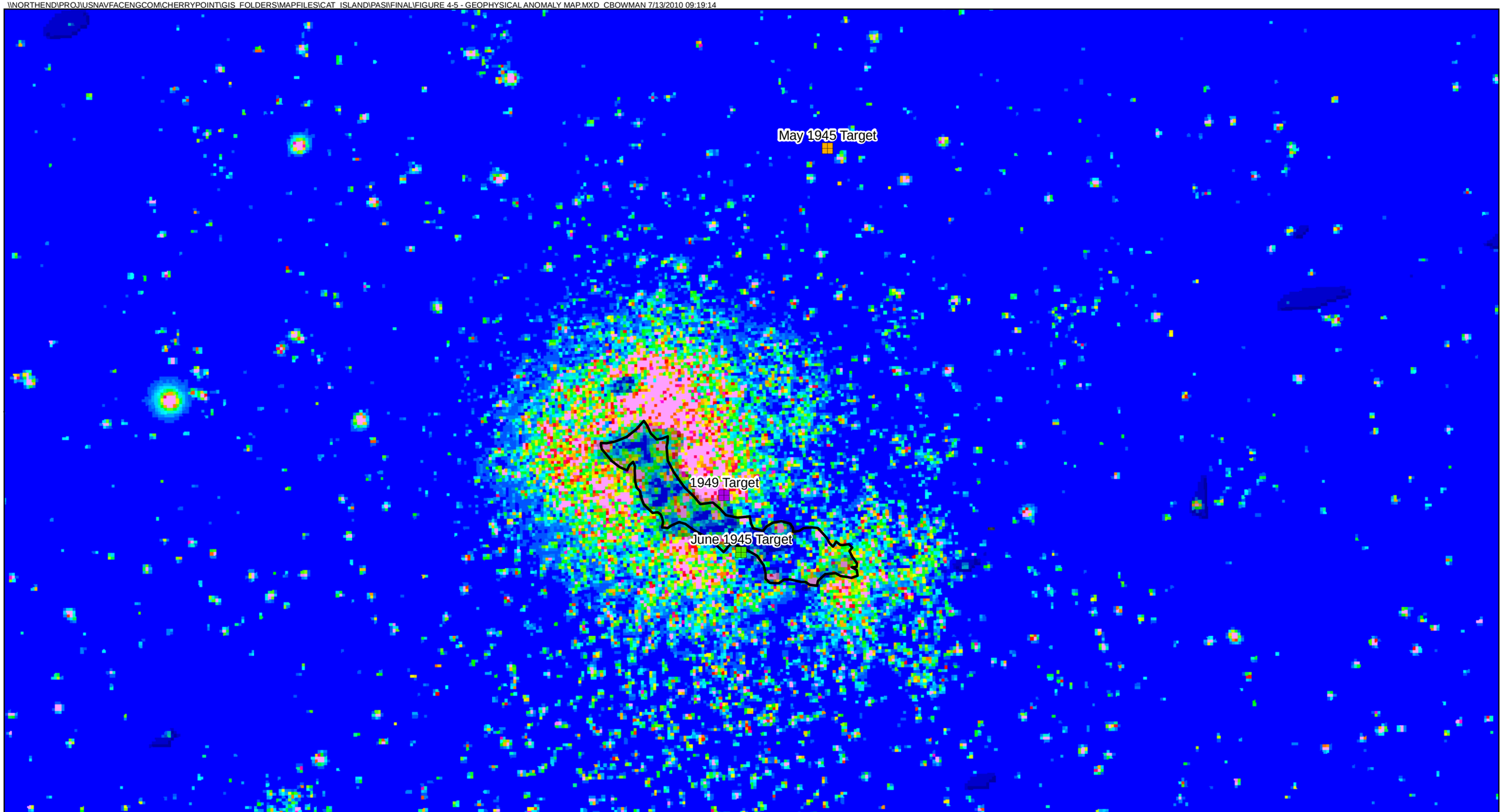

Legend

- May 1945 Target
- June 1945 Target
- 1949 Target
- Areas flown above 4 meters altitude
- Area covered by ADGM investigation

Anomaly Density

0.2 0.4 0.6 0.8 1.1 1.3 1.5 1.7 2.0 2.2 2.4 2.6 2.9 nT/m

nT/m = nanotesla per meter

N W E S

0 250 500 1,000 Feet

Figure 4-5
Geophysical Anomaly Map: Wood Island
Former Cat Island Bomb Target BT-2
and Surface Danger Zone
MCAS Cherry Point
North Carolina

CH2MHILL

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SECTION 5

Human Health Risk Assessment

The surface soil, sediment, and surface water analytical data collected at BT-2 during the SI were evaluated to determine the potential for human health risks associated with exposure to these media. A human health risk screening (HHRS) using appropriate human health risk-based screening values and site-specific background samples (for surface water and sediment) was performed. The HHRS also included the performance of a risk ratio evaluation.

The data evaluated during the HHRS are presented in **Appendix D** and were summarized in **Tables 4-1 through 4-3.** The samples evaluated in the HHRS are summarized in **Table 5-1**. The data included in the risk evaluation were all validated. The validated data were evaluated to determine the reliability of the data for use in the HHRS. A review of the data identified the following criteria for data usability:

Estimated values flagged with a J, J+, or J- qualifier were treated as detected concentrations.

For duplicate samples, the maximum concentration between the two samples was used as the sample concentration.

5.1 Human Health Conceptual Site Model

The human health conceptual site model (CSM) presents an overview of site conditions, potential contaminant migration pathways, and exposure pathways to potential receptors. The human health CSM for surface soil, surface water, and sediment is presented on **Figure 5-1**. Section 2 presents the site history and setting, which are summarized below.

MCAS Cherry Point historical records identified BT-2 as being located in Western Carteret County in Bogue Sound, between Emerald Isle and the mainland. All bombing activities known to have been performed at BT-2 were targeted in the immediate vicinity of the island now known as Wood Island. The northern one-third (4 acres) of the island is a dune with an elevation of 9 feet above msl. The southern two-thirds of the island is less than 3 feet above mean sea level. Except for the higher elevation dune habitat, the land is subject to tidal flooding; the dune areas may occasionally be flooded by strong storm tides. The area is posted with “danger” signs due to munitions debris remaining at the site. However, the area is accessible to the public and there is evidence that it has been used recreationally. The surface water on and around the island is salt water.

The primary land use at Wood Island and the surrounding area is recreational. Recreational uses of the area include fishing, crabbing, boating, and swimming. Potential current receptors include recreational adult, youth, and children. The current receptors may come in contact with surface soil, surface water, and sediment while swimming, boating, fishing, and crabbing at and near the site. Exposure routes may include incidental ingestion of and dermal contact with these media. Based on the historic site use and expected contaminant exposure associated with the use, the inhalation pathway is not considered a significant contribution to potential risks.

Potential future receptors include the current receptors, and although very unlikely, future residents, construction workers, and industrial workers. Future receptors could be exposed to the same media as the current receptors through the same exposure pathways.

5.2 Methodology

The HHRS was conducted in three steps using a risk ratio technique (DoN, 2000). If chemicals of potential concern (COPCs) were identified after Step 1, the COPCs were evaluated in Step 2. If COPCs were identified after Step 2, the COPCs were evaluated in Step 3. Results of the risk-based screening and risk ratio evaluation are presented in the Table 2 series in **Appendix E**. A detailed description of the three-step screening process is provided below.

5.2.1 Step 1

The maximum detected constituent concentrations for each medium were compared to USEPA RSLs (USEPA, 2010), other human health risk screening levels (if appropriate), and the site-specific upgradient/background samples (for surface water and sediment). RSLs based on noncarcinogenic effects were divided by 10 to account for exposure to multiple chemicals (i.e., were adjusted to a hazard quotient [HQ] of 0.1 from the HQ of 1.0 used in the USEPA RSL table). RSLs based on carcinogenic endpoints were used as presented in the RSL table and are based on a carcinogenic risk (CR) of 1×10^{-6}.

The surface soil and sediment data were compared to residential soil RSLs. Although the site is not currently residential, and future residential use is unlikely, the residential RSLs were used for the screening as they are the most conservative, and therefore, protective of all current and potential future site uses. The surface water data were compared to North Carolina (NC) Water Quality Standards (NC2B) for human health NCDENR, 2010) (if available), or the NRWQC (USEPA, 2009a) for Human Health (organisms). The criteria based on ingestion of organisms only (and not ingestion or potable use of water) was used as the surface water is salt water and would not be used as a potable water supply. If neither the NC2B standard nor the NRWQC were available for a constituent, the adjusted USEPA tap water RSL was used for comparison and identification of COPCs.

The detection limits for the non-detected constituents were also compared to the screening levels discussed above. However, if the detection limits exceeded the screening levels, the constituents were not selected as COPCs, but were discussed as uncertainties.

If the maximum detected concentration in surface soil, surface water, or sediment exceeded the appropriate screening value, the screening level risk evaluation proceeded to Step 2 for that medium.

5.2.2 Step 2

For chemicals identified as COPCs in Step 1, a corresponding risk level was calculated using the following equation:

$$\textit{corresponding risk level} = \frac{\textit{concentration x acceptable risk level}}{\textit{RSL}}$$

The concentration is the maximum detected concentration (the same concentration that was used in Step 1). The acceptable risk level is 1 for noncarcinogens and 10^{-6} for carcinogens. RSLs for noncarcinogenic effects were not adjusted by 10 as was done in Step 1. Instead, they were used as presented in the RSL table. All of the corresponding risk levels for each constituent within a medium were summed to calculate the cumulative corresponding hazard index (HI) (for noncarcinogens) and cumulative corresponding CR (for carcinogens). A cumulative corresponding hazard index was also calculated for each target organ/effect. If the cumulative corresponding hazard index for a target organ/effect was greater than 0.5, or the cumulative corresponding CR was greater than 5×10^{-5}, the chemicals contributing to these values were retained as COPCs and carried forward to Step 3.

For surface water, it is not appropriate to use the NC Water Quality Standards (NC2B) for human health or the NRWQC for Human Health, as these values are not necessarily risk based. Therefore, for surface water Step 2 screening, the USEPA tap water RSL was used as the screening level.

5.2.3 Step 3

A corresponding risk level was calculated as discussed above for Step 2. However, the 95 percent upper confidence limit (UCL) was used in place of the maximum detected concentration, if five or more samples were available for that media, to obtain a more site-specific risk ratio. If the cumulative corresponding HI by target organ/effect is greater than 0.5, or the cumulative corresponding CR is greater than 5×10^{-5}, then chemicals contributing to these values are considered COPCs and further evaluation of the media may be warranted.

The most current version of the ProUCL software program (USEPA, 2009b) was used to test the data distribution and to calculate 95 percent UCL exposure point concentrations (EPC) used for the Step 3 risk ratio calculations. In cases where there were less than five samples in the data set, or the recommended UCL exceeded the maximum detected concentration, the maximum detected concentration was used as the EPC.

5.3 Human Health Risk Screening Results

The HHRS (comparison to risk-based criteria and background criteria, Step 1) and risk ratio evaluation (Steps 2 and 3) were performed for surface soil, surface water, and sediment.

5.3.1 Surface Soil

Tables 2.1 and 2.1a, **Appendix E**, present the risk-based screening and risk ratio evaluation for surface soil. As shown in **Table 2.1, Appendix E**, three metals (arsenic, chromium and iron) exceeded the first step of the screening and were identified as COPCs for evaluation in Step 2. Based on Step 2 of the screening process (Table 2.1a, **Appendix E**), all of the Step 1 COPCs were eliminated as COPCs for surface soil. Therefore, no unacceptable human health risks were identified from exposure to surface soil at BT-2.

5.3.2 Surface Water

Tables 2.2 through 2.2b**, Appendix E**, present the risk-based screening and risk ratio evaluation for surface water. As shown in Table 2.2, **Appendix E**, one chemical, cadmium, exceeded the first step of the screening and was selected as a COPC for evaluation in Step 2.

The screening value was the adjusted tap water RSL, as there is no NC 2B standard or NRWQC for cadmium. Based on Step 2 of the screening process (risk ratio using maximum detected concentrations, Table 2.1a**, Appendix E**), cadmium could not be eliminated as a COPC and was carried forward to Step 3. The 95% UCL calculated for cadmium using ProUCL was greater than the maximum detected concentration; therefore, the maximum detected concentration was used for Step 3, which resulted in a cumulative corresponding hazard index for a target organ/effect slightly greater than 0.5. However, the cumulative corresponding hazard index is only slightly greater than 0.5 (the HI is 0.6) and is based on a residential use (i.e., use of water as a potable water supply), which is unlikely for the surface water since it is not freshwater. Although cadmium was detected in all five samples, it should be noted that it was detected only once at a level exceeding the screening value and all other detections of cadmium were essentially equal to the background. Therefore, no unacceptable human health risks were identified from exposure to surface water at BT-2.

5.3.3 Sediment

Tables 2.3 and 2.3a, **Appendix E**, present the risk-based screening and risk ratio evaluation for sediment. As shown in Table 2.3, **Appendix E**, two metals (arsenic and chromium) exceeded the first step of the screening and were selected as COPCs for evaluation in Step 2. Based on Step 2 (risk ratio using maximum detected concentration, Table 2.2a**, Appendix E)**, both of these constituents were eliminated as COPCs. Therefore, no unacceptable human health risks were identified from exposure to sediment at BT-2.

5.3.4 Comparison of Detection Limits for Non-Detected Analytes to Screening Levels

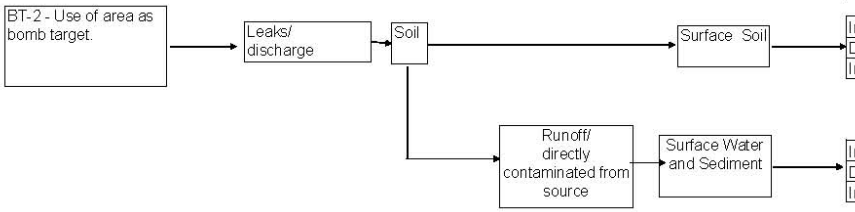
For surface soil, there was one explosives residue and three metals with detection limits that exceeded the screening levels and for sediment, there was one explosives residue and two metals with detection limits that exceeded the screening levels; however, the detection limits were within an order of magnitude of the screening value. For surface water, there were four metals with detection limits that exceeded the screening levels.

Therefore, there is some uncertainty associated with constituents that were not detected and had detection limits above the screening levels. However, based on past site use and the HHRS results of those constituents detected in the site media, it is concluded that this uncertainty does not affect the results of this risk evaluation.

TABLE 5-1
Samples Evaluated in the Human Health Risk Screening
Former Cat Island Bomb Target BT-2 and Surface Danger Zone
MCAS Cherry Point, North Carolina

Medium	Sample Date	Sample	Analytes
Surface Soil			
	3/3/2009	CI-SS01-0309	Explosives, Metals
	3/3/2009	CI-SS02-0309	Explosives, Metals
	3/3/2009	CI-SS03-0309	Explosives, Metals
	3/3/2009	CI-SS03-D-0309[1]	Explosives, Metals
	3/3/2009	CI-SS04-0309	Explosives, Metals
	3/3/2009	CI-SS05-0309	Explosives, Metals
	3/3/2009	CI-SS06-0309	Explosives, Metals
Surface Water			
	5/28/2009	CI-SW01-0509	Explosives, Total Metals, Dissolved Metals
	5/28/2009	CI-SW02-0509	Explosives, Total Metals, Dissolved Metals
	5/28/2009	CI-SW02-P-0509[1]	Explosives, Total Metals, Dissolved Metals
	5/28/2009	CI-SW03-0509	Explosives, Total Metals, Dissolved Metals
	3/3/2009	CI-SW04-0309	Explosives, Total Metals, Dissolved Metals
	3/4/2009	CI-SW05-0309	Explosives, Total Metals, Dissolved Metals
	3/4/2009	CI-SW05-D-0309[1]	Explosives, Total Metals, Dissolved Metals
	5/28/2009	CI-SW06-0509[2]	Explosives, Total Metals, Dissolved Metals
Sediment			
	5/27/2009	CI-SD01-0509	Explosives, Metals
	5/27/2009	CI-SD02-0509	Explosives, Metals
	5/27/2009	CI-SD03-0509	Explosives, Metals
	5/27/2009	CI-SD03-P-0509[1]	Explosives, Metals
	5/27/2009	CI-SD04-0509	Explosives, Metals
	5/27/2009	CI-SD05-0509	Explosives, Metals
	5/27/2009	CI-SD05-P-0509[1]	Explosives, Metals
	5/27/2009	CI-SD06-0509	Explosives, Metals
	5/27/2009	CI-SD07-0509	Explosives, Metals
	5/27/2009	CI-SD08-0509	Explosives, Metals
	5/27/2009	CI-SD09-0509	Explosives, Metals
	5/27/2009	CI-SD10-0509	Explosives, Metals
	5/27/2009	CI-SD11-0509[2]	Explosives, Metals
	5/27/2009	CI-SD12-0509[2]	Explosives, Metals

Notes:
[1] Duplicate sample of sample listed above
[2] Upgradient/background sample. Was not evaluated in site sample data set, but was included as background sample.
Generated by: Jeremy Diner
Checked by: Renee Clore



	Potential Human Receptors						
	Future				Current/Future		
Exposure Route	Residential Adult	Residential Child	Construction Worker	Industrial Worker	Recreational Adult	Recreational Youth	Recreational Child
Ingestion	X	X	X	X	X	X	X
Dermal Contact	X	X	X	X	X	X	X
Inhalation	X	X	X	X	X	X	X
Ingestion	NA	NA	X	X	X	X	X
Dermal Contact	NA	NA	X	X	X	X	X
Inhalation	NA	NA	NA	NA	NA	NA	NA

NA - Not Applicable or pathway is incomplete
X - Potentially complete exposure pathways

CH2MHILL

Figure 5-1
Human Health Risk Screening Conceptual Site Model
Former Cat Island Bomb Target BT-2
and Surface Danger Zone
MCAS Cherry Point
North Carolina

SECTION 6

Ecological Risk Screening

Results for constituents in soil, sediment, and surface water were screened against benchmarks intended to be protective of ecological receptors. All data evaluated in the ecological risk screening were collected in March and May 2009. Background concentrations for inorganic constituents in soil at MCAS Cherry Point were assumed to be representative of background conditions on Wood Island although this site is approximately 15 miles south of MCAS Cherry Point.

This screening evaluates BT-2 and the associated SDZ (**Figure 2-2**). The marshland soils at Wood Island are level and very poorly drained mucks. The northern one-third (4 acres) of the island is a forested dune with an elevation of 9 feet above mean sea level; the southern two-thirds is less than 3 feet above mean sea level. Except for the dune habitat, the land is subject to tidal flooding. Marshlands on the island contain semi-permanently saturated and flooded soils. Strong storm tides may flood the terrestrial dune habitat (USMC, 2001). Surface water at this site is marine (saltwater).

6.1 Ecological Screening Methodology

For each medium (surface soil, sediment, and surface water), the maximum and average concentrations are presented along with representative Ecological Screening Values (ESVs) intended to be protective of ecological receptors. HQs were calculated by dividing these statistics by the ESVs.

For locations with multiple data points (i.e., either a parent and duplicate sample were available or a constituent was reported for multiple analytical methods), data were reduced to the value of the greatest detected concentration or greatest detection limit if there was no detection. Where average concentrations are reported, one half of the detection limit was used as the representative concentration in the case of a non-detection when determining the average.

ESVs were identified from the following sources:

- USEPA Region 4 Recommended Ecological Screening Values (USEPA, 2001).
- USEPA National Recommended Water Quality Criteria (USEPA, 2009a).
- USEPA Ecological Soil Screening Levels (USEPA, 2008).

A hierarchy was used for soil in which the data were first screened against the USEPA Ecological Soil Screening Levels (EcoSSLs). When no EcoSSL was available for a constituent, the Region 4 value was selected. A selection hierarchy was also applied to surface water. The NRWQC was selected over the Region 4 value. However, when no NRWQC was available for a constituent, the Region 4 value was selected as the ESV for that constituent. For sediment, EPA Region 4 values were used. The ecological risk screening for each medium is shown in Tables F-1 through F-3 of **Appendix F** and summarized below.

6.2 BT-2 and SDZ Ecological Screening

Data were collected and analyzed from 6 surface soil, 12 sediment, and 6 surface water sample locations. Analyses performed include explosives residue, perchlorate, and metals. Samples of surface water were analyzed for both total and dissolved metals concentrations. The results of the screening are presented below.

6.2.1 Ecological Surface Soil Screening

Maximum detected concentrations of the following constituents in surface soil exceeded ESVs (**Appendix F**, Table F-1): aluminum, iron, lead, selenium, vanadium, and zinc. However, the concentrations of these constituents appear to be generally consistent with natural background conditions in the Coastal Plain of North Carolina based on a comparison to the background data sets from nearby MCAS Cherry Point and MCB Camp Lejeune. For example, the maximum concentrations of aluminum (4,320 mg/kg), iron (5850 mg/kg), and vanadium (14.1 mg/kg) are all less than their respective MCAS Cherry Point two times average background concentration. With regard to lead, selenium, and zinc, the detected concentrations in only one out of 6 samples for each constituent were outside of the range of background concentrations for that constituent at MCAS Cherry Point and all but one zinc concentration were within the range of background concentrations for MCB Camp Lejeune.

Overall, risk from metals is unlikely. Concentrations were generally within the range of background concentrations and the magnitudes of ESV exceedances were generally low. Additional ecological evaluation of metals in surface soil is not recommended.

6.2.2 Ecological Sediment Screening

No detected metals concentrations exceeded ESVs for sediment (**Appendix F**, Table F-2). Therefore, metals are not expected to pose ecological risk to sediment receptors.

6.2.3 Ecological Surface Water Screening

Maximum detected concentrations of cadmium, lead, and silver exceeded ESVs (**Appendix F**, Table F-3). However, as discussed in Section 4, the detected concentrations of metals in the surface water samples were generally consistent with the concentrations in the background sample. Therefore, it is concluded that the concentrations of these metals are representative of natural or anthropogenic conditions rather than evidence of a site-related release. Based on these findings and the relatively low magnitudes of the ESV exceedances, cadmium, lead, and silver in surface water are not anticipated to pose unacceptable ecological risk. As a result, additional ecological evaluation of surface water is not recommended.

6.3 Uncertainty

In soil, compounds detected with no ESV included four metals, calcium, magnesium, potassium, and sodium. All four of these constituents are mineral nutrients (State of North Carolina, 2008) and are not considered to pose potential ecological risk to receptors.

None of the 16 explosive compounds analyzed for in soil were detected in any of the 6 soil samples. Only 1 of the 16 compounds, nitrobenzene, had an ESV. The HQ for nitrobenzene

based on the ESV was less than 1. Detection limits for all explosive compounds were less than 1 mg/kg. It is concluded that these constituents are unlikely to pose a risk to ecological receptor populations.

In sediments, seven detected metals (aluminum, barium, calcium, iron, magnesium, manganese, and vanadium) lacked ESVs. Maximum concentrations for all seven analytes were located at sample location CI-SD11, which is one of the background sample locations. It should be noted, however, that the maximum concentrations of barium and manganese were both less than the associated apparent effect thresholds of 48 mg/kg and 490 mg/kg, respectively (Barrick et al., 1988). Calcium, iron, and magnesium are all mineral nutrients and not likely to pose significant risk to ecological receptors. Of the nondetect metals, silver was the only analyte with an HQ above 1 (based on the average of the detection limits). However, the magnitude of the exceedance was low (HQ = 1.67) and silver was not detected in any of the 12 samples.

In surface water, five explosive compounds were detected but lacked ESVs including 1,3,5-trinitrobenzene; 2,6-dinitrotoluene; 2-nitrotoluene; 4-nitrotoluene; and RDX. However, 1,3,5-trinitrobenzene and 2,6-dinitrotoluene were both below the suggested Navy screening levels (DoN, 2007). Navy screening levels were not available for the other three analytes but detected concentrations were low and analytes were detected in only 1 or 2 of 6 samples. The remaining 10 explosive compounds were not detected. Detection limits for all explosive compounds were low with maximum detection limits of 0.0002 mg/L. The data suggest that explosive contaminants are not widespread or present at high concentrations. RDX had the highest detected concentration at 0.0023 mg/L.

SECTION 7

Conclusions and Recommendations

This section presents the conclusions from the various elements of this Site Inspection.

7.1 Conclusions

7.1.1 Aerial Digital Geophysical Mapping

A total of 10,400 magnetic anomalies were detected during the ADGM of 6,600 acres of Bogue Sound within the BT-2 SDZ. The geophysical survey results do not differentiate between munitions items and other metallic debris. Therefore, the magnetic anomalies identified may or may not be related to the former military use of BT-2. The largest concentration of anomalies is located within a 650-foot radius of Wood Island, the location of the former bomb target location. The remaining detected anomalies are sporadically distributed throughout the survey area, punctuated by smaller clusters of low-amplitude anomalies. The clusters of low-amplitude anomalies do not resemble typical munitions target patterns observed at bomb target sites. However, the high concentration of anomalies observed in the immediate vicinity of Wood Island is consistent with typically observed munitions target patterns. According to the ADGM survey results, the density of metallic objects decreases with increased distance from Wood Island.

7.1.2 Environmental Investigation

The environmental investigation of surface soil, sediment and surface water identified the presence of explosives residues and perchlorate at concentrations that did not exceed regulatory screening criteria. Metals were detected at concentrations exceeding regulatory screening criteria in surface soil, sediment, and surface water. However, the metals concentrations in soil were generally consistent with regional background concentrations in the study area portion of the Coastal Plain of North Carolina based on a comparison of data to the background data sets for soil at two nearby facilities: MCAS Cherry Point and MCB Camp Lejeune. With regard to the sediment and surface water results, it was determined that the concentrations of metals in the site samples were consistent with generally similar concentrations in the background samples collected as part of the SI. It is concluded that the concentrations of metals found in all of these media during the SI do not provide significant evidence of a site-related release and are instead representative of natural or anthropogenic conditions.

7.1.3 Human Health Risk Assessment

A HHRS was performed for surface soil, sediment, and surface water at BT-2 that included a risk ratio evaluation. The results of the HHRS indicate that exposure to surface soil, sediment, and surface water at BT-2 would not result in any unacceptable human health risks to current or likely future receptors.

7.1.4 Ecological Risk Screening

An ecological risk screening was performed for surface soil, sediment, and surface water at BT-2. The results of the ecological risk screening indicate that there are no unacceptable risks for ecological receptors exposed to BT-2 surface soil, sediment, or surface water as a result of historical military operations or site-related activities at BT-2. No further ecological investigation activities are warranted.

7.2 Recommendations

The environmental investigation was conducted to evaluate the presence of MC contamination and to evaluate risk to human health and ecological receptors. The HHRS and the ecological risk screening conducted for BT-2 concluded that surface soil, surface water, and sediment are not anticipated to pose any unacceptable risk to human health or ecological receptors; therefore, no further evaluation of these media is recommended.

Due to the presence of MEC on Wood Island and the high concentration of anomalies identified in the waters around Wood Island, it is recommended that additional investigation be performed to assess the nature of the identified anomalies and determine what remedial actions will be taken at this site.

SECTION 8

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Appendix A
Archival Records Search Report

Archives Search Report
For Former Cat Island Bomb Target (BT-2) and Surface Danger Zone

Marine Corps Air Station Cherry Point
Havelock, North Carolina

Contract Task Order 201

December 2008

Prepared for

Department of the Navy
Naval Facilities Engineering Command
Mid-Atlantic

Under the

NAVFAC CLEAN III Program
Contract N62470-02-D-3052

Prepared by

CH2MHILL

Charlotte, North Carolina

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Attachment

A-1 Resource Review Summary

Acronyms and Abbreviations

ASR	Archive Search Report
BT	Bomb Target
DON	United States Department of the Navy
MCAS	Marine Corps Air Station
MEC	Munitions and Explosives of Concern
mm	millimeter
MR	Munitions Response
NARA	National Archives and Records Administration
NCNHP	North Carolina Natural Heritage Program
SDZ	Surface Danger Zone
SI	Site Inspection
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USGS	United States Geological Survey
USMC	United States Marine Corps
UXO	Unexploded Ordnance

SECTION A.1

Introduction, Purpose, and Scope

This archive records review is being conducted in support of a Munitions Response (MR) Site Inspection (SI) at the former Cat Island Bomb Target (BT)-2, associated with Marine Corps Air Station (MCAS) Cherry Point. The archives search report (ASR) is an investigative review of existing information about the site and its surrounding area, with an emphasis on obtaining information from personnel and historical resources that might indicate a potentially hazardous release to the environment, specifically with munitions and explosives of concern (MEC). The scope of the report includes:

- A review of existing information about the site (including maps, drawings, and reports).
- Collection of additional information about the site.

A complete listing of resources identified and investigated for this report is provided in Attachment 1. Attachment 1 includes details concerning the reviews of the historical information from the Marine Corps Library, National Archives and Records Administration (NARA) map and text files, and MCAS Cherry Point files.

SECTION A.2

Background Information

A.2.1 Site Information

Cat Island is a partially submerged shoal which is mostly under water even at low tide. It was identified in the Range Identification and Preliminary Range Assessment (USACE, 2001) as BT-2 and was often referred to as Wood Island on Topographical Maps. The site is located in Western Carteret County in Bogue Sound, between Emerald Isle and the mainland at Latitude 34º 41′ 12″N and Longitude 76º 57′ 06″ W. It is approximately 2.2 miles south, south west of the mouth of Broad Creek and 0.5 mile north of Bogue Banks (Emerald Isle), just east of Emerald Isle Fishing Pier.

Cat Island, which is associated with MCAS Cherry Point, was used from the mid-1940s through the 1970s for flight operations training. Between 1943 and 1955, Cat Island was leased by the U.S. Navy from Mrs. Anita Maulick. Operations at Cat Island included inert smoke bomb type operations between 1943 and 1952. In 1952, the use of live ammunition was initiated at this site (DON, 1957a). Air-delivered ordnance up to 2,000-pound bombs was known to have been used on the island. There are three bomb target coordinates associated with Cat Island with surface danger zones (SDZs) ranging from 2,000 yards to three miles in radius. Two of the Cat Island bomb targets were located within Bogue Sound, approximately 550 yards north of the island (USACE, 2001). In approximately 1955, the use of live ordnance was discontinued due to the proximity of nearby residences (DON, 1956). In 1956, the island was acquired by the U.S. Navy through a Declaration of Taking (DON, 1957b). By 1972, the land was used for "dry run" type training (USACE, 2001).

A.2.1.1 Site Conditions

Cat Island is pock-marked with craters caused by bomb explosions. The surface contains bomb fragments and scraps of metals from rockets and miniature bombs (USMC, 1956). The island covers an area of approximately 12 acres, four of which are forested with the remainder being marshland. It is accessible only by boat and contains potentially live munitions from prior use as a bombing target. Evidence of surface MEC was observed during a 2007 site visit.

A.2.1.2 Climate and Meteorology

A discussion of site climate and meteorology are provided in the Work Plan.

A.2.1.3 Topography, Geology and Hydrology

A discussion of site topography, geology and hydrology are provided in the Work Plan.

A.2.1.4 Natural Communities

In 1992 and 1993, the North Carolina Natural Heritage Program (NCNHP) did an inventory of the rare species, natural communities, and critical areas of MCAS Cherry Point and its

surrounding areas which included Cat Island. A visit to the island on June 8, 1993, revealed that it was an exemplary special habitat for the wading bird rookery. The blue heron and the snowy egret were also documented nesting at Cat Island. There is a possibility that there are several species of egrets, herons, and ibises on the island. The *Yucca gloriosa*, a rare plant species, was also found. The marshland of the southern two thirds of Cat Island supports the salt marsh community and is dominated by saltmarsh cordgrass. The northern third supports a small maritime evergreen forest community dominated by live oak, greenbriers and poison ivy. The ground surface of the maritime evergreen forest is disturbed by bomb craters creating microhabitats some of which include weedy species. According to the *Inventory of the Rare Species, Natural Communities, and Critical Areas of the Cherry Point Marine Corps Air Station, North Carolina* issued in 1994, Cat Island has been designated a special management area due to the rare species of animals and plants that are indigenous to this island and infrequent human disturbance (LeBlond, Fussell, and Braswell, 1994).

A.2.2 Ownership and Operational History

A.2.2.1 Ownership History

The history of Cat Island's land ownership is documented primarily through real estate files, memoranda, congressional correspondence and maps. The initial land was transferred to the Government in a lease dated March 19, 1943, that was executed between the United States of America and Anita Maulick and husband Harry Maulick. It stated that the lessee could make any use of the lands (Cat Island) demised necessary, appropriate, or desirable for the conduct of naval and military operations (Lease Agreement, 1943). On June 1, 1944, Lease NOy(R)36974 reiterated the lease agreement and stated that the property described as Cat Island was to be used exclusively as a site for practice targets for flight operations in connection with MCAS Cherry Point. On September 15, 1947 Permit NOy(R)-42573 was issued which reiterated the lease agreement and instructed the Government to maintain, decontaminate and restore the premises at a deferred date. The final Lease Agreement between the Maulicks and the government was effective October 29th, 1952. It stated that the lease would expire on June 30, 1953, and that it could be renewed annually up to June 30, 1970 (DON, 1957c).

A June 10, 1954, correspondence from the United States Marine Corps to Mr. Frank M. Wooten Attorney at Law indicated that Mrs. Anita Maulick had conveyed the ownership of lands known as Bogue Banks including the land known as Cat Island to Lewis R. Holding, William B. McLean et al. The correspondence indicated that this conveyance of property made by Mrs. Maulick may be conflicting with the rights conveyed by Mrs. Maulick to the United States of America in lease agreement NOy (R)-47263 (USMC, 1954).

Numerous debates followed discussing the validity of the Lease Agreement and who should take ownership of the land. In 1955, the government proposed to acquire the land and the Armed Services Committee of Congress approved that request. The acquisition was also authorized under the 1956 Public Works Program. The Navy indicated that the prime reasons for purchase of Cat Island was the fact that it was economically impractical to decontaminate the area and restore the property to its original ownership and for that reason it was far more economical to purchase the property (DON, 1956).

On April 24, 1956, the Navy acquired the land by condemnation proceedings and a Declaration of Taking (DON, 1957b). In 1975, the Navy concluded that Cat Island could not be released from Department of Defense control even though no operational requirement now exists for its use as the high cost of complete unexploded ordnance (UXO) removal makes disposal of the property infeasible (DON, 1972). Although the land is no longer being used, Cat Island is still retained by the Navy.

A.2.2.2 Operational History

Cat Island was initially leased by the Government as of March 19, 1943 (Lease Agreement, 1943). The *Range Identification and Preliminary Range Assessment* (USACE, 2001) indicates that a May 23, 1945, document requested the establishment of a danger area consisting of a 3,000-yard radius centered on 34º 41′ 30″N and 76º 56′ 59″W approximately 550 yards from Cat Island. This target was identified as BT-2. On June 21, 1945 the danger area was changed to 34º 41′ 09″N and 76º 57′ 05″W with a SDZ radius of 2,000 yards. This change was made to accommodate objections to surface danger zones. According to 16 July, 1949 Federal Register, the danger area for the Cat Island target range was located at 34º 41′ 12″N and 76º 57′ 06″W with a 3-mile radius. In 1951 the danger radius was reduced to 2,000 yards and the target was identified as a rocket range (USACE, 2001).

Operations at Cat Island included inert smoke bomb type operations between 1943 and 1952. In 1952, the use of live ammunition was initiated at this site (DON, 1957a). The *Range Identification and Preliminary Range Assessment* indicate that general purpose bombs, armor piercing bombs, semi-armor piercing bombs, depth bombs, rockets and machine guns (.30 Caliber to 20 millimeter [mm]) were used for training activities at Cat Island. The estimated depth of munitions is at the surface and varied in depth according to the type of munitions that were used (USACE, 2001). Air-delivered ordnance, including up to 2,000-pound bombs, was known to have been used on the island. A memorandum dated January 4, 1957, indicated that the use of live ordnance on Cat Island should be discontinued due to the proximity of nearby residences (DON, 1957d). In 1956, the island was acquired by the U.S. Navy through a Declaration of Taking (DON, 1957b).

Surface decontamination of Cat Island was completed in 1957. At this time it was concluded that there was a high probability that UXO was present below the surface of the island that could not be detected by probing, and that UXO may continue to be exposed through tidal action and storms. For this reason, it was stated that Cat Island would remain a potentially dangerous area (DON, 1957a).

On November 21 and 27, 1963, the MCAS Cherry Point EOD team swept Cat Island for UXO. No UXO was found; however, items of inert and expended ordnance were found. At that time, no responsible officer would certify that Cat Island had been decontaminated with respect to UXO dropped there during World War II due to the potential for ordnance to be buried to a depth of 30 feet or more and due to the potential for buried ordnance to be brought to the surface through tidal action and storms (USMC, 1963).

A.2.3 Current Operational Information

Currently the island is not being used for any military training, although it is still owned by the Navy. Warning signs on the island prohibit civilians from entering the site.

SECTION A.3

Findings

Based on the research activities, military training exercises involving the use of live munitions were conducted on Cat Island between 1952 and 1955. This resulted in the formation of craters on the surface of the island. The surface of Cat Island has been cleared several times. However, due to the potential for ordnance to be buried to a depth of 30 feet or more and the potential for buried ordnance to be brought to the surface through tidal action and storms, the island has not be decontaminated with respect to the UXO dropped there during World War II (USMC, 1963). Evidence of surface MEC was observed during a 2007 site visit.

SECTION A.4

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Attachment A-1
Resource Review Summary

Resource Review Summary

The following table provides a summary of the specific references identified for review, interview, or contact for the archives search report.

Resource	Actions Completed
Quantico, Virginia, Marine Corps Library Gray Research Center (Annette Amerman)	Contacted to determine availability of files related to Cherry Point. No relevant documents are available to review.
US National Archives (NARA II) Historical Files	Reviewed text and drawing files from Text Division and Cartographic Division and Still Photographs Research Division. See US National Archives Files Review
	Cherry Point Personnel
Dan Brown/Operations Director	Contacted to determine availability of files related to the Cherry Point Cat Island site. No relevant documents are available to review.
	Nara Atlanta Personnel
Guy Hall	Contacted to determine availability of files related to Cherry Point. No relevant documents are available to review.

National Archives and Records Administration Review

Text Division

Site visits on September 19-24, 2007

Reviewed 19 boxes of files associated with the Marine Corps, 1939-1958

- Record Group 127 (USMC), Office of the Commandant, General Correspondence, January 1939-June 1950, 1275/70-1115, Box 220.
- Record Group 127 (USMC), Office of the Commandant, General Correspondence, January 1939-June 1950, 1275/70-1115, Box 221.
- Record Group 127 (USMC), Office of the Commandant, General Correspondence, January 1939-June 1950, 1275/70-1115, Box 222.
- Record Group 127 (USMC), Office of the Commandant, General Correspondence, January 1939-June 1950, 1275/70-1115, Box 223.
- Record Group 127 (USMC), Office of the Commandant, General Correspondence, January 1939-June 1950, 1275/70-1115, Box 220.

- Record Group 127 (USMC), Office of the Commandant, General Correspondence, 1941-1949, Box 15.
- Record Group 127 (USMC), Office of the Commandant, General Correspondence, January 1939- June 1950, Box 1579.
- Record Group 127 (USMC), Office of the Commandant, General Correspondence, January 1939- June 1950, Box 1580.
- Record Group 127 (USMC), Office of the Commandant, General Correspondence, January 1939- June 1950, Box 1581.
- Record Group 127 (USMC), Office of the Commandant, General Correspondence and Subject Files, 1946- 1950, Box 57.
- Record Group 71 (USMC), Records of the Bureau of Yards and Docks, 1941- 1958, Box 906.
- Record Group 71 (USMC), Records of the Bureau of Yards and Docks, 1941- 1958, Box 907.
- Record Group 71 (USMC), Records of the Bureau of Yards and Docks, 1941- 1958, Box 908.
- Record Group 71 (USMC), Records of the Bureau of Yards and Docks, 1941-1958, Box 909.
- Record Group 71 (USMC), Records of the Bureau of Yards and Docks, 1941-1958, Box 910.
- Record Group 71 (USMC), Records of the Bureau of Yards and Docks, 1941- 1958, Box 911.
- Record Group 71 (USMC), Records of the Bureau of Yards and Docks, 1941- 1958, Box 912.
- Record Group 71 (USMC), Records of the Bureau of Yards and Docks, 1941- 1958, Box 913.
- Record Group 71 (USMC), Records of the Bureau of Yards and Docks, 1941- 1958, Box 914.
- Record Group 71 (USMC), Records of the Bureau of Yards and Docks, 1941- 1958, Box 915.

The boxes contained a variety of information primarily related to daily base operations, including annual reports, discipline files, real estate purchases, building blueprints, and various correspondences. One box contained War Diaries dated 1947. Much of the material was specific to Cherry Point, although some boxes included information for other MC bases.

Cartographic Division

The cartographic division did not contain any relevant information pertaining to historical ordnance use at any of the sites. Four topographic maps of Cat Island dating 1951, 1971, 1983, and 1994 were available. Aerial photographs of Cat Island dating 1938 and 1953 were also available, although there was not any means to capture the images.

List of Documents Obtained from National Archives

- Memorandum, dated July 3, 1957, Subject – "Cat Island, North Carolina; Practice Bombing Target for NAS, Cherry Point; request for opinion on proposed revestment of title".
- Memorandum dated July 12, 1957, Subject – "Cat Island, North Carolina; Practice Bombing Target for NAS, Cherry Point; request for opinion on proposed revestment of title".
- Memorandum, dated January 17, 1957, Subject – "Cat Island, North Carolina; Practice Bombing Target for NAS, Cherry Point; request for comment on".
- Memorandum, dated November 15, 1956, Subject – "Marine Corps Air Station, Cherry Point, North Carolina; acquisition of 240 acres of land known as Cat Island, Maw Point and Pamlico Point, North Carolina".
- Memorandum to the File, dated March 7, 1957, Subject – "Conference with Congressman Graham A. Barden, February 26, 1957, re acquisition of Cat Island, a bombing target in North Carolina".
- Commandant Letter, dated December 21, 1956 – Subject – "Cat Island Practice Bombing Range".
- Commandant Letter, dated January 4, 1957 – Subject – "Cat Island N.C. Practice Bombing Target".
- Commandant Letter, dated October 4, 1957 – Subject – "Marine Corps Air Station, Cherry Point, North Carolina; Cat Island Practice Bombing Target; proposed revestment of title in the former owners".
- Commandant Letter, dated April 25, 1957 – Subject – "Acquisition of bombing target, Cat Island, North Carolina; Visit to property owners".
- Letter, dated October 22, 1957 – Subject – "Marine Corps Air Station, Cherry Point, North Carolina; Cat Island Practice Bombing Target; proposed revestment of title in former owners".
- Letter, dated July 29, 1957 – Subject – "Marine Corps Air Station, Cherry Point, North Carolina; Cat Island Practice Bombing Target; proposed revestment of title in former owners".
- Letter from Ward and Tucker Attorneys at Law to Bureau of Yards and Docks, dated June 19, 1957.

- Letter from the Honorable Graham A. Barden to the Secretary of the Navy, dated November 28, 1956 – Subject – Cat Island, Carteret County, North Carolina".
- Letter from Chief of Naval Material to the Honorable Graham A. Barden, dated March 22, 1957.
- Letter from Assistant Commandant of the Marine Corps to the Honorable Graham A. Barden, dated December 7, 1956.
- Letter, dated March 11, 1957 – Subject – "Letter from Congressman Graham A. Barden to SECNAV dtd 28 Nov 1956 (SECNAV RS# 1 1163) RE ACQUISITION OF Cat Island, Carteret, North Carolina".
- Excerpts of Correspondence Relative to: Leaseholds pertaining to Cat Island, Bogue Sound, Carteret County, North Carolina, dated February 8, 1957.
- Excerpts from Correspondence and Memoranda Pertaining to Acquisition of Cat Island, Bogue Sound, Carteret County, North Carolina, dated February 8, 1957.
- "Semi-Annual Supplement to Original History of United States Marine Corps Air Station Cherry Point, North Carolina", dated January 1 – June 30, 1949, pages 36-37.
- "Semi-Annual Supplement to Original History of United States Marine Corps Air Station Cherry Point, North Carolina", dated July 1 – December 31, 1949, pages 56-57.
- Record Drawing – Marine Air Base, Cunningham Field, Cherry Point, North Carolina, Key Map, Outlying Fields Survey, June 2, 1942.
- Portion of US Coast Guard Chart No. 1234, Showing Cat Island & Radio Island.
- Map of US Marine Corps Air Station, Cherry Point, North Carolina, Showing Conditions of June 30, 1947.
- Map of US Marine Corps Air Station, Cherry Point, North Carolina, Showing Conditions of June 30, 1951.
- US Geological Survey Topographical Map – Salter Path, North Carolina Quadrant, 1951.
- US Geological Survey Topographical Map – Salter Path, North Carolina Quadrant, 1951, photorevised 1971.
- US Geological Survey Topographical Map – Salter Path, North Carolina Quadrant, 1949, photorevised 1983.
- US Geological Survey Topographical Map – Salter Path, North Carolina Quadrant, 1994.

Appendix B
Aerial Digital Geophysical Mapping Report

Final Report

Airborne Geophysical Survey

over

Bogue Sound, North Carolina

July 2009

Version 2

Prepared for

CH2M HILL

by

Battelle-Oak Ridge Operations

Executive Summary

In March and April, 2009, Battelle flew a low-altitude magnetic airborne geophysical survey over Bogue Sound, on the North Carolina coast, about five miles west of Morehead City. The objective of the survey was to detect and accurately locate ordnance-related metallic items to support a Site Investigation of the area in the vicinity of Bomb Target 2 (BT-2). The main survey area consisted of 6600 acres over the exceptionally shallow waters of Bogue Sound. A low-altitude magnetic gradient survey using Battelle's boom-mounted vertical magnetic gradient system (VG-16) encompassed this area with 1.7 m sensor spacing to attain 100% coverage. The typical survey altitude was 1-2 m above sea level. Background magnetic variation was low, and 10,400 magnetic anomalies were detected equal to or above a threshold of 0.331 nT/m. No immediate excavation was conducted to pursue subsurface anomalies.

A Geophysical Prove Out (GPO) line of inert ordnance items was established at Michael J. Smith Airport to verify proper system operation. Additional quality control items were placed in Bogue Sound by personnel from CH2M HILL.

The largest concentration of magnetic anomalies was in an approximately 200m radius from BT-2, located on and near Wood Island. In much of this zone, the magnetic anomalies are so dense they overlap. The sources of the anomalies in close proximity to Wood Island can be assumed to be fragments from exploded ordnance, and in some instances, unexploded ordnance. Currents and storms do not appear to have moved these items any great distances from their original target areas. However, the diffuse pattern of anomalies extending to the south of Wood Island a few hundred meters may be caused by current transport or storm surges. About 800 m to the SW of Wood Island is a small cluster of anomalies about 90m in diameter. There is no collection of anomalies in the vicinity of the presumed location of the May 1945 bomb target, about 600 m north of Wood Island. Given the tight bomb pattern around Wood Island, and the lack of evidence of significant redistribution of magnetic sources by currents, it is unlikely that very many of the other anomalies in Bogue Sound are ordnance related. Most magnetic anomalies a few hundred meters removed from BT-2 likely will be related to civilian use of Bogue Sound by fishermen, recreational boaters, and others.

Final data deliverables include digital data, geophysical maps of the collected data and a prioritized list of target anomalies.

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List of Acronyms

AS	Analytic signal
ASCII	American Standard Code for Information Interchange
BT-2	Bomb Target 2
EOD	Explosive Ordnance Disposal
GIS	Geographic Information System
GPO	Geophysical Prove Out
GPS, DGPS	(Differential) Global Positioning System
Hz	Hertz, a unit of frequency
MCAS	Marine Corps Air Station
NAD83	North American Datum 1983
NAVD88	North American Vertical Datum 1988
nT/m	nanoTeslas per meter, a unit of magnetic gradient
QA	Quality Assurance
QC	Quality Control
TIF, GeoTIF	(Geographically referenced) Tagged Information File
UTM	Universal Transverse Mercator
UXO	Unexploded ordnance
VG	Vertical gradient (magnetic)
VG-16	Magnetic Vertical Gradient airborne system with 16 total sensors in 8 gradient pods

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1. Introduction

1.1. Background and Project Objectives

This report describes an airborne geophysical survey using Battelle's low-altitude magnetic gradient helicopter geophysical system carried out by Battelle for the purpose of detecting and mapping unexploded ordnance (UXO) and ordnance-relate debris in a 6600 acre area of Bogue Sound, on the Atlantic seaboard near Morehead City, North Carolina. Because of the large area involved, and because it was over very shallow water, airborne survey methods were considered the best possible option by which to obtain high-resolution geophysical data in support of ongoing site characterization activities. The survey used Battelle's VG-16 airborne vertical magnetic gradient system.

The objective of the airborne geophysical survey was to acquire high-resolution magnetic gradient data to indicate the level of ordnance-related contamination in Bogue Sound. Although the data are sufficient to localize potential sources to an accuracy of a few 10s of cm so as to permit subsequent reacquisition of anomalies of interest, the primary purpose of the wide-area assessment was to determine potential areas of concern with respect to ordnance-related contamination in Bogue Sound.

It is important for users of these data to understand the limitations in using airborne geophysical data. A lack of geophysical anomalies in an area should not be used to infer that an area is entirely devoid of ordnance contamination. A lack of anomalies may indicate ordnance types too small to be detected—such as 20mm rounds—or, alternatively, that magnetic responses were not strong enough because survey altitudes were too high (e.g., over some islands and other obstacles) or ordnance was too deeply buried.

1.2. Statement of Work

Battelle's tasks were: (1) to produce an airborne magnetometry survey workplan, (2) to mobilize to the base of operations (Morehead City, NC), (3) establish an instrument validation area in concert with CH2M HILL personnel, (4) perform an airborne magnetic gradiometry survey over the portion of Bogue Sound defined by CH2M HILL, providing daily progress and QC reports, and (5) submit a final report, data and maps to CH2M HILL.

1.3. Project Site History and Description

The Former Cat Island Bomb Target (BT-2) and Surface Danger Zone, illustrated in Figure 1.1, are associated with training activities conducted from the Marine Corps Air Station (MCAS) Cherry Point, located in Havelock, North Carolina. Commissioned in 1942, MCAS Cherry Point currently provides support facilities and services for the Second Marine Aircraft Wing, the Fleet Readiness Center East, Service Support Detachment 21 of the Second Force Service Support Group, the Naval Air Maintenance Training Group Detachment, and the Defense Reutilization and Marketing Office. MCAS Cherry Point maintains facilities for training and supporting the Atlantic Fleet Marine Force aviation units and is designated as a primary aviation supply point. In

the mid- to late 1940s, bomb targets were placed in Bogue Sound in the vicinity of Wood Island for bombing training by Marine and Navy aviators. The Navy's historical documents refer to the former bomb target as Cat Island, but more recent maps and local residents identify it as Wood Island. The Former Cat Island Bomb Target (BT-2) consisted of three locations on and around the island.

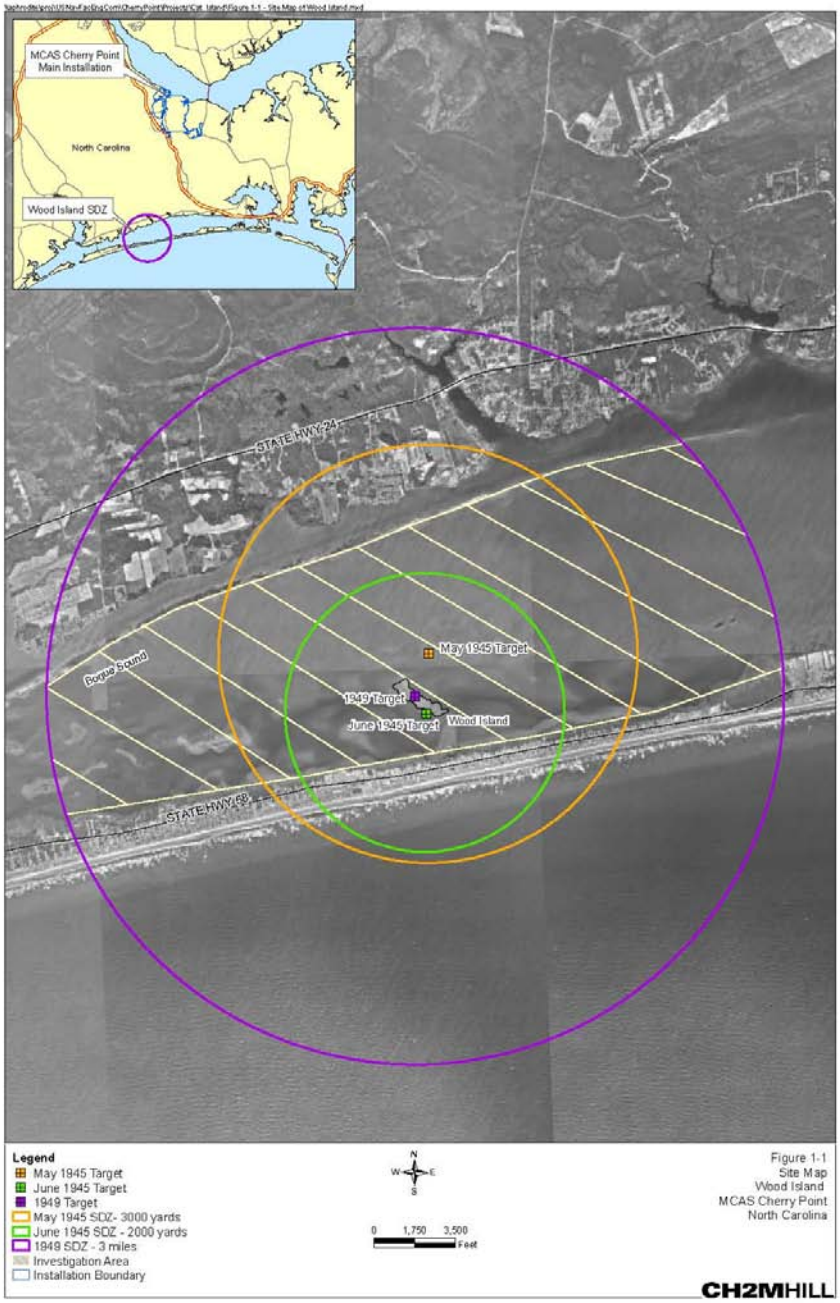


Figure 1.1: Former BT-2 and Wood Island Surface Danger Zone defined for the aerial survey. The 6600 acre survey area is contained within the yellow cross-hatched polygon.

1.4. Site Location, Physiography, Bathymetry, and Geology

The survey site centers on Wood Island, a low-lying, marshy island of approximately 10 acres, about 500m long and less than 100m at its widest point. It is located in Bogue Sound at Latitude 34 º 41’ 12”N and Longitude 76 º 57’ 06” W, about 800m inshore of Emerald Isle, in Carteret County, North Carolina, about 6.5 km offshore from Marine Corps Outlying Field Bogue, approximately 3 km SSW of the mouth of Broad Creek, and about 23 km southwest of MCAS Cherry Point. The specific survey area is defined to be bounded by the following coordinates and landmarks: 34° 41’ 13”N 77° 0’ 30”W to 34° 40’ 23”N 77° 0’ 12”W to 34° 41’ 23”N 76° 53’ 57”W to 34° 42’ 59”N 76° 54’ 46”W, or generally between Gales Creek, Salter Path, Humphreys Point, and Archer Point. The waters of Bogue Sound change after storms and different channels are moved and created every year. The bathymetry map of Bogue Sound, shown in Figure 1.2, indicated very shallow water depths, typically less than one meter. Adjacent to the north boundary of the survey area is the Intracoastal Waterway. It is about 5 m deep and is clearly marked.

Bogue Sound is in the North Carolina Coastal Plain physiographic province. The Coastal Plain is a wedge of mostly marine sedimentary deposits that gradually thickens from west to east. The most common sediment types are sand and clay, although a significant amount of limestone occurs in the southern part of the Coastal Plain. These geological units are usually not significantly magnetic and do not interfere with airborne magnetic survey data. However, the geology of North Carolina is variable enough that magnetic stones may have been deposited in Bogue Sound.

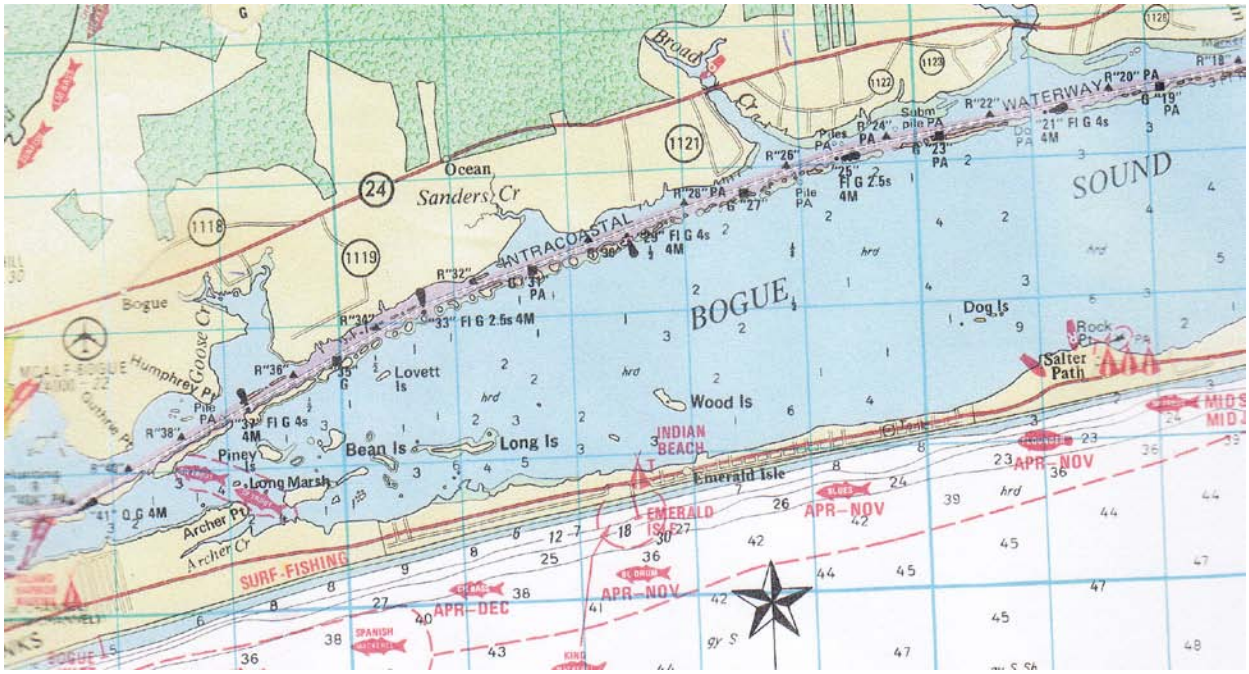


Figure 1.2: Bathymetric map of Bogue Sound. Water depth in feet. (Source: GMCO's Chartbook of North Carolina, grid chart 32, 1996)

2. Airborne Vertical Magnetic Gradient System

The airborne system used for magnetic data acquisition is the VG-16, developed and operated by Battelle. This system, shown in Figure 2.1, consists of eight vertical gradiometers; each consisting of a pair of cesium magnetometers vertically offset 50 cm from one another. The gradient arrangement serves to reject much of the magnetic noise caused by the proximity of the helicopter. The sensors mounted in the forward and side booms have 1.7 m horizontal separation, thus providing great sensitivity to small ordnance and greater positional accuracy for detected items.

Four gradiometer pods are located in the forward boom, and two gradiometer pods are located in each of the lateral booms (two on either side). The VG-16 system has been certified by the Federal Aviation Agency for use on a Bell 206 Long Ranger helicopter. It is flown as low to the earth's surface as safety permits, typically 1-2 meters above ground level, in pre-programmed traverses over the survey areas. Typical survey speeds are 20 m/s. Flight lines were spaced 12 m apart. Airborne magnetic data are acquired during daylight hours only.

The data positioning and system orientation (pitch, roll, yaw) is based on an integrated Global Positioning System (GPS) / Inertial Measurement Unit mounted on the centerline of the helicopter. A fluxgate magnetometer is mounted in the forward assembly to compensate for the magnetic signature of the aircraft. A laser altimeter is mounted beneath the helicopter to monitor sensor height above the ground, or in this survey, water. Data are recorded digitally on the console inside the helicopter in a binary format. The magnetometers are sampled at a 1200 Hz sample rate and desampled to 120Hz to allow sufficient bandwidth to eliminate helicopter rotor noise.

Figure 2.1: The Battelle VG-16 vertical magnetic gradient system.

3. Survey Parameters and Procedures

3.1. Survey Logistics

The airborne survey was completed during the 50 day period (on-site) between March 03 and April 22, 2009. Flights over Bogue Sound began on March 05. The geophysical survey crew included Les Beard, Jacob Sheehan, and Jeff Gamey from Battelle. The flight crew consisted of Doug Christie (pilot), Marcus Watson (system operator) and Milos Kapetanovic (engineer) from National Helicopters.

Operations were based out of the Michael J. Smith Airport in Beaufort, NC. Equipment installation was conducted at the airport and the helicopter returned to the airport for refueling between flights.

A local GPS base station was established at the airport and was used throughout the survey. Its designation is Beaufort/EA3068 and its location is 34°43’57.95507” N and 76°39’20.06656” W. The monument elevation is 1.956 meters above mean sea level (NAVD88).

All on-site data processing was performed at the Hampton Inn in Morehead City.

A comprehensive Operational Emergency Response Plan was developed and issued previously to address issues related to flight operations, safety, and emergency response. This plan was incorporated into an overall Mission Plan developed to manage field survey operations.

3.2. Magnetic Data Acquisition

Following arrival in Morehead City, NC, Battelle personnel set up a calibration grid at the Michael J. Smith Airport. The calibration grid or Geophysical Prove Out (GPO) consisted of a single line of items laid out on a N-S line. The items were placed 15 meters apart, and from the south consisted of the following: one inert 155mm projectile, one inert 105mm projectile, one inert 3 inch rocket warhead, one inert 2.75 inch rocket warhead, one inert 81 mm mortar round, one inert 60 mm mortar round, and an anchor tied to two 3-foot lengths of 3 inch diameter steel pipe. Copies of this latter item were placed in survey areas in Bogue Sound for quality control purposes by CH2M HILL. Prior to placement of the calibration targets, the area was swept with a hand held Schonstedt magnetic detector to avoid pre-existing subsurface anomalies. Test lines were flown over the GPO at the start and end of each survey day.

The helicopter and Battelle crew arrived on-site on March 3 and equipment installation was conducted on March 4. A kickoff meeting involving Navy and Marine Corps representatives, National Helicopters, Battelle and CH2M HILL personnel took place the morning of March 5, after which system calibration and compensation flights were carried out at the Michael J. Smith Airport. Data acquisition at Bogue Sound started on March 6 and continued through April 22.

The VG-16 data were desampled in the signal processing stage from 1200Hz to a 120 Hz recording rate. All other raw data were interpolated to a 120 Hz rate. This results in a down-line

sample density of approximately 10cm at average survey speeds. Data were converted to an ASCII format and imported into a Geosoft format database for processing. With the exception of the differential GPS post-processing and the calculation of compensation coefficients, all data processing was conducted using the Geosoft Oasis Montaj software suite.

Quality Control checks were performed throughout the survey. These included twice daily surveys of the controlled test items at the GPO, except where high winds at the airport precluded safe low-level flight, as well as QC checks (by CH2M HILL) of test items distributed in Bogue Sound by the CH2M HILL EOD technicians. The Bogue Sound test items consisted of two lengths of steel pipe attached to an anchor.

The Bogue Sound survey area was divided into five approximately equal area blocks, and each of these, with the exception of Blocks 3 and 5, were flown exclusively either E-W or N-S. This arrangement allowed the aircrew to take advantage of changing wind directions without causing undue survey complications. Block 3, flown at the start of the survey, contains a combination of E-W and N-S lines. Block 5 was the last survey area flown, and likewise contains a combination of E-W and N-S lines.

Winds on Bogue Sound proved to be a challenge to the aircrew. Wind speeds were often high, but their gusty nature on Bogue Sound made low-altitude surveying difficult. Abruptly changing wind speed and direction can cause the helicopter to lose altitude quickly, a dangerous situation when survey altitudes are only a few meters above the water.

3.3. Positioning

The pilot was guided during flight by an on-board navigation system using Omnistar satellite corrections. This provides sufficient accuracy for data collection (approximately 1m). To increase the accuracy of the post-processed data positions to an accuracy of a few decimeters, a GPS base station was established at Michael J. Smith Airport, approximately 25km from the center of the Bogue Sound survey area. The coordinates of this site were established by a reference monument at the airport.

Raw GPS positional data were collected in the aircraft and on the ground for differential corrections. These were applied in post-processing to provide decimeter accuracy in the antenna positioning (based on the software's quality assurance parameters). The final latitude and longitude data were projected onto an orthogonal grid using the NAD83 datum, UTM Zone 18N (meters) for presentation.

The locations of each magnetometer sensor were measured relative to the GPS antenna and the location of each data point was determined by using the GPS antenna location and the aircraft orientation, as measured by an inertial navigation unit that samples at a 100Hz rate. This system outputs pitch, roll and azimuth. These data are combined with the physical geometry of the array to calculate the position and relative height of each magnetometer sensor. Vertical positioning was monitored by laser altimeter with an accuracy of 2cm, although this resolution can be degraded by reflections from vegetation and may be inaccurate over water. It is usually possible

to identify errant altimeter data, discard it, and interpolate between accurate points. Alternately, GPS data can be used to establish survey altitude. In any case, altitude inaccuracy does not affect anomaly amplitudes or mapping products produced from them.

4. Data Processing

The magnetic data were processed in several stages. This included correction for time lags, removal of sensor dropouts, compensation for dynamic helicopter effects, correction for sensor heading error, array balancing, and removal of helicopter rotor noise. The vertical magnetic gradient was calculated by subtracting readings from pairs of total field magnetometers. The magnetic analytic signal (total gradient) was derived from the vertical gradient through a fast Fourier transform integral algorithm.

4.1. Quality Control

The data were examined in the field to ensure sufficient data quality for final processing. The adequacy of the compensation data, heading corrections, time lags, orientation calibration, overall performance and noise levels, and data format compatibility were all confirmed during data processing. During survey operations, flight line locations were plotted to verify full coverage of the area. Missing lines or areas where data were not captured were rejected and reacquired. Data were also examined for high noise levels and data drop outs. Lines deemed to be unacceptable were re-flown during the acquisition stage. Occasional lines deviated from a straight flight path due to obstacle avoidance.

4.2. Time Lag Correction

There is a lag between the time the sensor makes a measurement and when it is time-stamped and recorded. Accurate positioning requires a correction for this lag. Time lags between the magnetometers, fluxgate and GPS signals were measured by a proprietary utility. This utility sends a single electromagnetic pulse that is visible in the data streams of all three instruments. This lag was corrected in all data streams before processing.

4.3. Sensor Drop-outs

Cesium vapor magnetometers have a preferred orientation to the Earth's magnetic field. As a result of the motion of the aircraft, the sensor dead zones will occasionally align with the Earth's field. In this event, the readings drop out, usually from a local average of over 50,000 nT to 0 nT. This usually occurs only during turns between lines, and rarely during on-line surveying (<1sec of data loss per day). All dropouts were removed manually during processing.

4.4. Aircraft Compensation

The presence of the helicopter in close proximity to the sensors causes considerable deviation in the readings, which requires compensation. The orientation of the aircraft with respect to the sensors and the motion of the aircraft through the earth's magnetic field are contributing factors. A calibration flight is flown to record the information necessary to remove these effects. The maneuver consists of flying a box-shaped flight path at high altitude to gain information in each of the cardinal directions. During this procedure, the pitch, roll and yaw of the aircraft are varied. This provides a complete picture of the effects of the aircraft at all headings in all orientations. The entire maneuver was conducted twice for comparison. The information was used to calculate coefficients for a 19-term polynomial for each sensor. The fluxgate data were used as the baseline reference channel for orientation. The polynomial is applied post flight to the raw data, and the results are referred to as the compensated data.

4.5. Rotor Noise

The aircraft rotor spins at a near constant rate of about 400rpm. This introduces noise to the magnetic readings at a frequency of approximately 6.6 Hz. Harmonics at multiples of this base are also observable, but have much smaller amplitudes. This frequency is usually higher than the spatial frequency created by near-surface metallic objects and is removed with a frequency filter.

4.6. Heading Corrections

Cesium vapor magnetometers are susceptible to heading errors. The result is that one sensor will give different readings when rotated about a stationary point. This error is usually less than 0.2 nT. Heading corrections are applied to adjust readings for this effect.

4.7. Vertical Magnetic Gradient

The vertical magnetic gradient is measured as the difference between measured values in each gradiometer pod (bottom magnetometer minus top). This is a distinction from total magnetic field surveys in which vertical magnetic gradient is calculated, rather than measured. In addition to reducing the effects of aircraft and rotor noise, this technique removes the necessity of monitoring and subtracting diurnal variations in the Earth's field. These data were gridded using a 0.5m interval.

4.8. Analytic Signal

The analytic signal is calculated from the gridded vertical magnetic gradient data as the square root of the sum of the squares of three orthogonal magnetic gradients. It represents the maximum rate of change of the magnetic field in three-dimensional space – a measure of how much the magnetic field would change by moving a small amount in the direction of maximum change.

There are several advantages to using the analytic signal. It is generally easier to interpret than total field or vertical gradient data for small object detection because it has a simple positive response above a zero background. The amplitude of the response depends on the strength of the magnetic anomaly. In comparison, total field and vertical gradient maps typically display a dipolar response to small, compact sources (having both a positive and negative deviation from the background). The actual source location is at a point between the two peaks that is dependent upon the magnetic latitude of the site and the properties of the source itself. Analytic signal is essentially symmetric about the target, is always a positive value and is less dependent on magnetic latitude. More generally, the analytic signal highlights the corners of source objects, but for small targets at the latitude of this survey, these corners converge into a single peak almost directly over the target.

The dominant noise source in analytic signal is residual line-to-line inconsistencies in the gridded data which impact the horizontal gradients. These may be caused by residual heading error, altitude variation or uncompensated aircraft effects. The minimum anomaly threshold was set above the analytic signal noise floor at 0.33 nT/m for single peaks. This represents the 10:1 signal-noise ratio based on a measured noise floor of 0.03 nT/m.

5. Quality Control

A line of calibration items was used for daily QC of field operations and to verify target response against the local geologic background. The items consisted of six inert ordnance items and a seventh item identical to the CH2M HILL blind seeds on Bogue Sound. The line was set up along the infield of the Michael J. Smith Airport and ran approximately N-S. The items, listed in Table 5.1, were placed 15 m apart on the surface of the ground. All were laid with the long dimension pointing W-E. On March 5, and again on March 6, Battelle flew the GPO line at nominal survey heights of 1, 2, 3, 5, 7, and 10 m above ground level in order to assess the magnetic anomalies of the test items at a representative variety of target-sensor offsets. Thereafter, the GPO was flown twice daily at 1-2m above ground level at the start and end of surveying for QC purposes.

Table 5-1: Items on GPO test line.*

item	description	relative location	x-CH2M HILL	y-CH2M HILL
1	155 mm round	0	348411.78	3844812.79
2	105 mm round	15	348412.22	3844827.86
3	3 inch rocket warhead	30	348412.52	3844842.83
4	2.75 inch rocket warhead	45	348412.89	3844857.83
5	81 mm mortar round	60	348413.22	3844872.80
6	60 mm mortar round	75	348413.56	3844887.78
7	anchor and 2 pipes	90	348413.97	3844902.79

*Table 5-1: All position and distance units are in meters. Datum is NAD83, UTM Zone 18N. The locations were surveyed in by a contractor to CH2M HILL.

Figure 5.1 shows the analytic signal map produced by the seven test items in Table 5-1 from a typical low-altitude flyover. The uppermost anomaly is from the CH2M HILL blind seed item which consists of two three foot long steel pipes and a 15 pound boat anchor. The anchor alone produced a very small magnetic anomaly; therefore, the two lengths of pipe were added. All test items were detected on all low altitude QC passes, with the exception of the 60mm mortar round, which was only occasionally detected. The bottom anomaly, produced by a 155mm artillery round, is unusually small for that type of ordnance. The locations of the anomalies with respect to the circles that mark the location of the center of the items show that the positioning is accurate. The long axis of each item was E-W, perpendicular to the flight line. This produces a slightly elongated anomaly in the E-W direction.

Of the possible causes for the low response of the 155mm round, the most likely—though still improbable—is that the round possessed remanent magnetization, and was placed in such a way that the remanent magnetization magnitude and direction partially cancel the earth's induced field. This kind of fortuitous field alignment must be rare, as we have not observed it in any other GPO test line in other surveys. We chose not to move or rotate the item during the field survey so as to maintain source continuity.

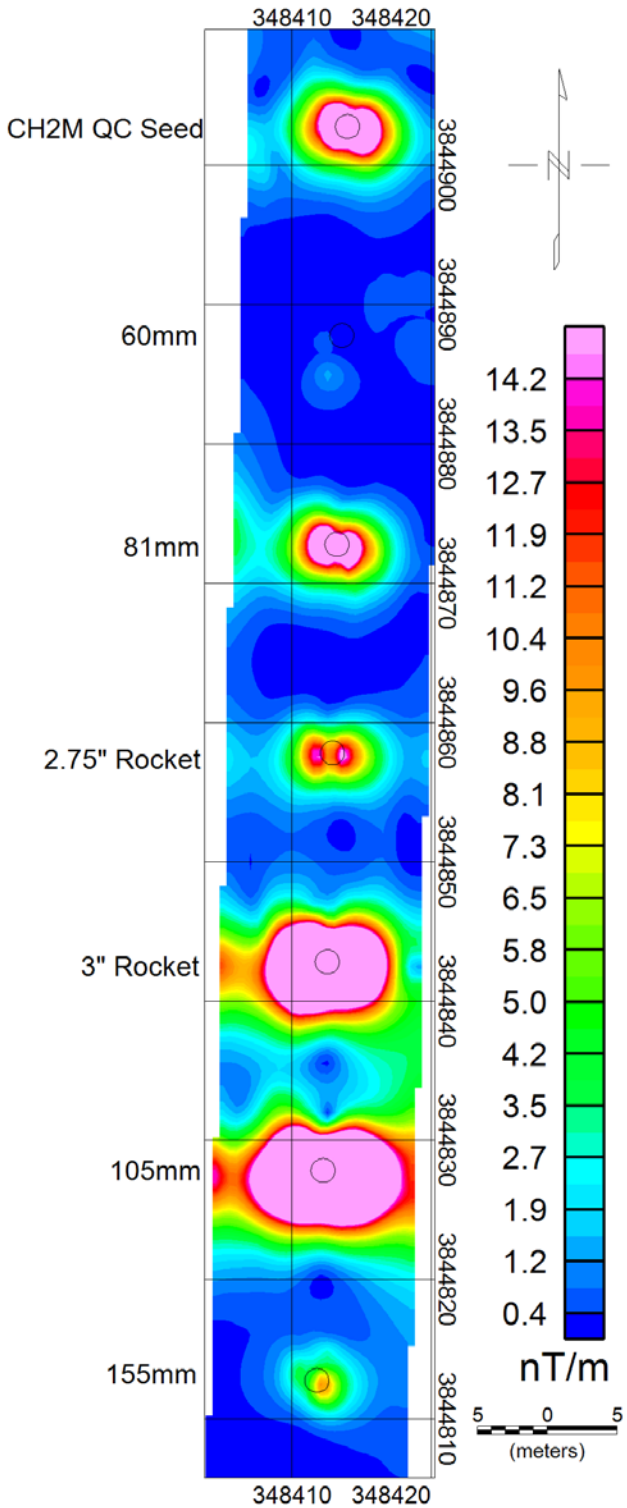


Figure 5.1: Analytic signal map from a typical low-level QC pass over the calibration line. Circles represent seeded target locations.

Figure 5.2 shows the analytic signal profiles produced by the seven test items in Table 5-1 from passes at altitudes ranging from 1.6m above ground level to 9.6m. The anomaly at the extreme right is from the CH2M HILL blind seed item which consists of two three foot long steel pipes and a 15 pound boat anchor.

Figure 5.2 gives some indication as to the size of items that can be detected in Bogue Sound. The 81mm mortar round shows an 8 nT/m anomaly at a source-sensor separation of 3.2 m, has a 1.5 nT/m anomaly at 4.9 m, and falls below 0.3 nT/m at 6.8 m. The 60mm mortar is undetectable at all but the lowest source-sensor separation of 1.6 m. These data indicate that items as small as 81mm rounds should be detectable over almost all of the survey area, but that 60mm mortar rounds are too small to be detected anywhere in Bogue Sound.

CH2M HILL personnel emplaced QC items in the survey area. The items were identically constructed and consisted of a boat anchor with two lengths of pipe attached. On the airport GPO line, the QC seed produced an anomaly slightly in excess of an 81mm mortar round. CH2M HILL personnel compared the known locations of their QC items to anomalies on daily magnetic gradient maps produced by Battelle. During the survey, there was never a report to Battelle that an emplaced QC item had gone undetected.

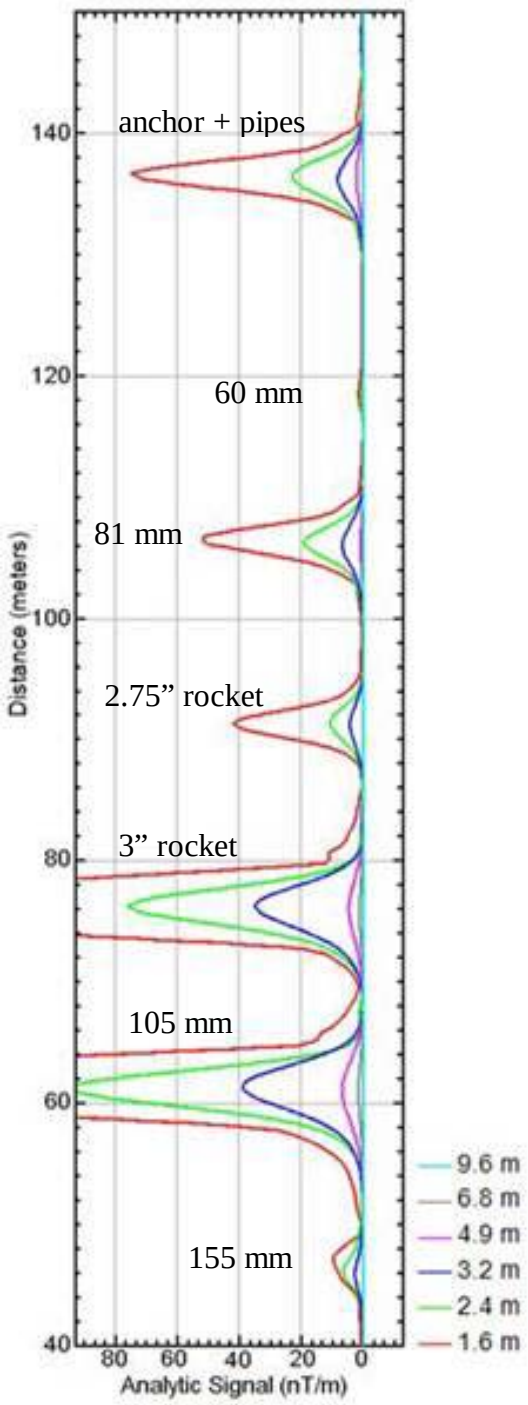


Figure 5.2: Analytic signal anomalies from passes over the calibration line with altitudes varying from 1.6m to 9.6m. From bottom to top, the anomalies are caused by a 155mm round (unusually small anomaly), a 105 mm round, a 3 inch rocket warhead, a 2.75 inch rocket warhead, an 81mm mortar round, a 60mm mortar round (anomaly barely visible), and the CH2M HILL seed item (a 15 pound boat anchor tied to two 3 foot long pipes).

6. Data Interpretation

6.1. Vertical Gradient and Analytic Signal Maps

Because of its size, the survey area was split up into five separate survey blocks. Block 3 was flown first because it contained the known bomb target BT-2 near and on Wood Island, and because of time criticality with respect to water fowl migration. The blocks are shown in Figure 6.1 overlain on a satellite photo of Bogue Sound.

Figure 6.2 shows a map of the measured vertical magnetic gradient at Bogue Sound, centered near Bomb Target 2. The map shows a dense cluster of high amplitude magnetic anomalies in the vicinity of BT-2 forming a roughly circular pattern about 400m in diameter. The overwhelming majority of these anomalies are likely to be exploded ordnance fragments, along with some unexploded ordnance items. There is a less dense scattering of anomalies to the south of BT-2. The sources of these anomalies may also be UXO or fragments. Strong currents from one or more storm events might have caused metallic items near BT-2 to be displaced southward. About 800m SW from Wood Island is a 90m diameter cluster of magnetic anomalies centered near 320500E, 3839500N. Historical documents indicate that a formerly used defense site known as the Bogue Sound Rectangular Bomb and Rocket Target existed on the east side of the survey zone. However, there is no anomaly pattern in the eastern survey area that strongly suggests a target. Candidates for investigation are two small areas near the south shoreline that have a high density of anomalies (seen better in Figure 6.3), and a few large amplitude anomalies in the extreme east about one km offshore. However, we note that there is no indication that the sources of these anomalies are necessarily related to military activity.

There are hundreds more anomalies in the survey area outside the immediate vicinity of BT-2. We note that Europeans have inhabited the region for almost 400 years, and that period of time allows for accumulation of a wide variety of ferrous metal artifacts.

An analytic signal map computed from the vertical magnetic gradient data is shown in Figure 6.3. The analytic signal can be understood as the magnitude of the total gradient. Unlike the vertical gradient, the analytic signal is always a positive quantity. This map shows effectively the same anomaly pattern as the vertical gradient map; however, as was mentioned earlier, the small anomaly clusters near the south shoreline on the east side of the survey area show up more clearly in the analytic signal map.

Figure 6.4 shows the measured sensor height above water level for each gradient pod. The only sizeable areas in Bogue Sound where survey heights exceeded 3.5 m were Long Island (near 318700E, 3839500N), which has tall trees, and Wood Island, which has metal warning signs all around it. There are also a few areas along the north boundary of the survey area where the helicopter pulled up before reaching the Intracoastal Waterway. There are more than thirty small areas in the Sound where the helicopter had to pull up a few meters over duck blinds, signs, or other obstacles. The area of the altitude excursion over these obstacles is typically 0.1 to 0.3 ha (0.25 acre to 0.75 acre).

Figure 6.1: Satellite image of Bogue Sound with survey blocks superimposed. (Extracted from Google Earth.)

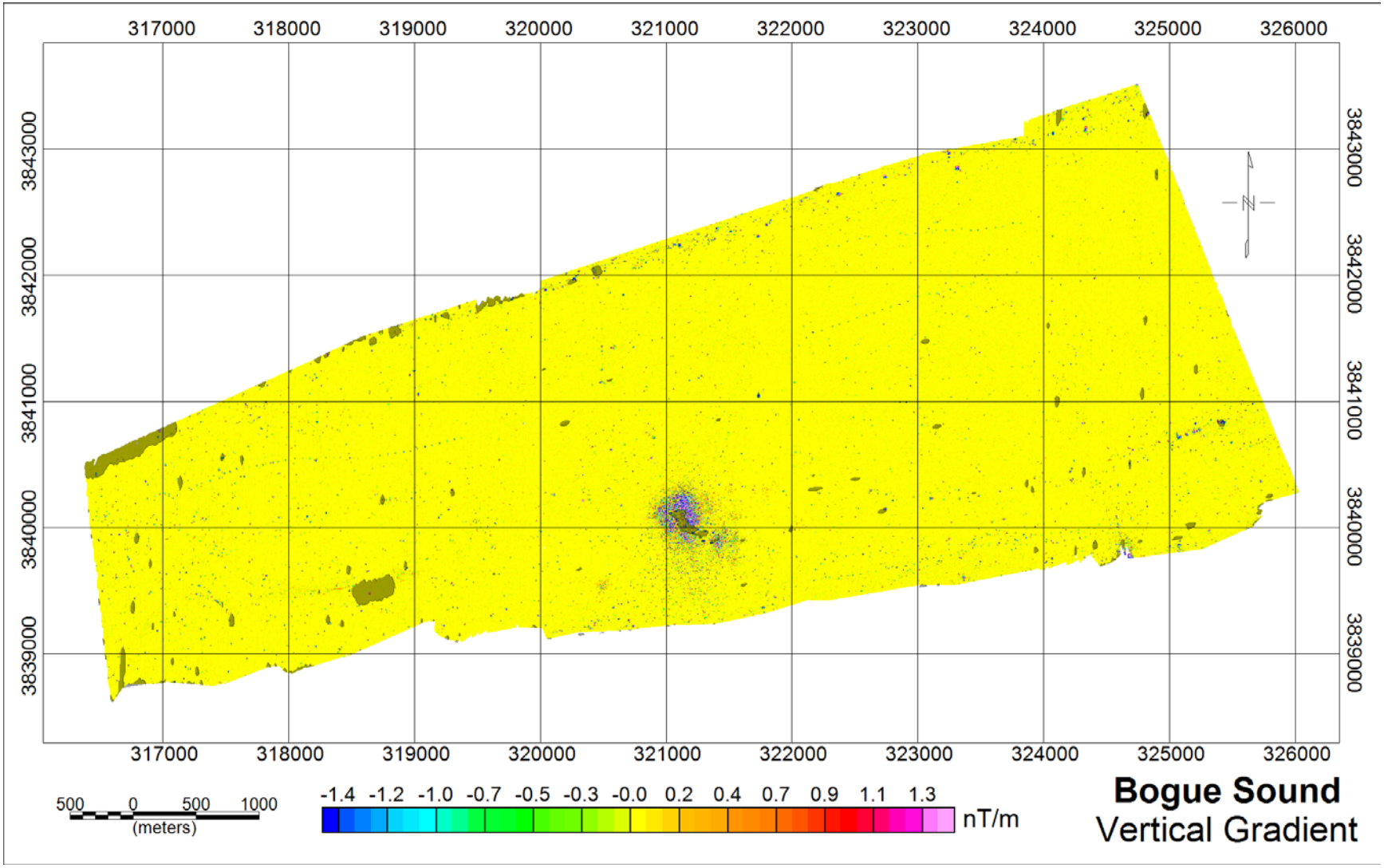


Figure 6.2: Vertical magnetic gradient map of Bogue Sound. Shaded sections represent areas which were flown above 4.0m altitude.

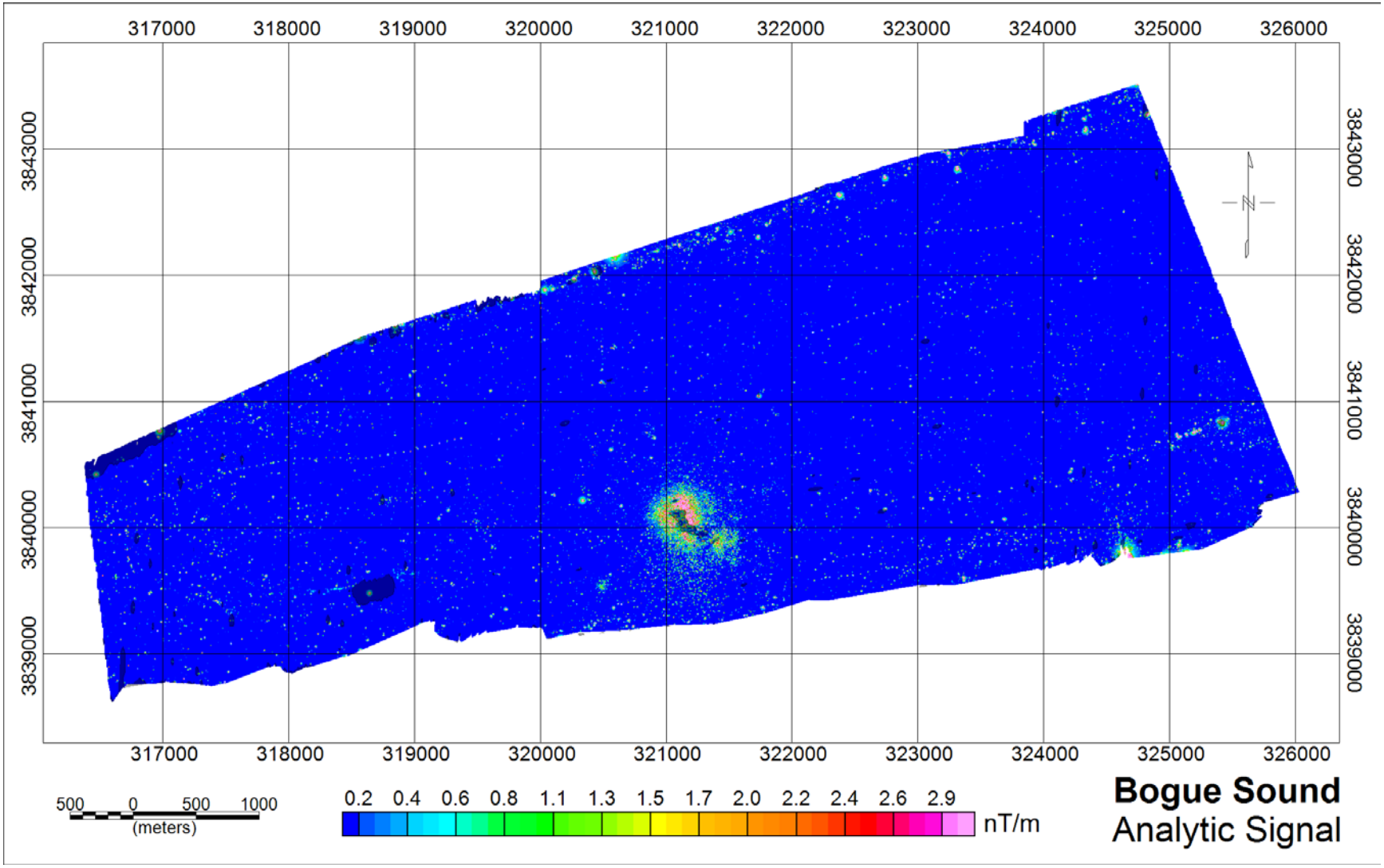


Figure 6.3: Analytic Signal map of Bogue Sound. Shaded sections represent areas which were flown above 4.0m altitude.

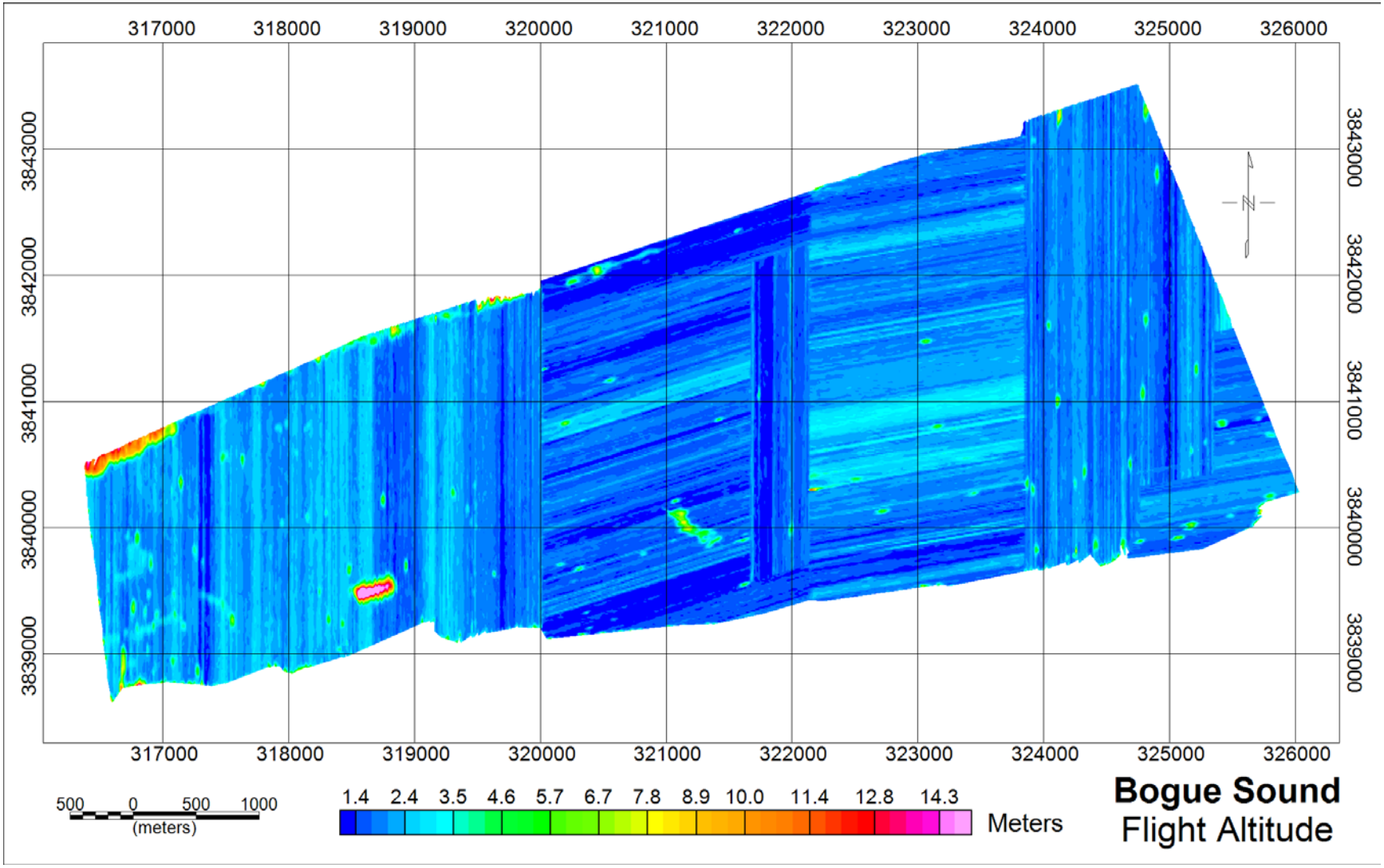


Figure 6.4: Survey altitude map of Bogue Sound showing flight height in meters over water.

A close-up view of BT-2 is shown in Figure 6.5. It is evident from this view that the target area is full of magnetic debris that cause overlapping anomalies. The blue zone in the center of the target appears to have few anomalies because the helicopter had to fly higher over the island to miss warning signs surrounding the island.

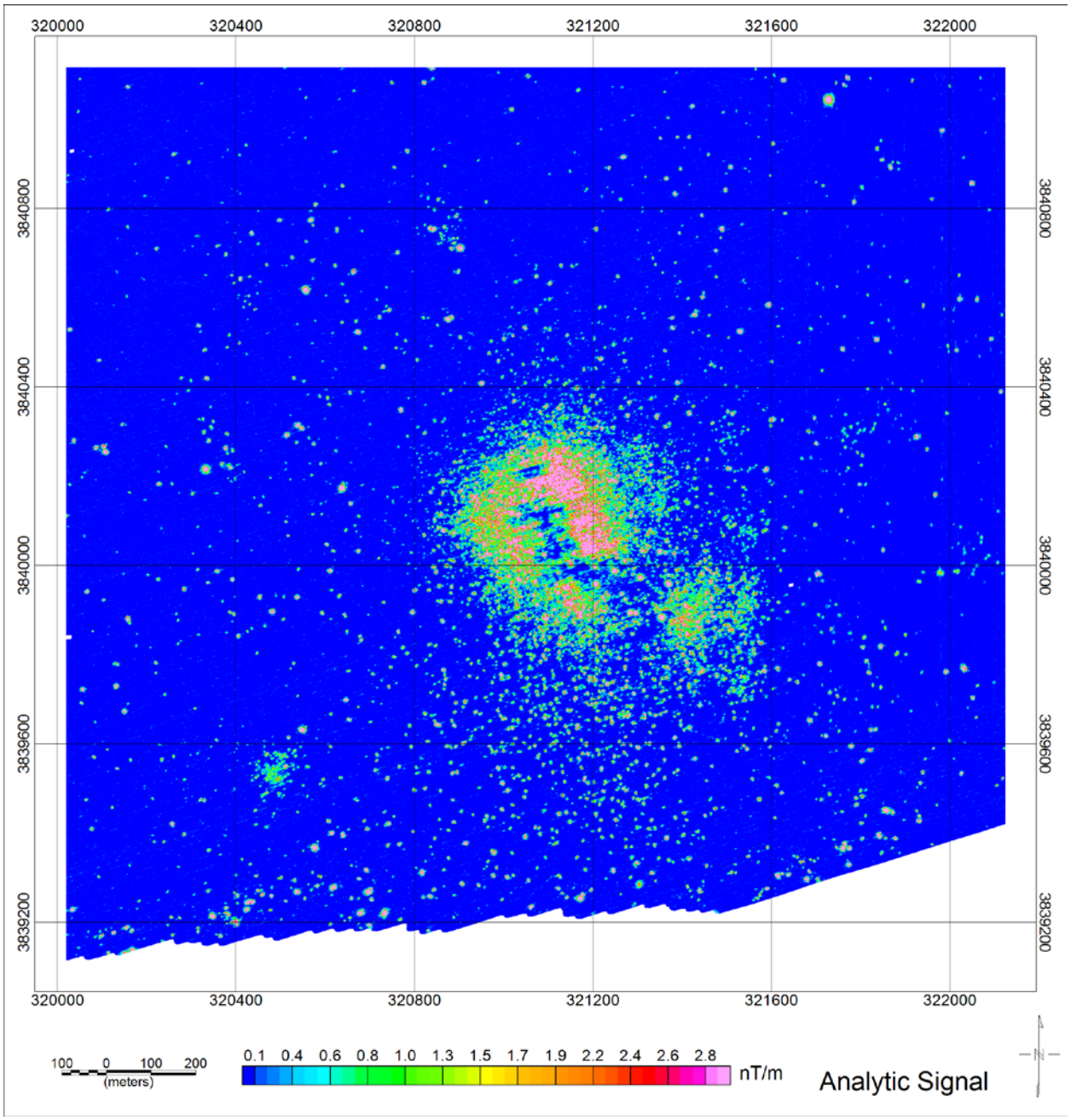


Figure 6.5: Close up view of analytic signal anomalies at BT-2.

6.2. Anomaly Lists

The entries in the anomaly list are picked from the peaks of analytic signal anomalies. Experience has shown that the position of the peak of the analytic signal anomaly for an isolated item is usually accurate to within a 1 m radius of the actual location of the buried item. This accuracy may degrade in areas where the density of metal is such that superposition of anomalies occurs. It is also possible that in a dynamic seacoast environment the sources of magnetic anomalies can move between the time of the survey and the time of any intrusive investigation.

The file labeled "BogueSoundAnomalyList2009.xyz" is an ASCII file containing the locations and amplitudes of 10,400 analytic signal anomalies equal to or exceeding a threshold of 0.331 nT/m. This threshold is well in excess of the magnetic noise background of 0.03 nT/m that was typical of the surveyed area. Target coordinates are provided in NAD83, UTM Zone 18N (meters). The file is ordered by survey block, and within a given survey block by anomaly amplitude from largest to smallest.

Figures 6.6 and 6.7 show the anomaly picks overlain on the VG map (with survey block outlines shown) and on the AS map. Figure 6.8 shows an anomaly density map of the Bogue Sound survey area with density expressed as analytic signal peak (at or above the 0.331 nT/m threshold) per hectare. The west side of the map appears to have moderately higher density than the east side. However, this may be a result of slightly deeper waters in the east attenuating some of the small anomalies (see bathymetric map in Figure 1.2). It is likely that the anomaly density in the vicinity of BT-2 is underreported since in many instances superposed anomalies may appear as single peaks.

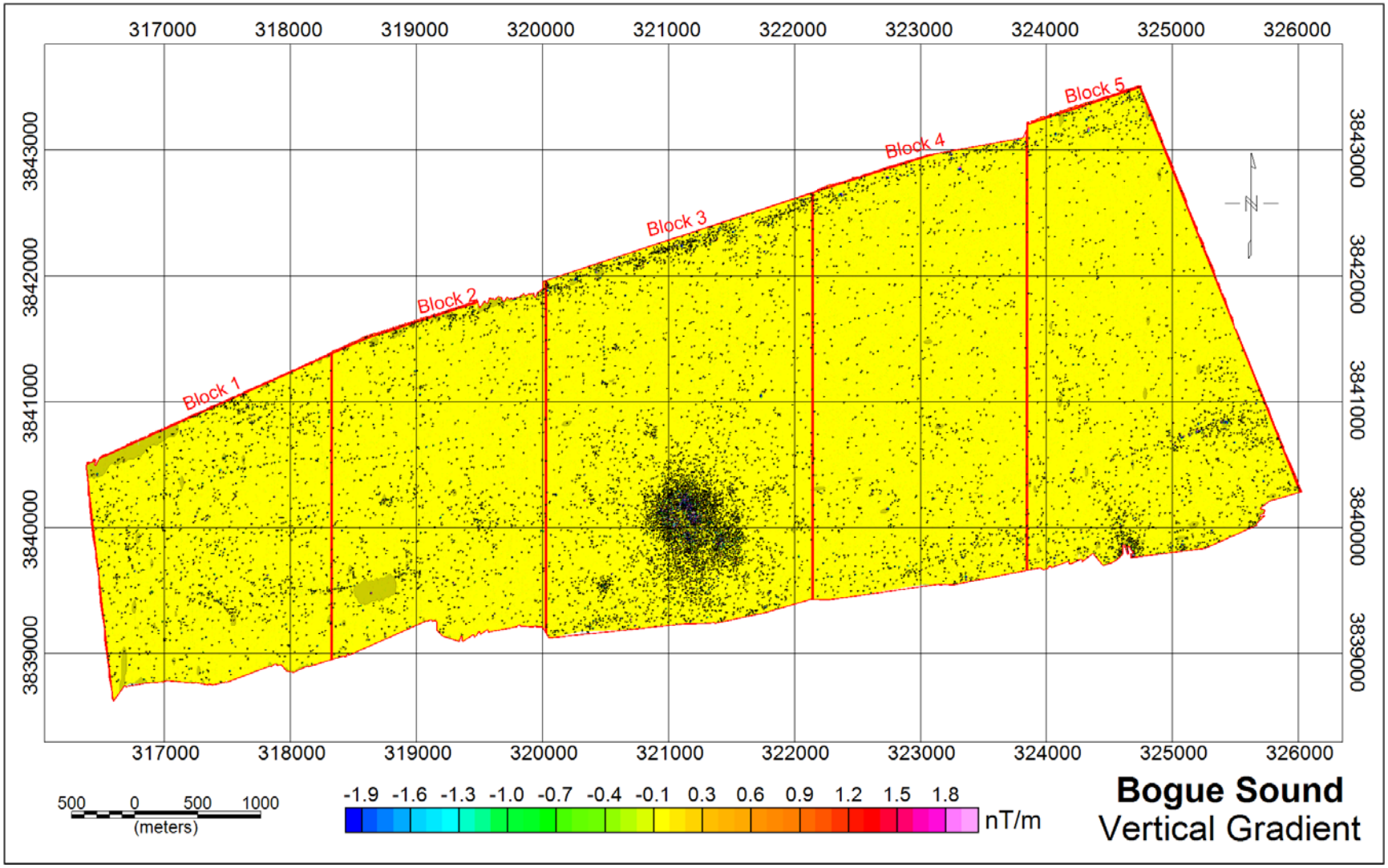


Figure 6.6: Detected anomalies overlaid on georeferenced VG map image. Shaded sections represent areas flown above 4m altitude. Survey blocks are outlined in red.

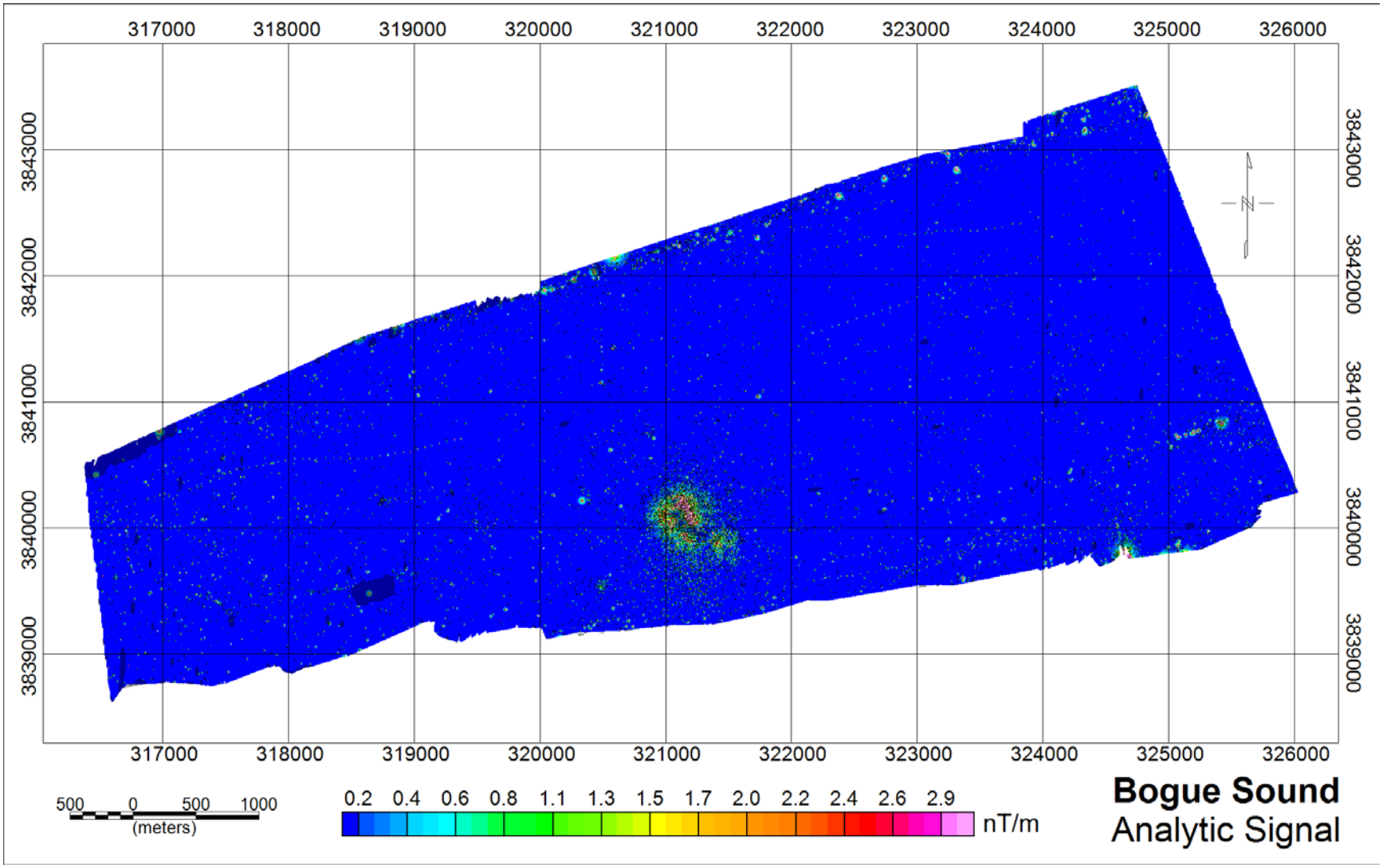


Figure 6.7: Detected anomalies overlaid on georeferenced AS map image. Shaded sections represent areas flown above 4m altitude.

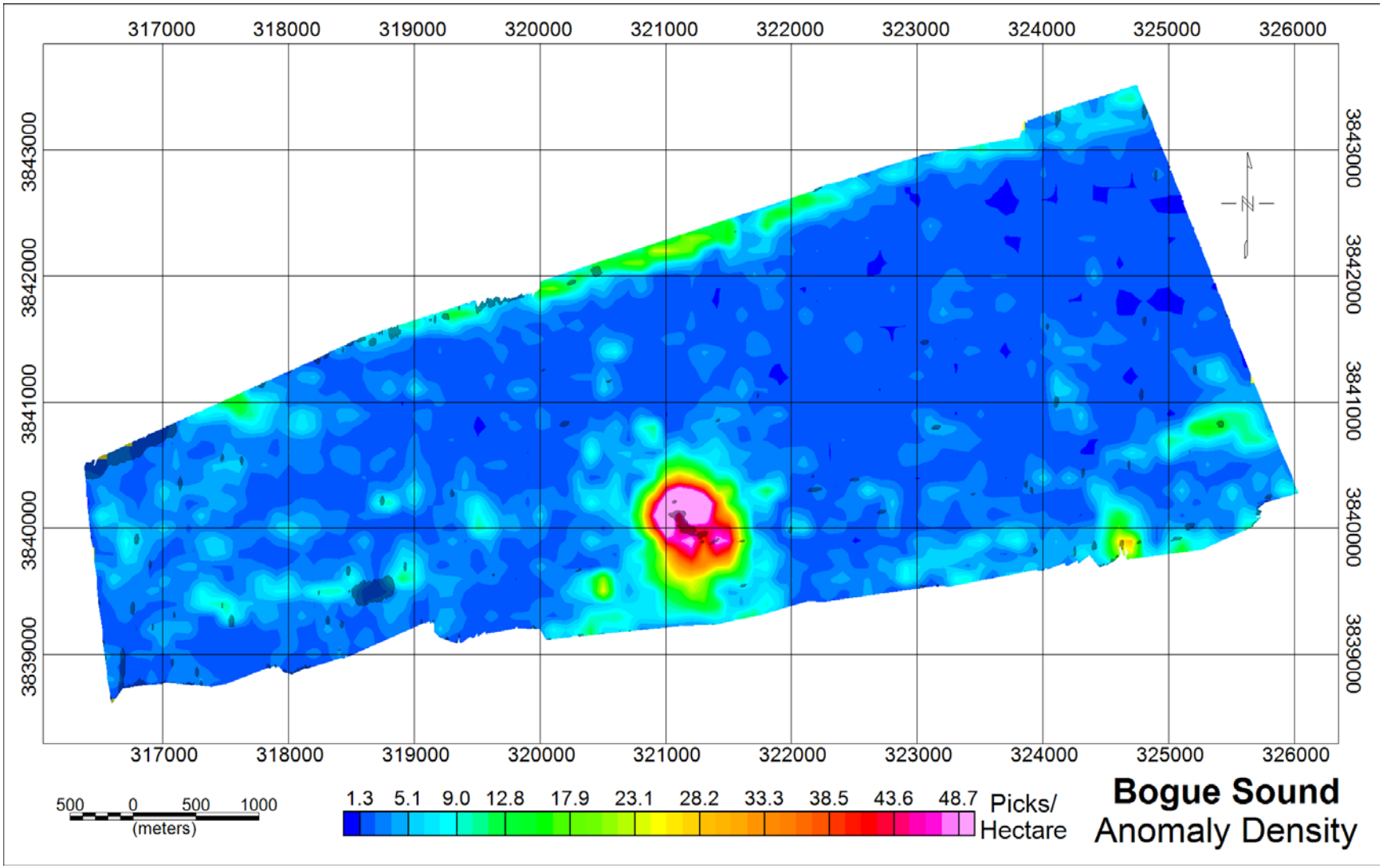


Figure 6.8: Anomaly density map of Bogue Sound. Colors represent variability of anomaly density in anomalies per hectare without reference to anomaly amplitude, except that no anomalies smaller than 0.331 nT/m were included in the calculation.

7. Data and Image Archive

Original Geosoft format files are provided as the principal digital format. This includes database files with georeferenced point data (GDB) and interpolated grid files (GRD). A free data viewer is included with the digital data and is also available online at www.geosoft.com (Oasis Montaj Viewer). Map data are provided as image files in Tiff format in addition to the smaller reproductions included in this report. These maps are provided with a digital resolution of 300 dpi. GeoTiff format files of the geophysical data alone are provided for quick inclusion into other GIS platforms, but the resolution is not as high as the original Geosoft GRD files. Image files are named as follows:

Bogue Sound vg.tif	Vertical gradient map
Bogue Sound vg.grd	Vertical gradient grid (Geosoft format)
Bogue Sound vg only.tif	Vertical gradient map with data only (for GIS import)
Bogue Sound as.tif	Analytic signal map
Bogue Sound as.grd	Analytic signal grid (Geosoft format)
Bogue Sound as only.tif	Analytic signal map with data only (for GIS import)
Bogue Sound alt.tif	Flight altitude map
Bogue Sound alt.grd	Flight altitude grid (Geosoft format)
Bogue Sound alt only.tif	Flight altitude map with data only (for GIS import)
Bogue Sound Density.tif	Anomaly density (picks per hectare)
Bogue Sound Density.grd	Anomaly density (picks per hectare) (Geosoft format)
Bogue Sound Density only.tif	Anomaly density (picks per hectare) (for GIS import)
GPO.tif	Calibration line analytic signal with item locations
Bogue Sound as picks.tif	AS map with picks
Bogue Sound picks only.tif	Geotiff of picks only (for GIS import)

Databases are provided in Geosoft format (GDB) and ASCII (xyz) and are the primary data source. They represent the highest data resolution, but have no visual component. Lines in the vertical gradient survey database represent the trace of a single sensor as it travels down the line. Lines are numbered "L####.S", where #### is the survey line number and S is the sensor number (1-8 from left to right across the VG-16 array). Data columns or channels in the vertical gradient databases are bulleted below.

- Xm — Easting coordinate in UTM Zone 18N meters.
- Ym — Northing coordinate in UTM Zone 18N meters.
- hae — Height above ellipsoid.
- alt — Sensor altitude above ground level in meters.
- vg_scrb — Total field magnetic values in nanoTesla per meter.
- line — Flight line number.
- date — Date.

The final data type provided is the anomaly list file (also known as a dig list or pick file) in ASCII format. This file is named "BogueSoundAnomalyList2009.xyz" and contains the following four columns:

- ID Number of the specific analytic signal anomaly
- x X coordinate in meters (UTM zone 18N)
- y Y coordinate in meters (UTM zone 18N)
- as_anom Magnitude of analytic signal anomaly

8. Conclusions

8.1. Summary

Airborne vertical magnetic gradient data were acquired using Battelle's VG-16 system over a 2670 hectare (6600 acre) portion of Bogue Sound, in the vicinity of Wood Island. The purpose of the survey was to perform a wide-area assessment to determine potential areas of concern with respect to past bombing operations. A total of 10,400 magnetic anomalies were detected equal to or above a threshold of 0.331 nT/m. This cutoff level was well above the estimated magnetic noise background of 0.03 nT/m.

8.2. GPO Evaluation

The results from the Geophysical Prove Out (GPO) line at Michael J. Smith Airport demonstrated that the sensitivity of the VG-16 system was adequate for ordnance mapping in Bogue Sound. Six of the seven items in the GPO line were detected on low-level passes 100% of the time. Only the 60mm mortar round was occasionally missed because of the low magnetic response of the type of ordnance. Measurements at various altitudes over the GPO items show that ordnance as small as 81mm mortar rounds are easily detectable at source-sensor separations of less than 3 m, and that artillery and rocket warheads produced detectable anomalies at source-sensor separations of up to 7m.

8.3. Anomaly Distribution

The vast majority of the 10,400 anomalies in Bogue Sound were grouped tightly around BT-2, the training bomb targets on or near Wood Island in a dense cluster of high amplitude magnetic anomalies forming a roughly circular pattern about 400m in diameter. No other large clusters of anomalies appear in the data that suggest significant military training activities.

8.4. Deliverables

Original Geosoft format files are provided as the principal digital format. This includes database files with georeferenced point data (GDB), and interpolated grid files (GRD). Map data are provided as image files in Tiff or GeoTiff format in addition to the smaller reproductions included in this report. The databases in Geosoft (GDB) and ASCII are the primary data source. They represent the highest data resolution, but have no visual component. The final data type provided are anomaly list files (also known as dig list or pick files) in ASCII format.

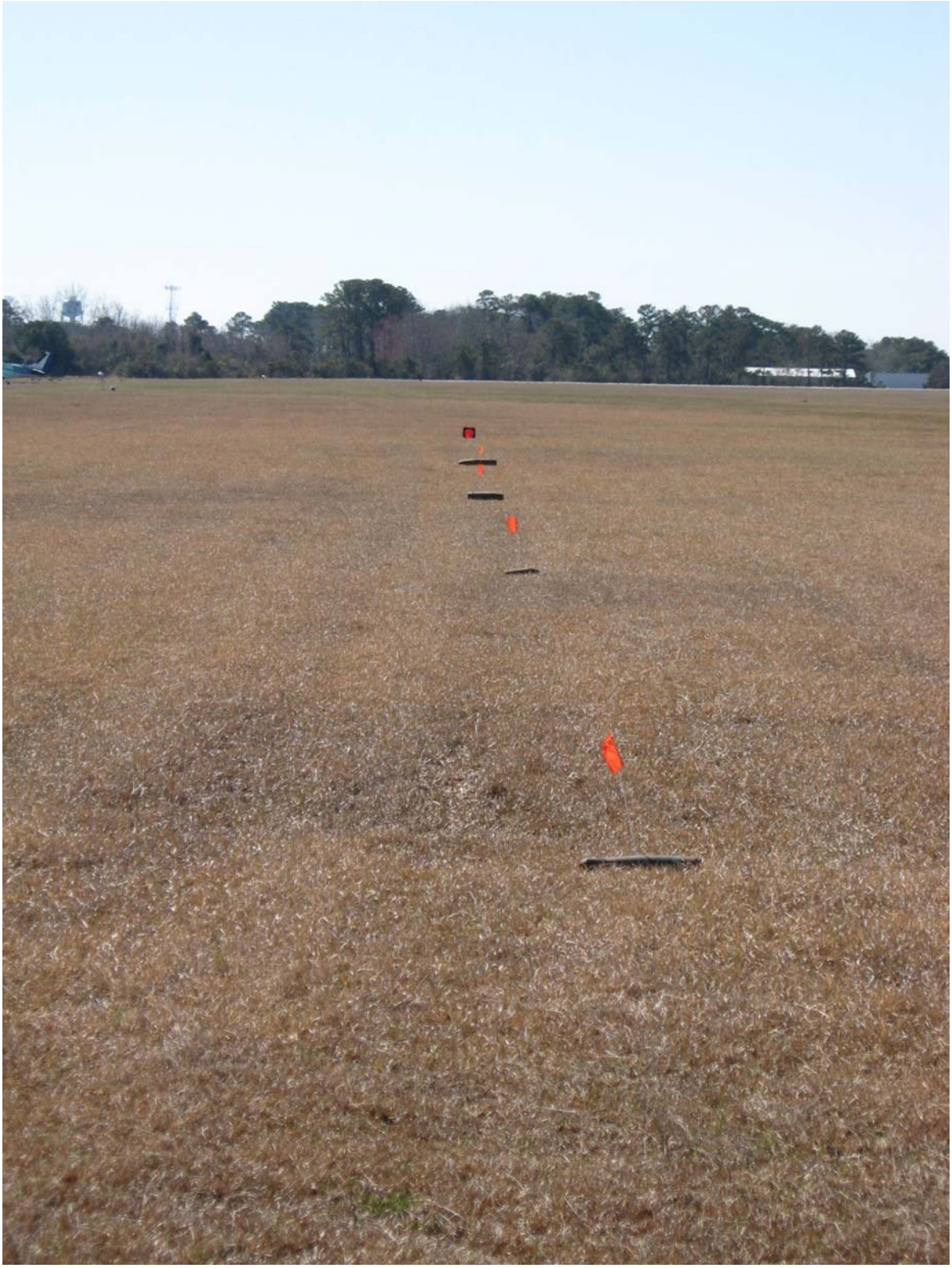
All data presented in this report are suitable for follow-up and other analyses intended to understand the relationship between concentrations of airborne anomalies and the density of UXO at the site. The airborne data are *not* suitable for declaring an area completely free of ordnance contamination, as some ordnance types fall below the detection threshold of the system, and only a percentage of other ordnance types will be detected.

Attachment 1
Photographs

Attachment 1
Photos from Bogue Sound Geophysical Survey

Installation of booms.

Gradiometer pairs on front boom.



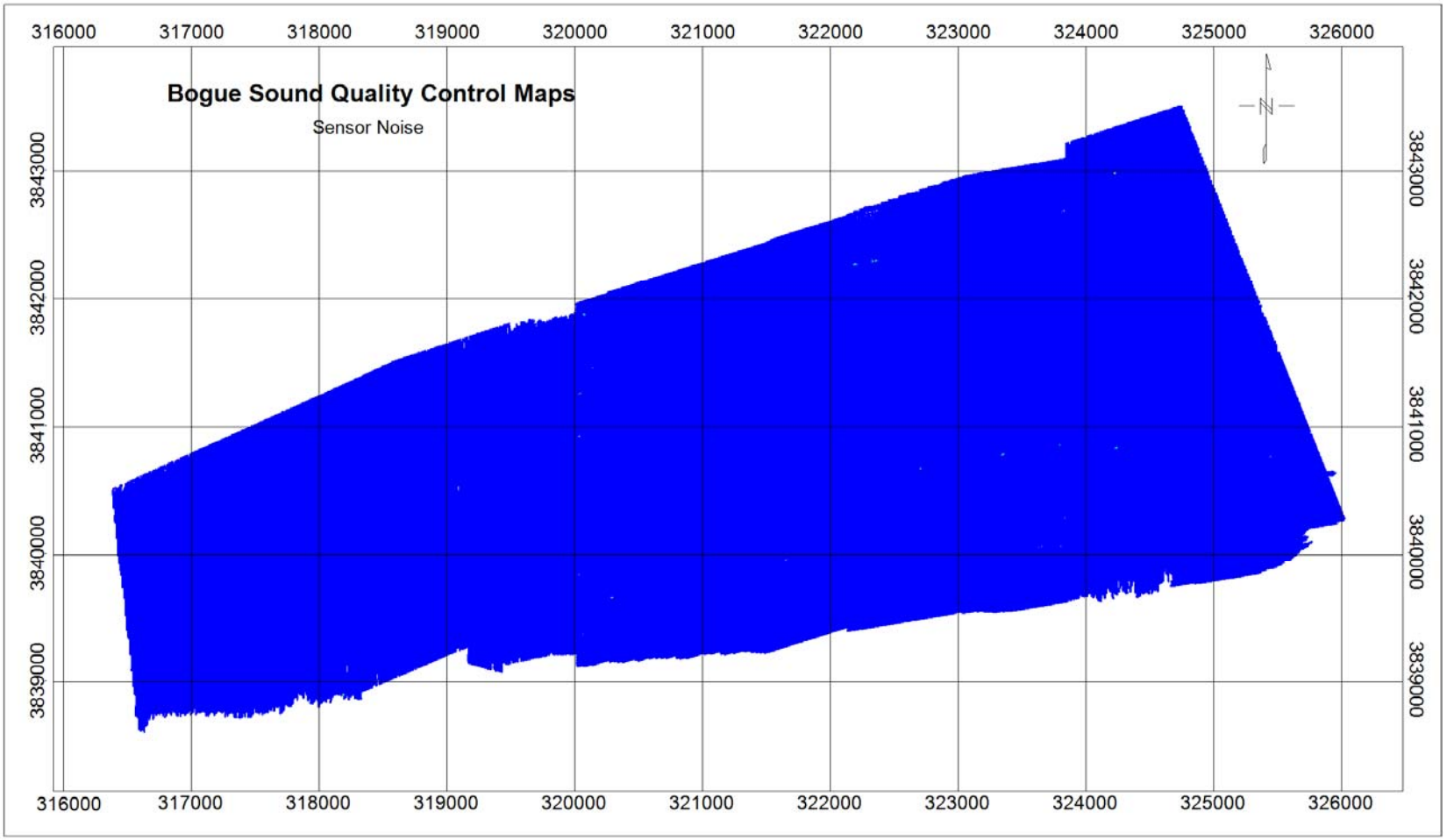
Portion of GPO line at Michael J. Smith Airfield.

VG-16 surveying over Bogue Sound.

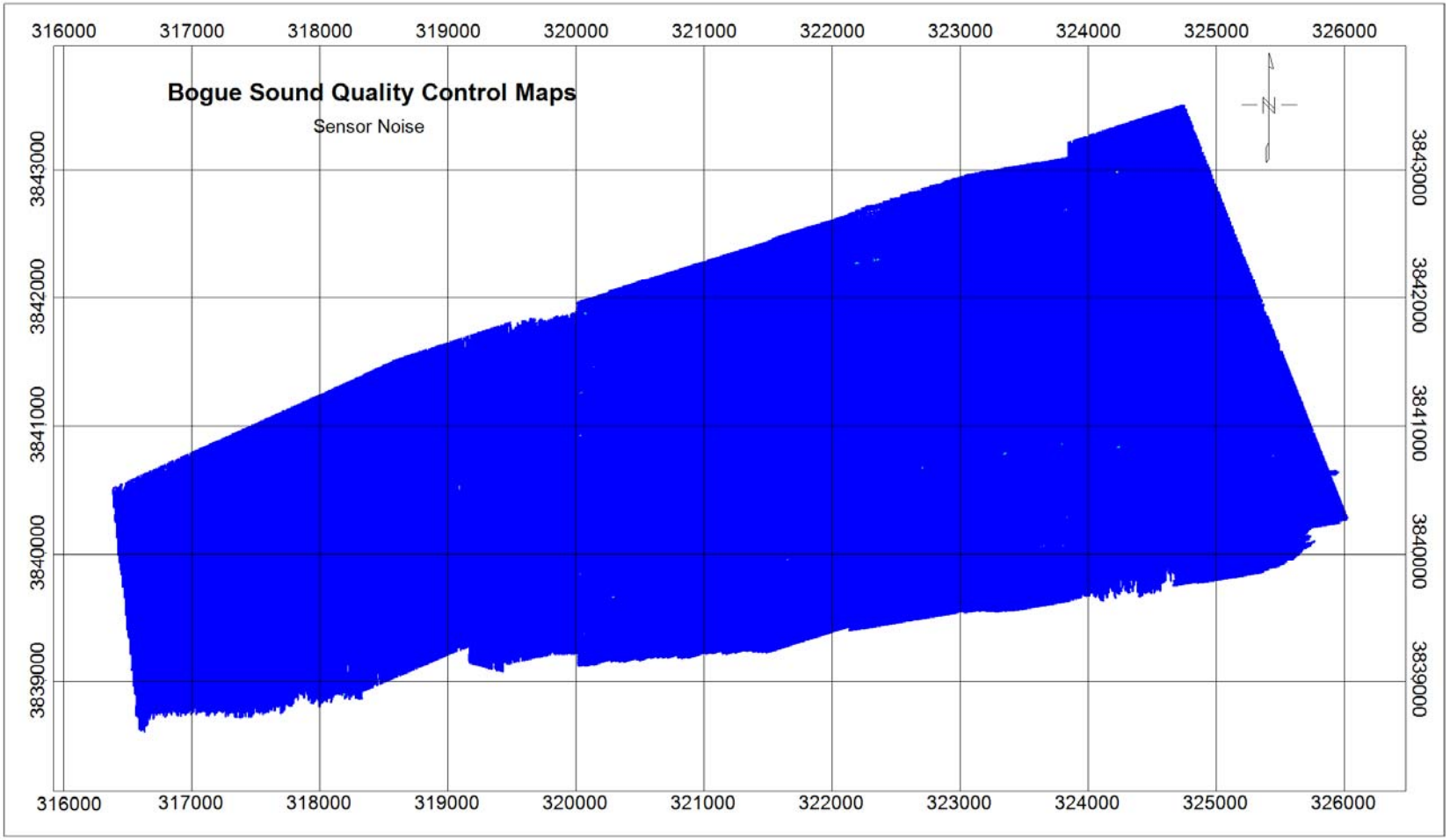
VG-16 surveying over Bogue Sound.

Attachment 2
QC Maps

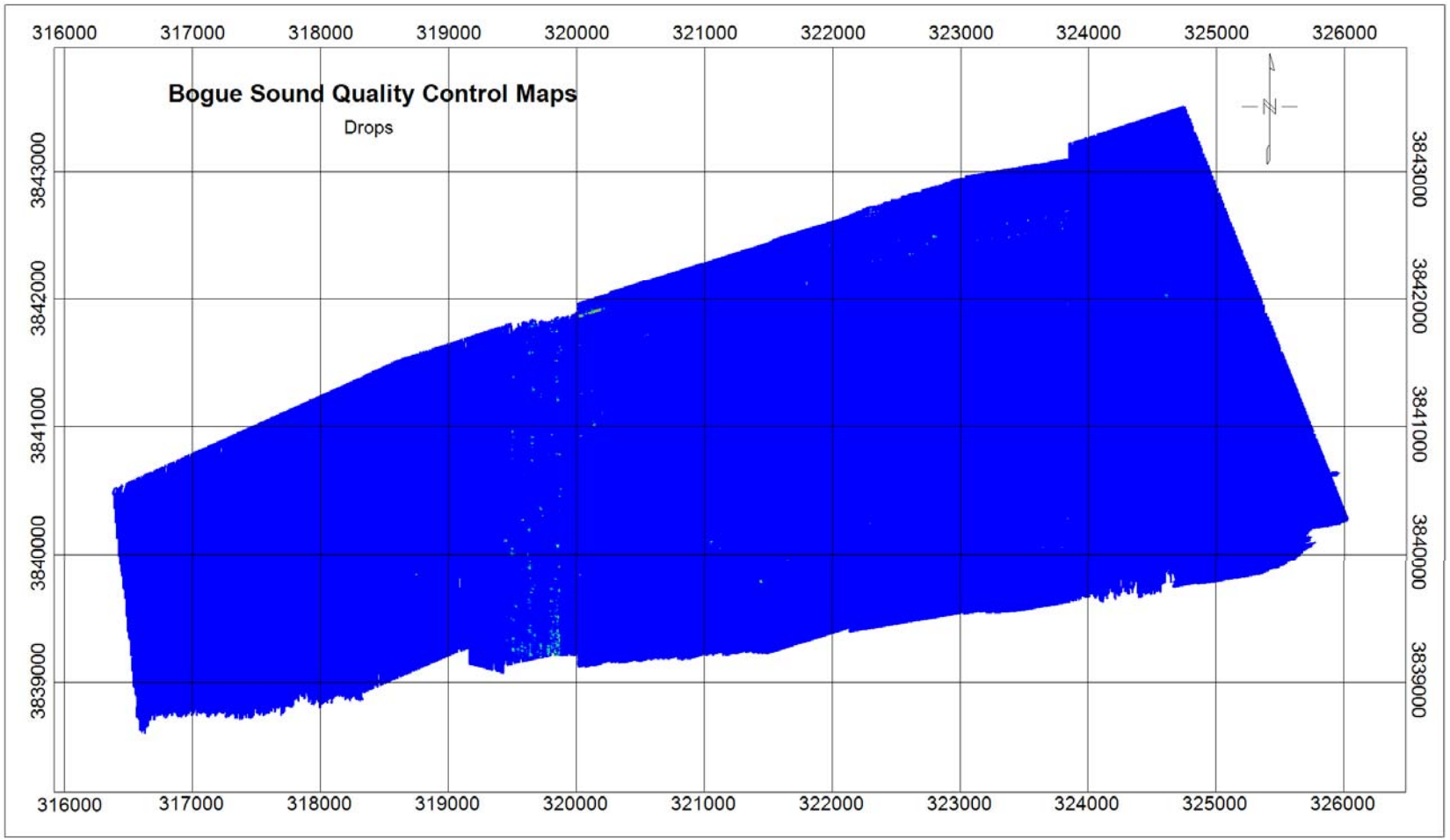
Attachment 2
Quality Control Maps



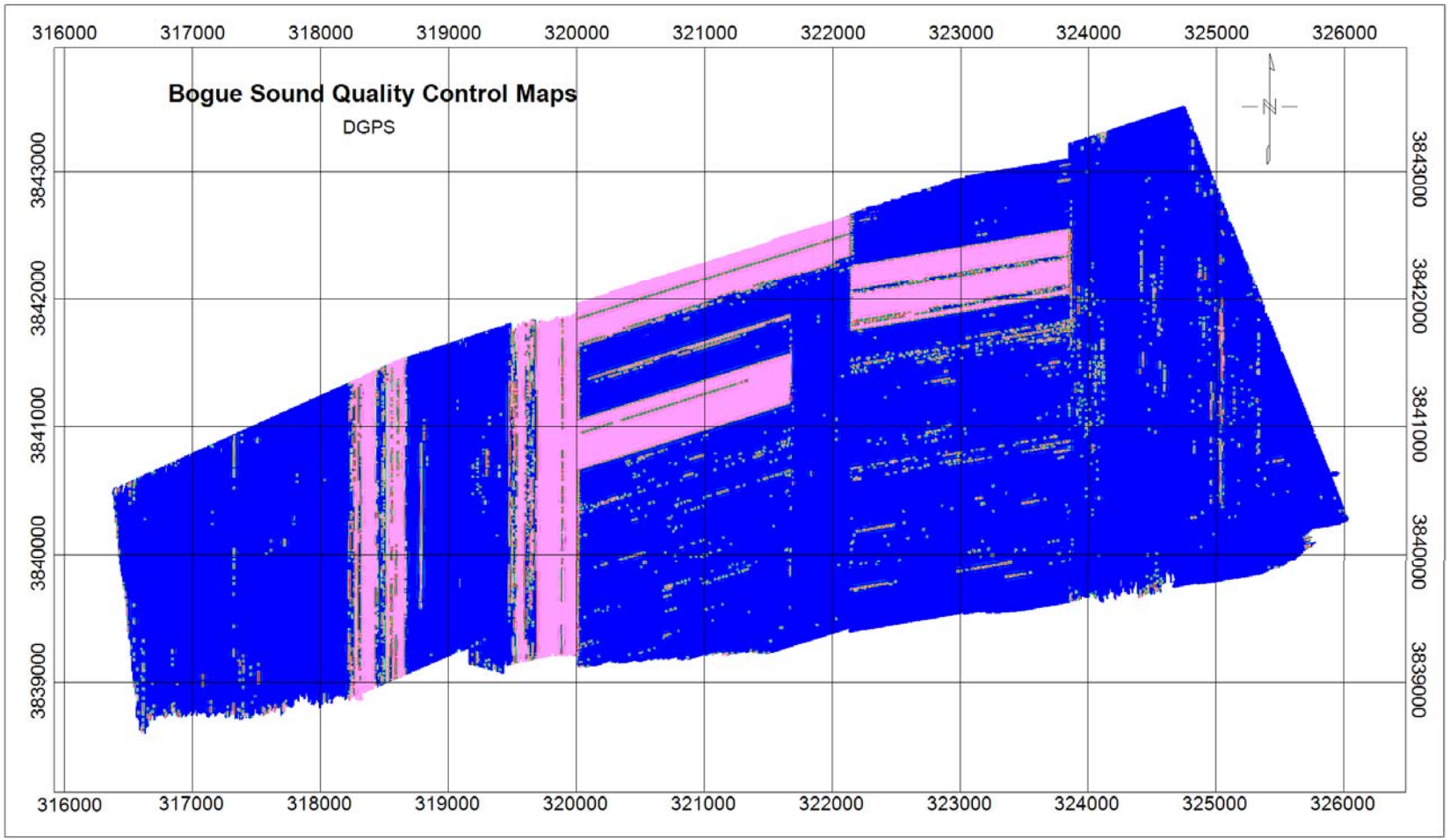
Airspeed quality control map: There are no areas where the speed exceeded our maximum.



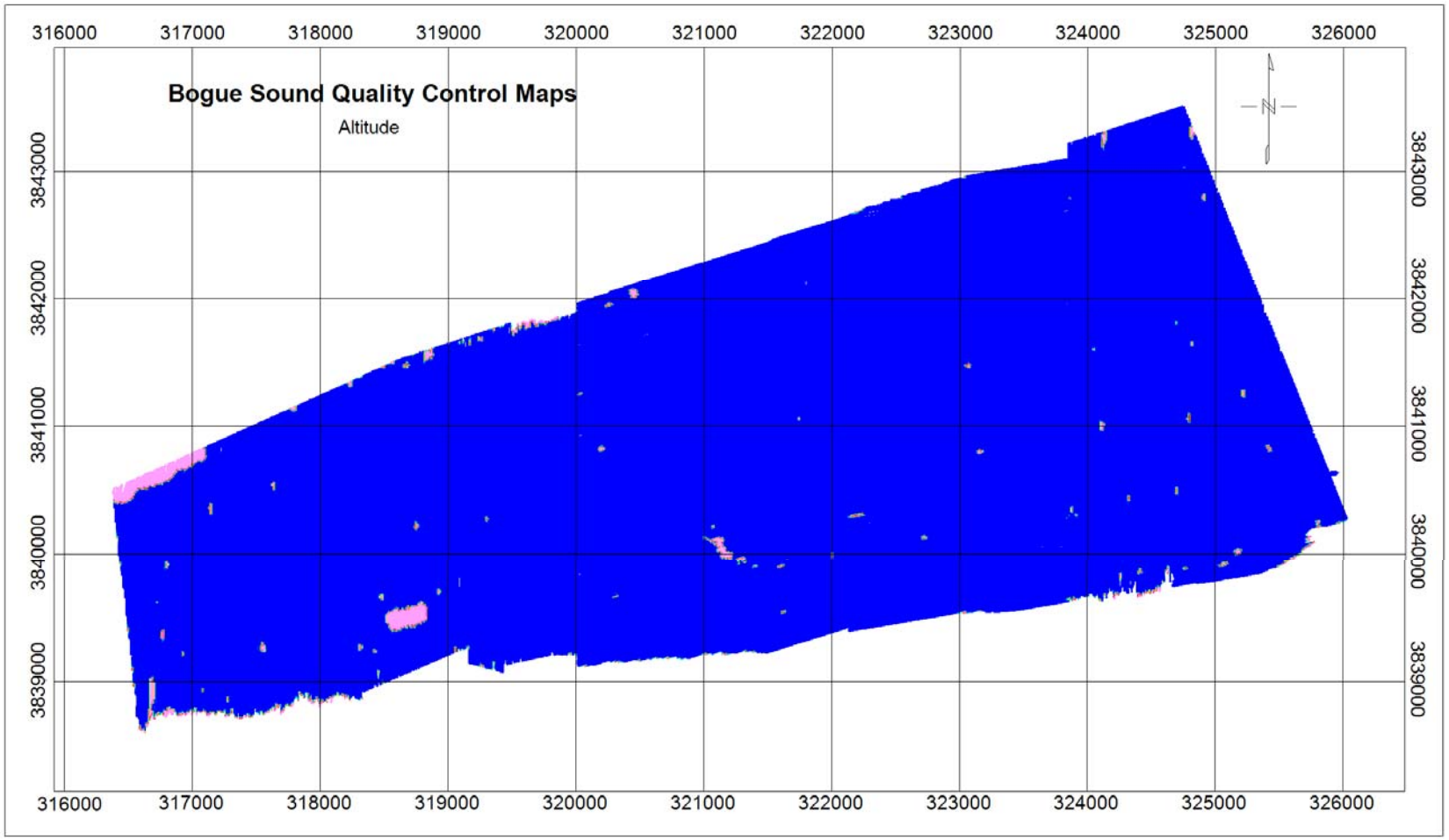
Sensor noise quality control map: There are only a few, very isolated noise QC failures.



Data dropout map: There are very little dropped data. When there is data dropped it is for very short time periods and does not result in lost data coverage.



GPS quality control map: The low level flight over water caused multi-path effects that degraded GPS data quality. Positional accuracy is still about 1 m even in the degraded areas.

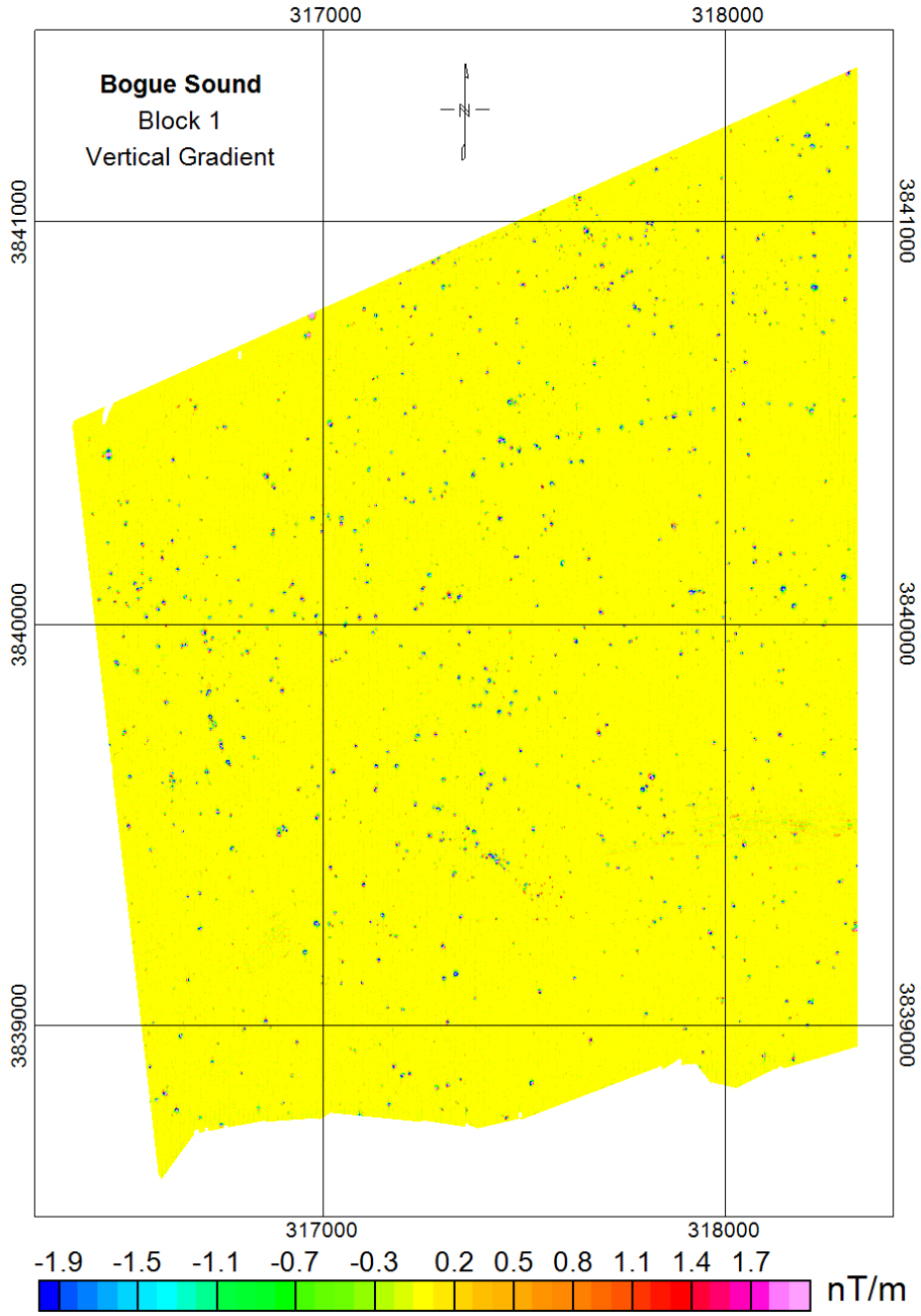


Altitude quality control map: There are areas where the altitude exceeded the 5m QC threshold, but these are all caused by obstacles such as duck hunting stands, islands, docks or other such features.

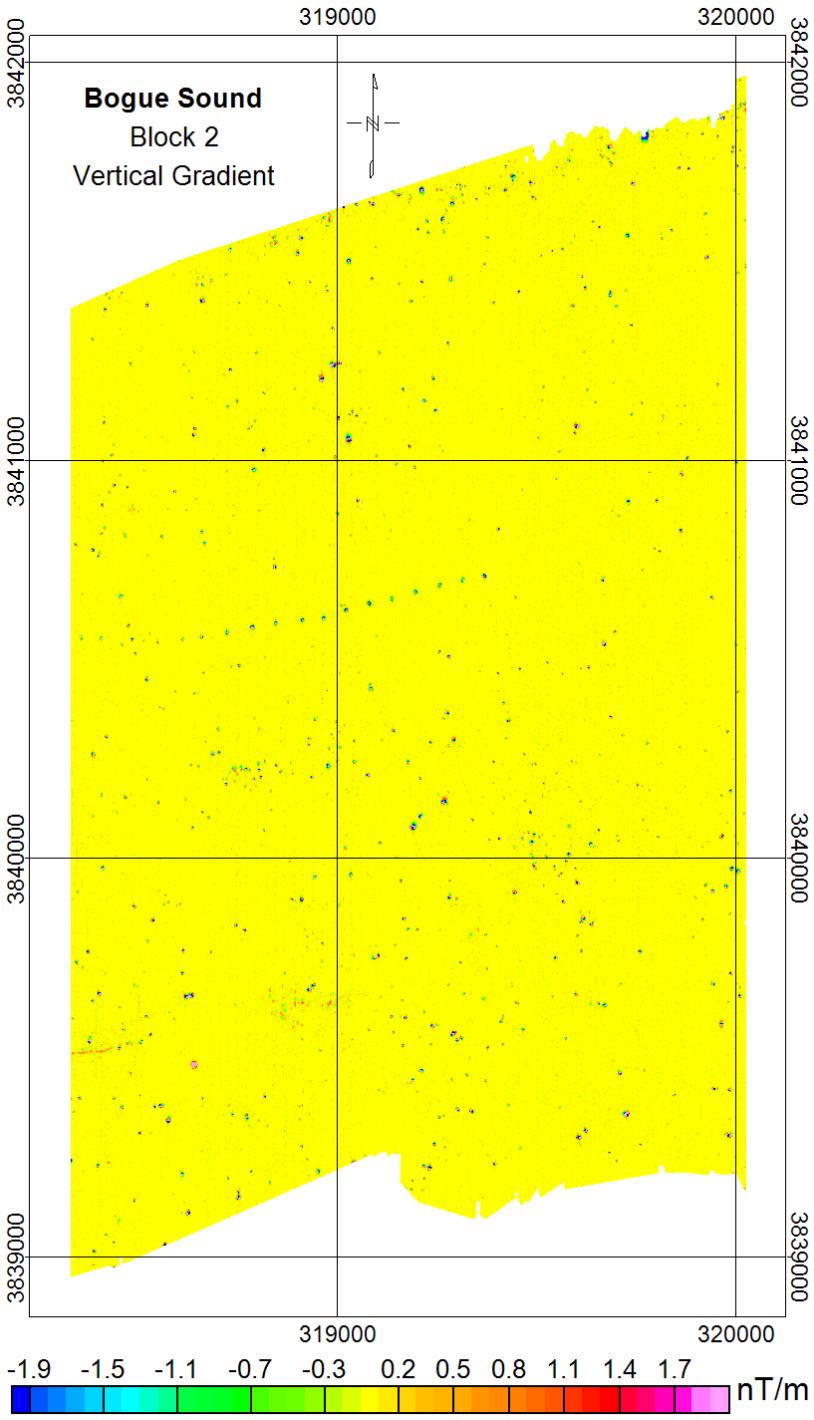
Attachment 3
VG Maps of Sub-Areas

Attachment 3
Vertical Gradient Plots over Survey Blocks

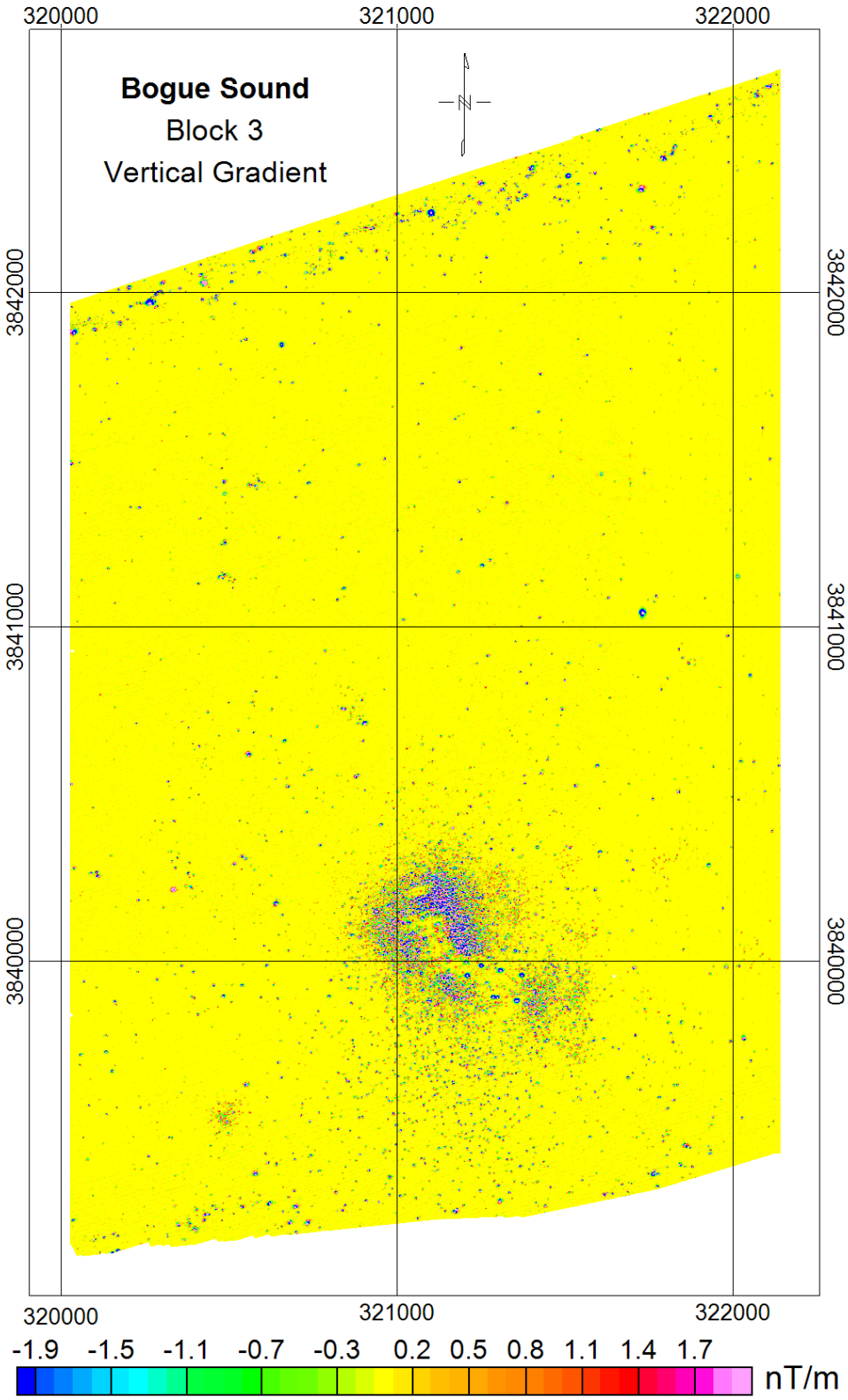
This attachment shows vertical magnetic gradient maps of each of the five survey blocks in Bogue Sound.



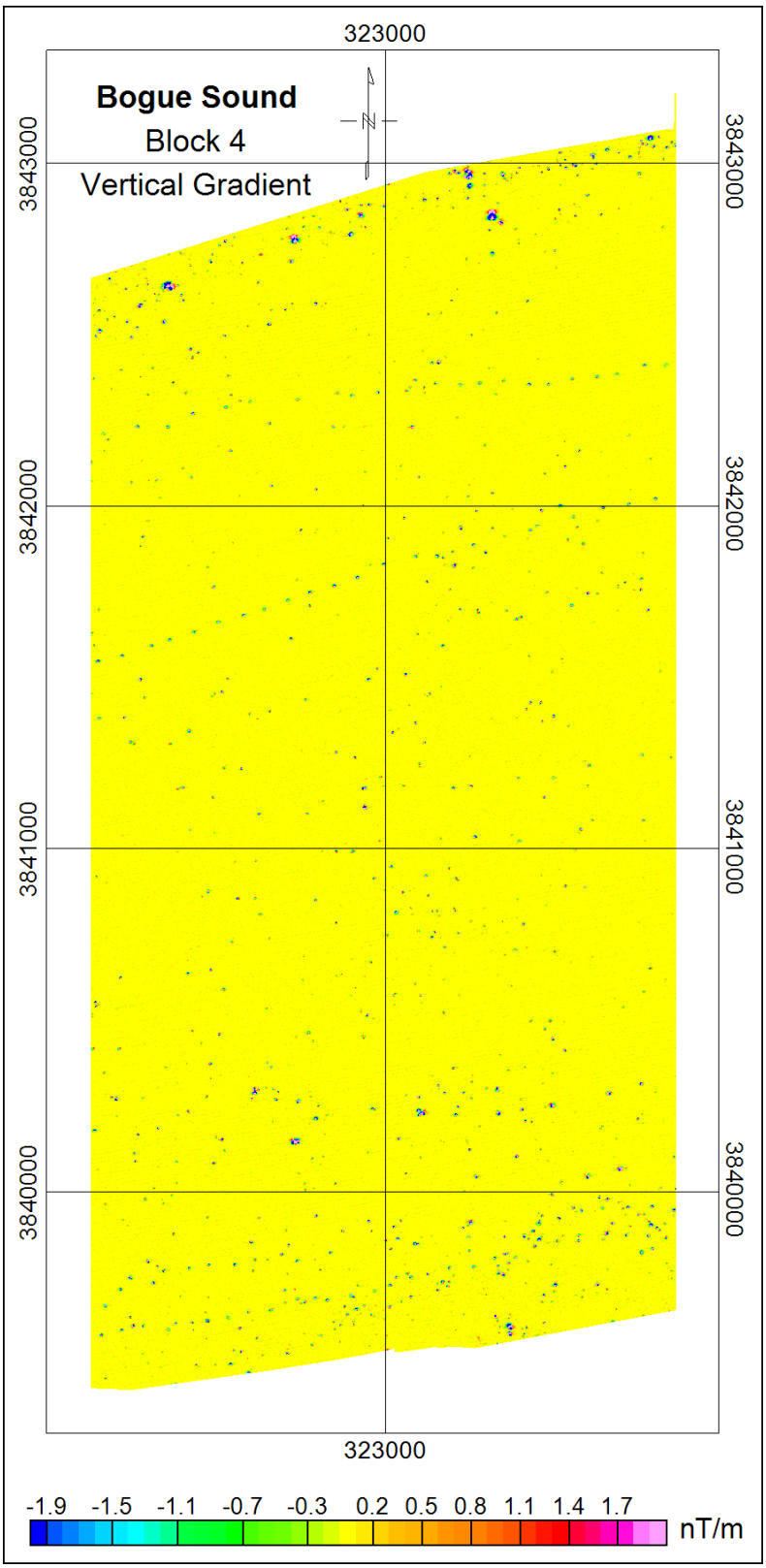
Block 1, the westernmost survey area in Bogue Sound.



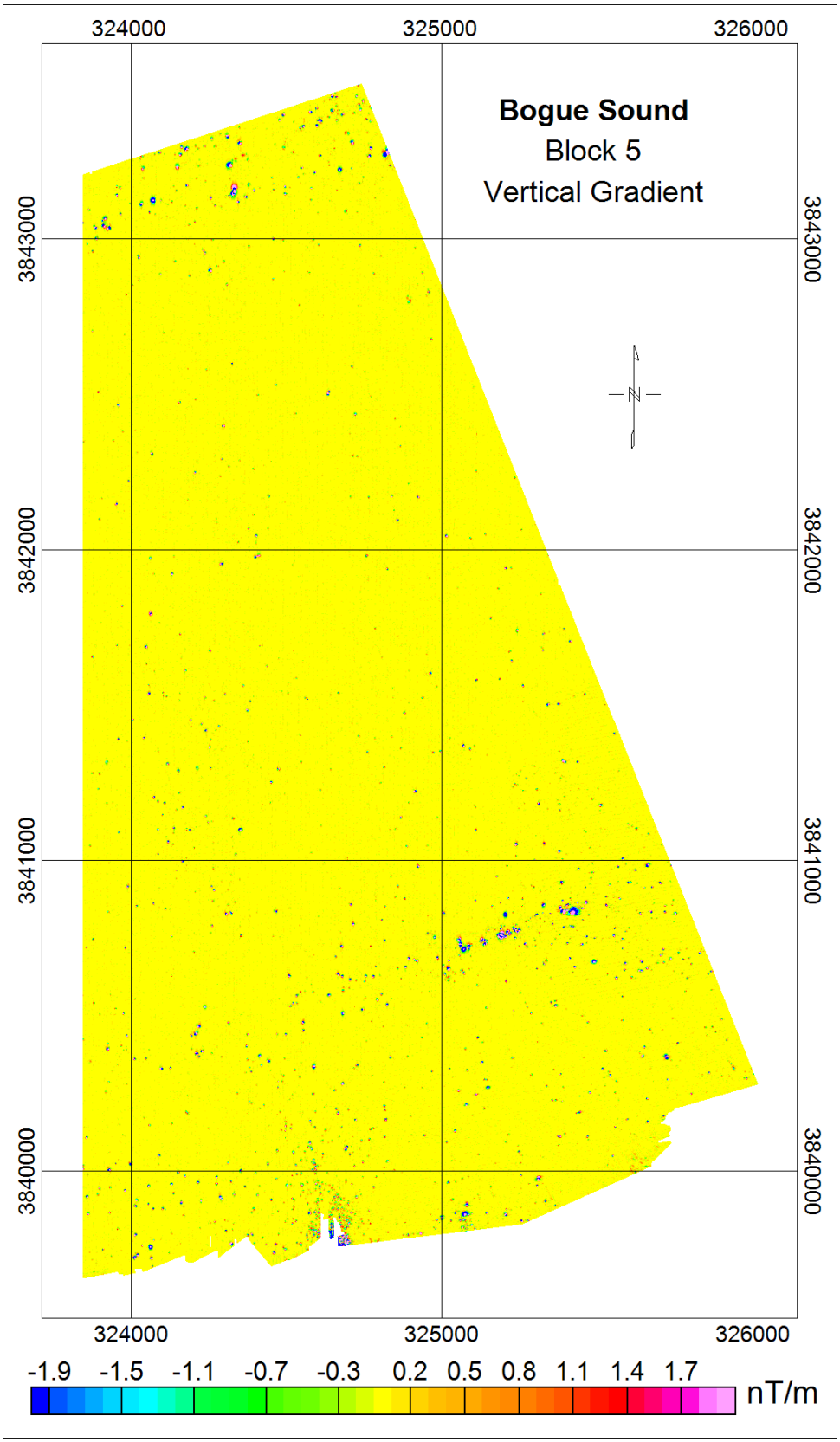
Block 2, located immediately east of Block 1.



Block 3, the central survey area encompassing Wood Island and Bomb Target 2.



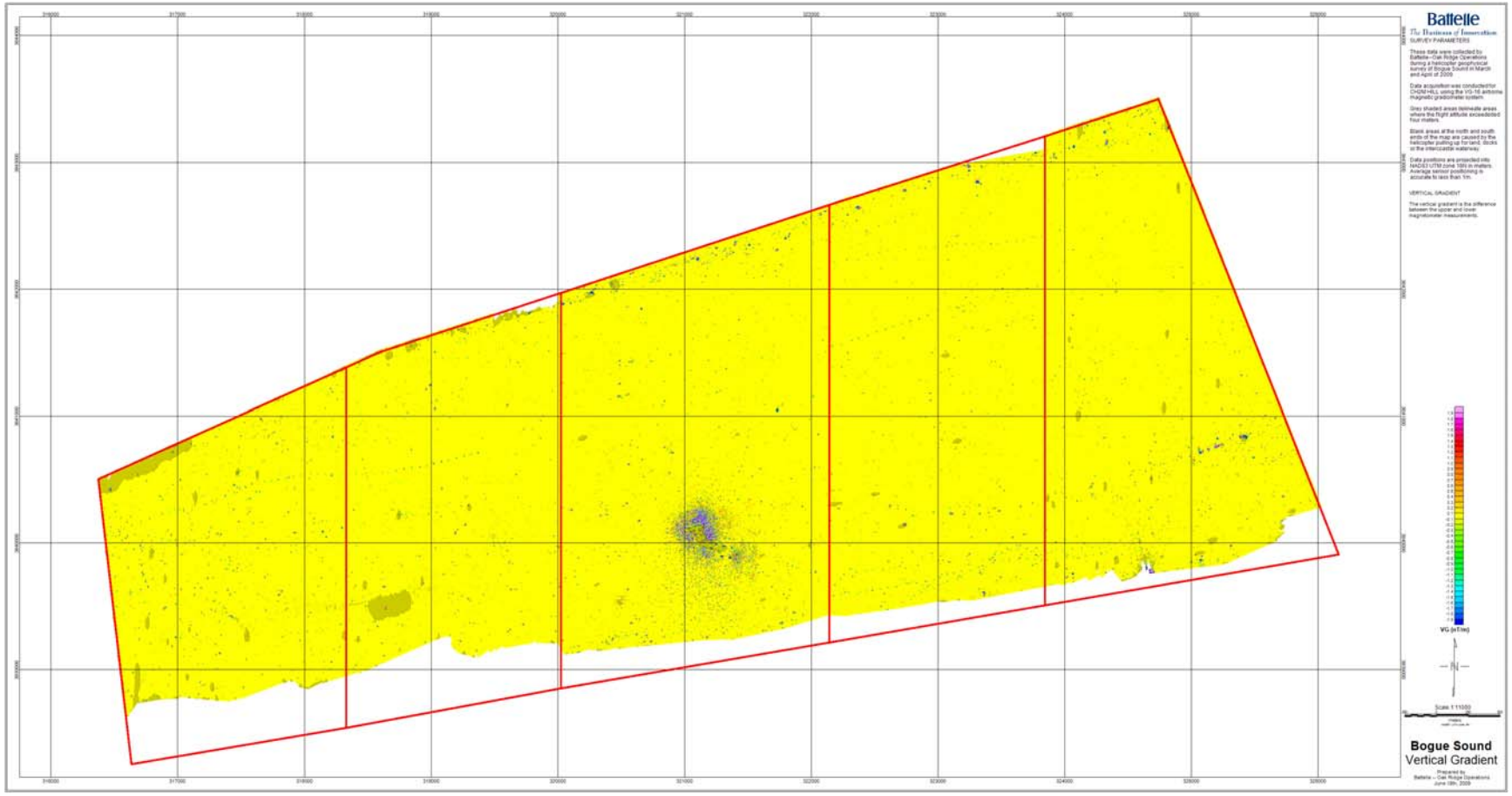
Block 4, located immediately east of Block 3.



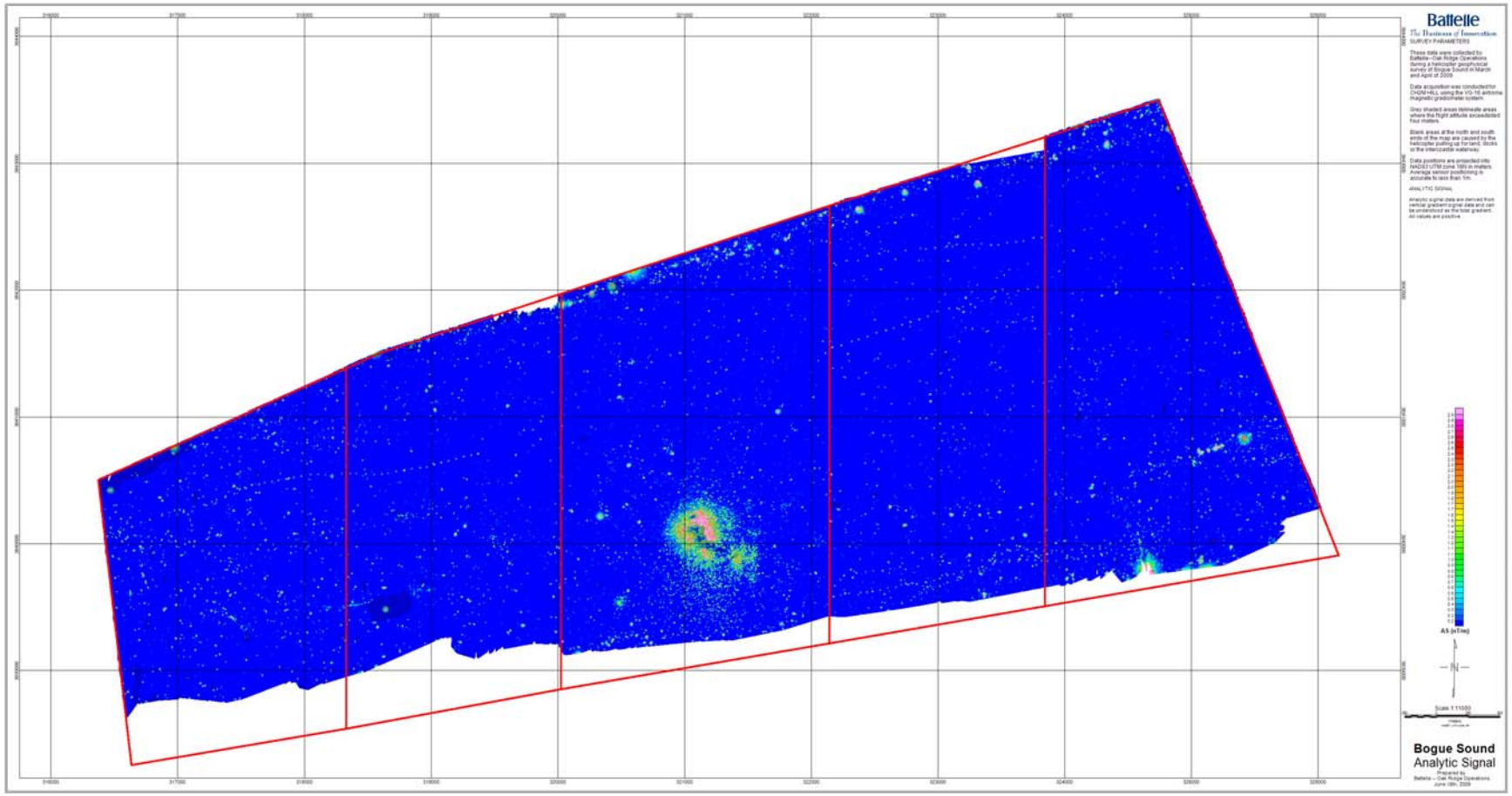
Block 5, the easternmost survey area in Bogue Sound.

Attachment 4
Geophysical Maps of Bogue Sound

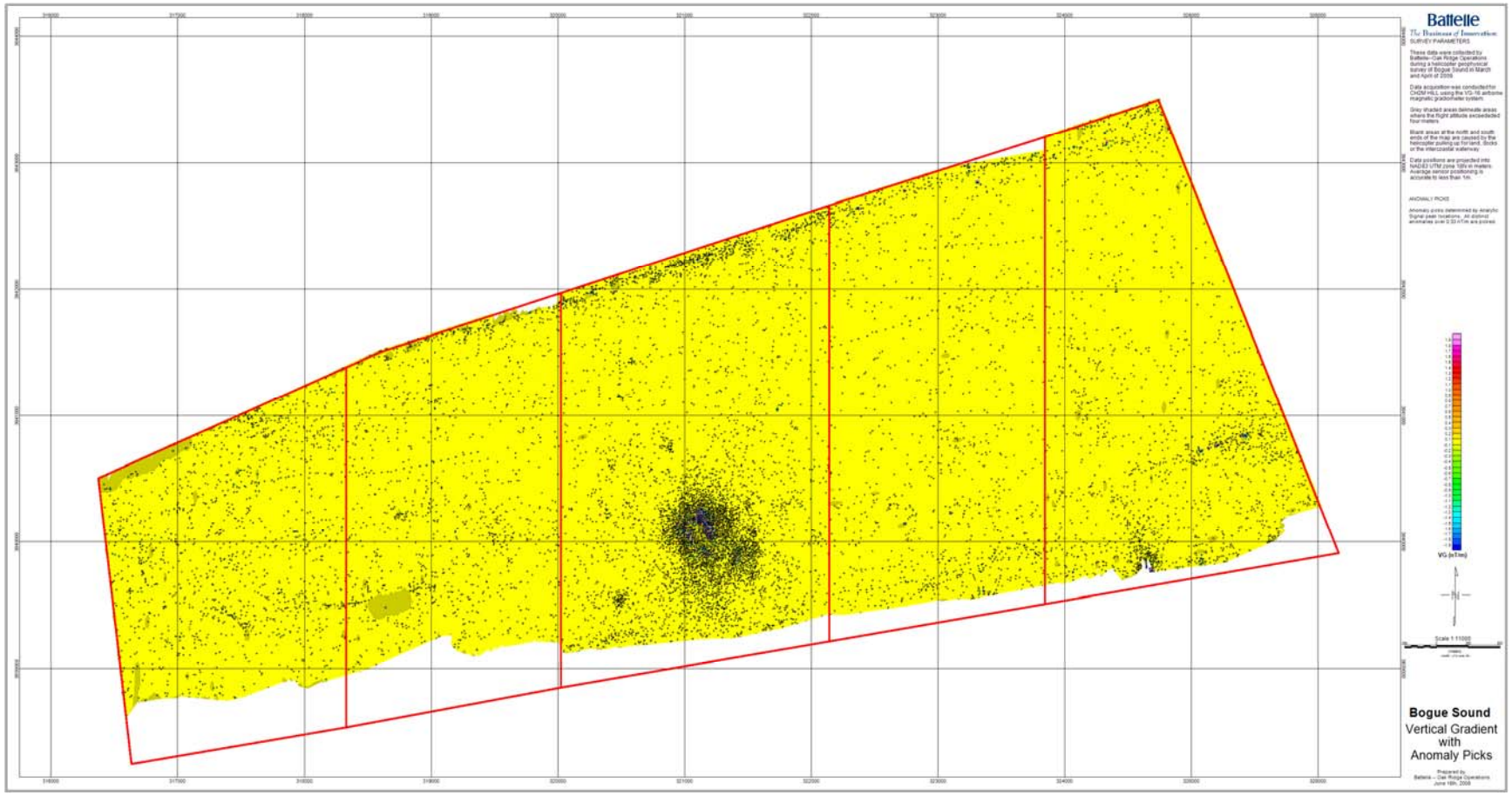
Attachment 4
Airborne Geophysical Survey Maps of Bogue Sound



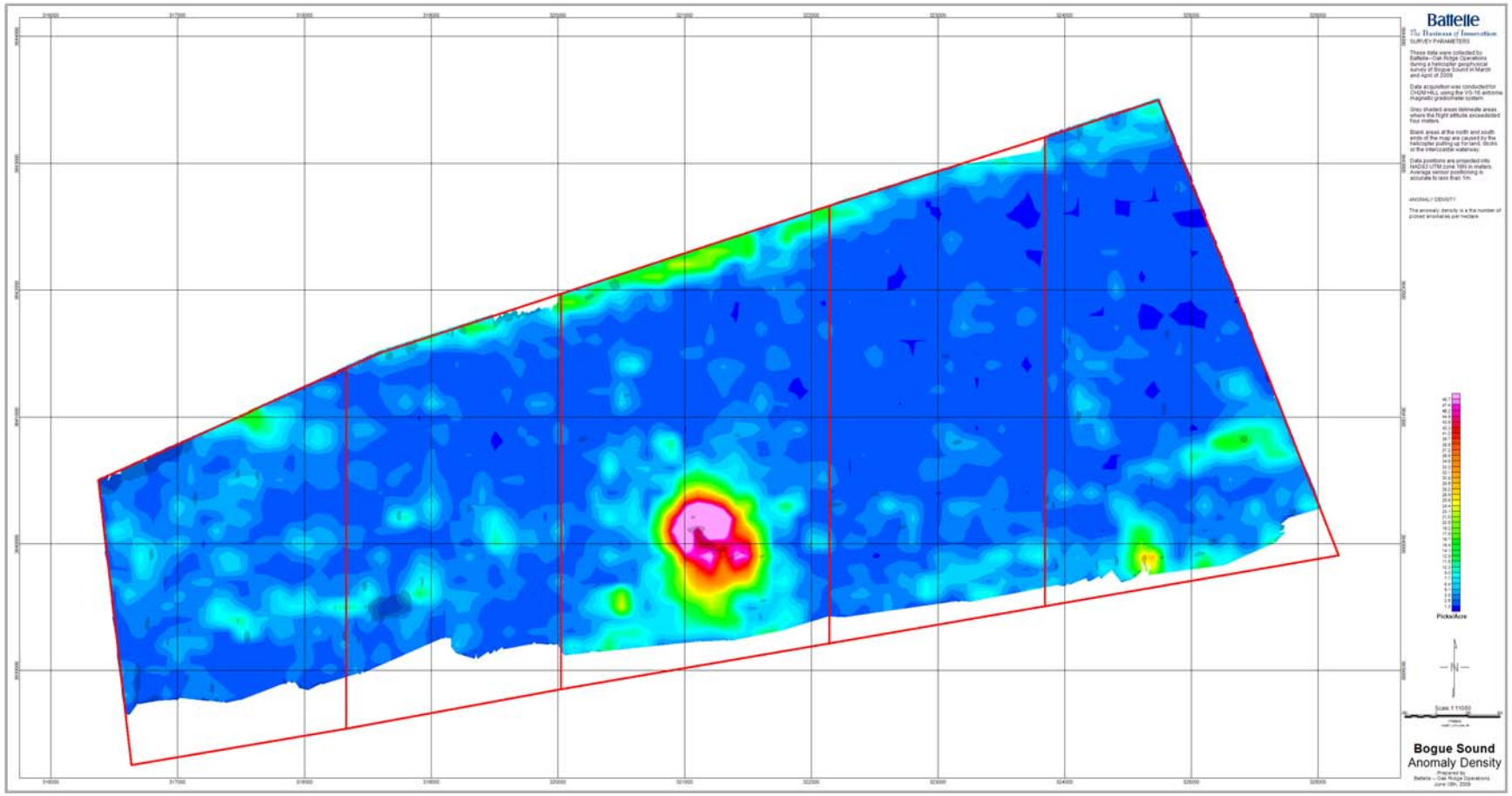
Vertical magnetic gradient map of Bogue Sound in the vicinity of Bomb Target 2.



Analytic signal map derived from vertical magnetic gradient map.



Vertical magnetic gradient map of Bogue Sound with anomaly locations overlain.



Anomaly density map derived from anomaly picks in previous map.

Attachment 5
Daily Activities Log

Attachment 5
Daily Activity Log with Standby and Staffing Notes

This log summarizes project activities. Its primary purpose is to record survey progress and to flag events that may impact progress. Detailed notes of specific meetings or decisions are maintained elsewhere. Notes that have an impact on the billing or deliverables are indicated in red.

Down-days for weather or standby are defined as "one (1) hour or less of flight time during a standard survey project day". Survey days do not include days for mobilization, installation, calibration or reflights. This provides sufficient time for one reconnaissance flight in marginal weather conditions to make an attempt at data collection, but is less than half a single production flight. Provision was also made in the contract for half days, which were defined as "more than one (1) but less than five (5) hours of flight time".

Down-days may be the result of unsafe weather conditions (including rain, fog, high winds or glassy water conditions), maintenance (equipment failure or regularly scheduled helicopter maintenance) or base activities (limited or no site access due to base activities). The onus for each down-day has been attributed to either Battelle or CH2M HILL, depending on the circumstances. There were several down-days caused by a structural failure of the airborne system, and weather days during the collection of reflight lines which Battelle must accept. Similarly, there were several down-days attributed to weather during regular survey days that CH2M HILL must accept. These are all included in the summary below.

Housing and per diem costs have been tabulated for each day. Crew rotations have been noted in the logs and the number of staff-days have been itemized for each survey day. Down days for maintenance and reflights show zero housing costs because these costs are borne by Battelle. Full standby days show zero housing costs because these costs have been included in the standby rate. Half standby days show half the number of staff because half of these costs are covered by the half-day standby rate.

Summary of down-days attributable to Battelle

23-March-09	maintenance, 1.0 flt hrs	full day	
24-March-09	maintenance, 0.0 flt hrs	full day	
25-March-09	maintenance, 0.0 flt hrs	full day	
20-April-09	weather, reflights, 2.0 flt hrs		half day
21-April-09	weather, reflights, 2.4 flt hrs		half day

Summary of down-days attributable to CH2M HILL

06-March-09	weather, 3.8 flt hrs		half day	LB, JS
11-March-09	weather, 1.8 flt hrs		half day	LB, JS
12-March-09	weather, 0.9 flt hrs	full day		LB, JS
13-March-09	weather, 0.0 flt hrs	full day		LB, JS
14-March-09	weather, 3.0 flt hrs		half day	LB, JS
15-March-09	weather, 0.7 flt hrs	full day		LB, JS
16-March-09	weather, 1.3 flt hrs		half day	LB, JS
17-March-09	weather, 4.8 flt hrs		half day	LB, JS
20-March-09	weather, 0.8 flt hrs	full day		LB, JS
21-March-09	weather, 4.3 flt hrs		half day	LB, JS
28-March-09	weather, 0.0 flt hrs	full day		JG
29-March-09	weather, 0.0 flt hrs	full day		JG
30-March-09	weather, 2.0 flt hrs		half day	JG
1-April-09	weather, 0.0 flt hrs	full day		JG
2-April-09	weather, 0.7 flt hrs	full day		JG
3-April-09	weather, 0.0 flt hrs	full day		JG
4-April-09	weather, 1.2 flt hrs		half day	JG
6-April-09	weather, 0.0 flt hrs	full day		JG
7-April-09	weather, 0.0 flt hrs	full day		JG
8-April-09	weather, 1.0 flt hrs	full day		JG
9-March-09	weather, 2.9 flt hrs		half day	JG
10-April-09	weather, 1.5 flt hrs		half day	JG
11-April-09	weather, 1.5 flt hrs		half day	JG
14-April-09	weather, 1.5 flt hrs		half day	JG
15-April-09	weather, 4.9 flt hrs		half day	JG, JS
16-April-09	weather, 0.0 flt hrs	full day		JG, JS
17-April-09	weather, 2.5 flt hrs		half day	JS
19-April-09	weather, 1.8 flt hrs		half day	JS

Standby 1: 13 full days
Standby 2: 15 half days

Housing/per diem: 120.5 staff days total attributable to CH2M HILL

Details of daily activities:

Date	02-March-09	
Primary Activity	Mobilization	2.5 flt hrs
Survey Block	n/a	5 days housing
Notes	Battelle and National Helicopter field crew depart for site.	
Flags	-	

Date	03-March-09	
Primary Activity	Mobilization	4.9 flt hrs
Survey Block	n/a	5 days housing
Notes	Battelle and National Helicopter field crew arrive on site (Les Beard, Jacob Sheehan, Doug Christie, Marcus Watson, Milos Kapetonovic)	
Flags	-	

Date	04-March-09	
Primary Activity	Installation	0.0 flt hrs
Survey Block	n/a	5 days housing
Notes	Safety briefing with CH2M HILL. Complete installation of VG16 system.	
Flags	-	

Date	05-March-09	
Primary Activity	Kick-off, Calibration, GPO	3.3 flt hrs
Survey Block	n/a	5 days housing
Notes	Kick-off meeting with CH2M HILL, Navy, Marines. Check flight Compensation flight GPO flight Reconnaissance flight of Bogue Sound Survey flights over Block 3	
Flags	-	

Date	06-March-09	
Primary Activity	Survey	3.8 flt hrs – CH2M HILL
Survey Block	3	2.5 days housing (standby)
Notes	QC anchor item augmented to match 81mm signature strength. Survey Block 3 Down for wind ~1pm	
Flags	-half day for weather	

Date	07-March-09	
Primary Activity	Survey	5.1 flt hrs
Survey Block	3	5 days housing
Notes	Survey Block 3	
Flags	-	

Date	08-March-09	
Primary Activity	Survey	5.2 flt hrs
Survey Block	3	5 days housing
Notes	Survey Block 3	
Flags	-	

Date	09-March-09	
Primary Activity	Survey	5.5 flt hrs
Survey Block	3	5 days housing
Notes	Survey Block 3	
Flags	-	

Date	10-March-09	
Primary Activity	Survey	5.9 flt hrs
Survey Block	3	5 days housing
Notes	Survey Block 3	
Flags	-	

Date	11-March-09	
Primary Activity	Survey	1.8 flt hrs – CH2M HILL
Survey Block	2	2.5 days housing (standby)
Notes	One flight attempt on Block 2 Down for wind 10am	
Flags	-half down day for weather	

Date	12-March-09	
Primary Activity	Survey	0.9 flt hrs – CH2M HILL
Survey Block	n/a	0 days housing (standby)
Notes	Down for wind 9am. One attempted flt.	
Flags	-full down day for weather	

Date	13-March-09	
Primary Activity	Survey	0.0 flt hrs – CH2M HILL
Survey Block	n/a	0 days housing (standby)
Notes	Down for wind all day	
Flags	-full down day for wind	

Date	14-March-09	
Primary Activity	Survey	3.0 flt hrs – CH2M HILL
Survey Block	3	2.5 days housing (standby)
Notes	Three flight attempts, only one successful. Survey Block 3	
Flags	-half down day for weather	

Date	15-March-09	
Primary Activity	Survey	0.7 flt hrs – CH2M HILL
Survey Block	n/a	0 days housing (standby)
Notes	Rain all day. One flight attempt.	
Flags	-full down day for weather	

Date	16-March-09	
Primary Activity	Survey	1.3 flt hrs – CH2M HILL
Survey Block	n/a	2.5 days housing (standby)
Notes	Rain and fog all day. One flight attempt on Block 3	
Flags	-half down day for weather	

Date	17-March-09	
Primary Activity	Survey	4.8 flt hrs – CH2M HILL
Survey Block	2	2.5 days housing (standby)
Notes	Morning rain, late start. Survey Block 2	
Flags	-half down day for weather	

Date	18-March-09	
Primary Activity	Survey	7.0 flt hrs
Survey Block	2, 3, 4	5 days housing
Notes	Morning fog, late start. Survey Block 3, 4, 2. Block 3 complete.	
Flags	-	

Date	19-March-09	
Primary Activity	Survey	6.3 flt hrs
Survey Block	2, 4	5 days housing (standby)
Notes	Glassy water conditions on first flight. Survey Block 2, 4.	
Flags	-	

Date	20-March-09	
Primary Activity	Survey	0.8 flt hrs – CH2M HILL
Survey Block	n/a	0 days housing (standby)
Notes	One flight attempt. Down for wind, gusts over 25kts.	
Flags	-full down day for weather	

Date	21-March-09	
Primary Activity	Survey	4.3 flt hrs – CH2M HILL
Survey Block	2, 4	2.5 days housing (standby)
Notes	Winds increasing during the day. Survey Block 2, 4	
Flags	-half down day for weather	

Date	22-March-09	
Primary Activity	Survey	6.0 flt hrs
Survey Block	1, 2, 4	5 days housing
Notes	Survey Block 2, 1, 4 Block 2 complete.	
Flags	-	

Date	23-March-09	
Primary Activity	Survey	1.0 flt hrs – Battelle
Survey Block	4	0 days housing (maintenance)
Notes	Structural problem with VG16 brackets. Aircraft grounded for maintenance. Jeff Gamey arrives to replace Les Beard & Jacob Sheehan	
Flags	-full down day for maintenance	

Date	24-March-09	
Primary Activity	Survey	0.0 flt hrs – Battelle
Survey Block	n/a	0 days housing (maintenance)
Notes	Aircraft grounded for maintenance. Les Beard departs.	
Flags	-full down day for maintenance	

Date	25-March-09	
Primary Activity	Survey	0.0 flt hrs – Battelle
Survey Block	n/a	0 days housing (maintenance)
Notes	Aircraft grounded for maintenance. Aircraft recertified for survey work 5pm. Jacob Sheehan departs	
Flags	-full down day for maintenance	

Date	26-March-09	
Primary Activity	Survey	5.5 flt hrs
Survey Block	1	4 days housing
Notes	Survey Block 1	
Flags	-	

Date	27-March-09	
Primary Activity	Survey	5.9 flt hrs
Survey Block	1	4 days housing
Notes	Glassy water in am, extends to noon. Survey Block 1	
Flags	-	

Date	28-March-09	
Primary Activity	Survey	0.0 flt hrs – CH2M HILL
Survey Block	n/a	0 days housing (standby)
Notes	Marginal to bad weather all day. Rain, mist, thunderstorms.	
Flags	-full down day for weather	

Date	29-March-09	
Primary Activity	Survey	0.0 flt hrs – CH2M HILL
Survey Block	n/a	0 days housing (standby)
Notes	High winds 14-23kts, morning rain.	
Flags	-full down day for weather	

Date	30-March-09	
Primary Activity	Survey	2.0 flt hrs – CH2M HILL
Survey Block	n/a	2.0 days housing (standby)
Notes	High winds 2 attempts at flights, no success	
Flags	-half down day for weather	

Date	31-March-09	
Primary Activity	Survey	7.1 flt hrs
Survey Block	4	4 days housing
Notes	Winds good in am, increasing in pm Wind direction perfect 3 long flights	
Flags	-	

Date	01-April-09	
Primary Activity	Survey	0.0 flt hrs – CH2M HILL
Survey Block	n/a	0 days housing (standby)
Notes	Winds 14kts, SE, gusty, rain	
Flags	-full down day for weather	

Date	02-April-09	
Primary Activity	Survey	0.7 flt hrs – CH2M HILL
Survey Block	n/a	0 days housing (standby)
Notes	Rain starting 8:20am One attempted flt	
Flags	-full down day for weather	

Date	03-April-09	
Primary Activity	Survey	0.0 flt hrs – CH2M HILL
Survey Block	n/a	0 days housing (standby)
Notes	Winds 20-25kts. Gale warning.	
Flags	-full down day for weather	

Date	04-April-09	
Primary Activity	Survey	1.2 flt hrs – CH2M HILL
Survey Block	4	2.0 days housing (standby)
Notes	Attempt one flt in am Winds 12kts gusting 18, too high, forecast to drop Winds increase to 16kts in pm	
Flags	-half down day for weather	

Date	05-April-09	
Primary Activity	Survey	7.7 flt hrs
Survey Block	1, 4	4 days housing
Notes	Complete Block 1, continue Block 4	
Flags	-	

Date	06-April-09	
Primary Activity	Survey	0.0 flt hrs – CH2M HILL
Survey Block	n/a	0 days housing (standby)
Notes	Weather watch for severe T-storms, tornadoes, gale warning. Winds 20-25kts gusting 40kts	
Flags	-full down day for weather	

Date	07-April-09	
Primary Activity	Survey	0.0 flt hrs – CH2M HILL
Survey Block	n/a	0 days housing (standby)
Notes	Winds averaging 16-23kts all day.	
Flags	-full down day for weather	

Date	08-April-09	
Primary Activity	Survey	1.0 flt hrs – CH2M HILL
Survey Block	5	0 days housing (standby)
Notes	Winds 10kts increasing to 15 during first attempt Winds 17 gusting 25kts for remainder of day	
Flags	-full down day for weather	

Date	09-April-09	
Primary Activity	Survey	2.9 flt hrs – CH2M HILL
Survey Block	5	2.0 days housing (standby)
Notes	Winds 15-20kts during first attempt Winds 17-23kts during remainder of day Winds decrease to 10-15kts in evening, second attempt	
Flags	-half down day for weather	

Date	10-April-09	
Primary Activity	Survey	1.5 flt hrs – CH2M HILL
Survey Block	5	2.0 days housing (standby)
Notes	Morning winds 10kts, increased to 20kts during first attempt Winds 20-25kts for remainder of day	
Flags	-half down day for weather	

Date	11-April-09	
Primary Activity	Survey	1.5 flt hrs – CH2M HILL
Survey Block	4	2.0 days housing (standby)
Notes	Wind 15 gusting 25 Attempted one morning flight and one evening flight	
Flags	-half down day for weather	

Date	12-April-09	
Primary Activity	Survey	7.5 flt hrs
Survey Block	5	4 days housing
Notes	Block 5, three full flts	
Flags	-	

Date	13-April-09	
Primary Activity	Survey	7.0 flt hrs
Survey Block	4, 5	4 days housing
Notes	Completed Block 4 Block 5 EW lines started Three full flights	
Flags	-	

Date	14-April-09	
Primary Activity	Survey	1.5 flt hrs – CH2M HILL
Survey Block	5	2.0 days housing (standby)
Notes	Morning 15kts and misty, dropping to 10kts with rain by noon Thunderstorms in afternoon Two attempts	
Flags	-half down day for weather	

Date	15-April-09	
Primary Activity	Survey	4.9 flt hrs – CH2M HILL
Survey Block	5	2.5 days housing (standby)
Notes	Morning mist and rain, slight clearing by noon Two full flights Jacob Sheehan arrives to replace Jeff Gamey	
Flags	-half down day for weather	

Date	16-April-09	
Primary Activity	Survey	0.0 flt hrs – CH2M HILL
Survey Block	n/a	0 days housing (standby)
Notes	15-25 kts in AM, increasing to 20-30kts by 3pm. Rain on site in the AM Jeff Gamey leaves	
Flags	-full down day for weather	

Date	17-April-09	
Primary Activity	Survey	2.5 flt hrs – CH2M HILL
Survey Block	5	2.0 days housing (standby)
Notes	One full AM flight, then wind gusts rest of day	
Flags	-half down day for weather	

Date	18-April-09	
Primary Activity	Survey	6.1 flt hrs
Survey Block	5	4 days housing
Notes	Area 5 EW plus EW reflights	
Flags	-	

Date	19-April-09	
Primary Activity	Survey	1.8 flt hrs – CH2M HILL
Survey Block	5	2.0 days housing (standby)
Notes	One partial flight, returned because of nav problems. High winds for remainder of day.	
Flags	-half down day for weather	

Date	20-April-09	
Primary Activity	Survey	2.0 flt hrs – Battelle
Survey Block	Reflights	0 days housing (reflights)
Notes	Rain clearing around 8am One partial flt before rain returns Winds 16-24 kts	
Flags	-half down day for weather	

Date	21-April-09	
Primary Activity	Survey	2.4 flt hrs – Battelle
Survey Block	Reflights/Demobilization	0 days housing (reflights)
Notes	First flight called back due to boat problems. Second flight gets remaining reflights – data checks out All data collection complete and approved by CH2M HILL Deinstallation begins	
Flags	-half day sufficient to complete survey, no down day	

Date	22-April-09	
Primary Activity	Demobilization	0 flt hrs
Survey Block	n/a	4 days housing
Notes	Helicopter released for return flight Battelle crew returns to Oak Ridge	
Flags	-	

Details of two sandbar landings in Bogue Sound

March 19, 2009

On the morning of March 19, 2009, the helicopter arrived at Bogue Sound to begin the first survey flight of the day. On arrival at the site, the pilot noted that the waters were unusually calm. The becalmed water produced a mirror effect that made it difficult for the pilot to visually judge his height above the water. After making a few attempts at flying survey lines, he radioed Captain Daniels at the on-site rescue boat that he wanted to land on a sand bar and wait for winds to pick up enough that ripples would be produced. Captain Daniels directed him to a particular sandbar location near the survey area boundary. The pilot landed the helicopter, waited less than one hour, and after winds picked up, resumed surveying. A full day of flying was completed.

March 23, 2009

On the first flight of the day on March 23, 2009, the VG-16 experienced a structural failure in the boom mounting brackets. A bolt which secured the rear boom to the airframe sheared with an audible crack. A single thud was felt by both the pilot and operator. The pilot made an immediate security landing on a nearby sand bar to inspect the system. Having assessed the damage as sufficient to take the aircraft out of service, the aircraft mechanic was summoned to the site. The bracket was removed and taken to a machine shop to remove the remainder of the sheared-off bolt. The bracket was then re-installed on the aircraft with a new bolt so that the aircraft could be returned to the airport for further maintenance. After discussions with the helicopter company and the aeronautical engineer most familiar with the design, additional maintenance was carried out including replacing the two rear hoops which secure the lateral booms, and all bolts throughout the mounting structure. The aircraft was grounded for a period of three days during this procedure. Subsequent analysis of the remaining bolt fragments indicated that this failure occurred along a latent stress fracture in the part. Duty cycles for hardware have been reduced as part of the internal lessons learned, and appropriate notification has been made to the FAA regarding the incident.

Attachment 6
Digital Magnetic Data

Attachment 6 is provided electronically on the attached DVD.

Appendix C
Sediment Boring Logs

CH2MHILL

Site Name: Cat Island Former Bomb Target
Project Name: Site Inspection for Former Cat Island Bomb Target (BT-2) and Surface Danger Zone
Project Number: 362275
Survey Duration: 5/26/09-5/29/09

Station ID:	CI-SD01	**Northing:**	347611.12		**Attempt 1**
Sampler(s):	T. Himmer	**Easting:**	2615165.51	**Penetration (ft):**	4.0'
	R. Clore	**Datum:**	NC State Plane	**Recovery (ft)**	3.2'
Survey Crew:	Athena	**Depth:**	2.8'	**Time:**	1018 5/27/09
		Tide:	N/A		**Attempt 2**
		St. Arrival:	1209	**Penetration (ft):**	NA
Vessel:	Pontoon VC Boat	**St.Depart**	1224	**Recovery (ft)**	NA
Collection:	Vibracore	**Logged by:**	R. Clore	**Time:**	NA

Weather:
Rainy, hot humid, party cloudy

Depth below water surface (ft)	Depth below mudline (ft)	Lithology	Type	Color (Munsell)	Consistency/ Density	Cementation/ Plasticity	Structure	Moisture Content	Maximum particle size	Odor	% gravel	% sand	% fines	Sample interval	Comments
	1		SP	5Y2.5/1 5Y4/2 5Y2.5/1	F H	N	M	SM	FS	N	0	95	5	0-1	Iron staining at 0.3'
	2														
	3														
	4														

Photographic Log:

Photo file name	Date	Initials	Subject of Photo
CI-SD01-0-1	**5/28/09**	**RC**	

Sample Summary (check boxes for analysis):

Sample ID	Exp Residue/Perchlorate/Total Metals	TOC	GS	Interval sampled	Time
CI-SD01-0509	**X**	**X**	**X**	**0-1'**	**1215**

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Reviewed by: T. Himmer/BOS Date: 5/28/09

CH2MHILL

Site Name: Cat Island Former Bomb Target
Project Name: Site Inspection for Former Cat Island Bomb Target (BT-2) and Surface Danger Zone
Project Number: 362275
Survey Duration: 5/26/09-5/29/09

Station ID:	CI-SD02	**Northing:**	347447.12		**Attempt 1**
Sampler(s):	T. Himmer	**Easting:**	2615495.26	**Penetration (ft):**	3.0'
	R. Clore	**Datum:**	NC State Plane	**Recovery (ft)**	2.6'
Survey Crew:	Athena	**Depth:**	1.9'	**Time:**	1232 5/27/09
		Tide:	N/A		**Attempt 2**
		St. Arrival:	1228	**Penetration (ft):**	NA
Vessel:	Pontoon VC Boat	**St.Depart**	1240	**Recovery (ft)**	NA
Collection:	Vibracore	**Logged by:**	R. Clore	**Time:**	NA

Weather:
Hot humid, party cloudy

Depth below water surface (ft)	Depth below mudline (ft)	Lithology	Type	Color (Munsell)	Consistency/ Density	Cementation/ Plasticity	Structure	Moisture Content	Maximum particle size	Odor	% gravel	% sand	% fines	Sample interval	Comments
	1	ΩΩΩ	SP	5Y5/1	F	N	M	SM	FS	N	0	95	5	0-1	Mottled with dark grey shell hash from 0.8 to 1.0'
	2														
	3														
	4														

Photographic Log:

Photo file name	Date	Initials	Subject of Photo
CI-SD02-0-1	**5/28/09**	**RC**	

Sample Summary (check boxes for analysis):

Sample ID	Exp Residue/Perchlorate/Total Metals	TOC	GS	Interval sampled	Time
CI-SD02-0509	**X**	**X**	**X**	**0-1'**	**1232**

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Reviewed by: T. Himmer/BOS Date: 5/28/09

CH2MHILL

Site Name: Cat Island Former Bomb Target
Project Name: Site Inspection for Former Cat Island Bomb Target (BT-2) and Surface Danger Zone
Project Number: 362275
Survey Duration: 5/26/09-5/29/09

Station ID:	CI-SD03	**Northing:**	347224.29		**Attempt 1**
Sampler(s):	T. Himmer	**Easting:**	2615713.99	**Penetration (ft):**	3.8'
	R. Clore	**Datum:**	NC State Plane	**Recovery (ft)**	3.1'
Survey Crew:	Athena	**Depth:**	2.3'	**Time:**	1249 5/27/09
		Tide:	N/A		**Attempt 2**
		St. Arrival:	1243	**Penetration (ft):**	NA
Vessel:	Pontoon VC Boat	**St.Depart**	1256	**Recovery (ft)**	NA
Collection:	Vibracore	**Logged by:**	R. Clore	**Time:**	NA

Weather:
Rainy, hot humid, party cloudy

Depth below water surface (ft)	Depth below mudline (ft)	Lithology	Type	Color (Munsell)	Consistency/ Density	Cementation/ Plasticity	Structure	Moisture Content	Maximum particle size	Odor	% gravel	% sand	% fines	Sample interval	Comments
	1		SP	5Y4/1	F	N	M	SM	FS	N	0	85	15	0-1	Medium brown sand with dark brown/grey mottling Small shell hash fragments and worms observed
	2														
	3														
	4														

Photographic Log:

Photo file name	Date	Initials	Subject of Photo
CI-SD03-0-1	**5/28/09**	**RC**	

Sample Summary (check boxes for analysis):

Sample ID	Exp Residue/Perchlorate/Total Metals	TOC	GS	Interval sampled	Time
CI-SD03-0509	**X**	**X**	**X**	**0-1'**	**1249**
CI-SD03D-0509	**X**	**X**	**X**	**0-1'**	**1249**

Reviewed by: T. Himmer/BOS Date: 5/28/09

CH2MHILL

Site Name: Cat Island Former Bomb Target
Project Name: Site Inspection for Former Cat Island Bomb Target (BT-2) and Surface Danger Zone
Project Number: 362275
Survey Duration: 5/26/09-5/29/09

Station ID:	CI-SD04	**Northing:**	347146.43		**Attempt 1**
Sampler(s):	T. Himmer	**Easting:**	2616107.54	**Penetration (ft):**	4.0'
	R. Clore	**Datum:**	NC State Plane	**Recovery (ft)**	3.1'
Survey Crew:	Athena	**Depth:**	2.7'	**Time:**	1307 5/27/09
		Tide:	N/A		**Attempt 2**
		St. Arrival:	1303	**Penetration (ft):**	NA
Vessel:	Pontoon VC Boat	**St.Depart**	1314	**Recovery (ft)**	NA
Collection:	Vibracore	**Logged by:**	R. Clore	**Time:**	NA

Weather:
Hot humid, party cloudy

Depth below water surface (ft)	Depth below mudline (ft)	Lithology	Type	Color (Munsell)	Consistency/ Density	Cementation/ Plasticity	Structure	Moisture Content	Maximum particle size	Odor	% gravel	% sand	% fines	Sample interval	Comments
			SP	5Y2.5/1	F	N	M	SM	FS	N	0	95	5	0-1	Mottled with dark grey sand
	1														
	2														
	3														
	4														

Photographic Log:

Photo file name	Date	Initials	Subject of Photo
CI-SD04-0-1	**5/28/09**	**RC**	

Sample Summary (check boxes for analysis):

Sample ID	Exp Residue/Perchlorate/Total Metals	TOC	GS	Interval sampled	Time
CI-SD04-0509	**X**	**X**	**X**	**0-1'**	**1307**

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Reviewed by: T. Himmer/BOS Date: 5/28/09

CH2MHILL

Site Name: Cat Island Former Bomb Target
Project Name: Site Inspection for Former Cat Island Bomb Target (BT-2) and Surface Danger Zone
Project Number: 362275
Survey Duration: 5/26/09-5/29/09

Station ID:	CI-SD05	**Northing:**	346847.35		**Attempt 1**
Sampler(s):	T. Himmer	**Easting:**	2616464.28	**Penetration (ft):**	4.0'
	R. Clore	**Datum:**	NC State Plane	**Recovery (ft)**	3.1'
Survey Crew:	Athena	**Depth:**	2.1'	**Time:**	1018 5/27/09
		Tide:	N/A		**Attempt 2**
		St. Arrival:	1010	**Penetration (ft):**	NA
Vessel:	Pontoon VC Boat	**St.Depart**	1031	**Recovery (ft)**	NA
Collection:	Vibracore	**Logged by:**	R. Clore	**Time:**	NA

Weather:
Rainy, hot humid, party cloudy

Depth below water surface (ft)	Depth below mudline (ft)	Lithology	Type	Color (Munsell)	Consistency/ Density	Cementation/ Plasticity	Structure	Moisture Content	Maximum particle size	Odor	% gravel	% sand	% fines	Sample interval	Comments
			SP	5Y4/2	S	N	H	M	FS	N	0	95	5	0-1	
					F							85	15		
	1														
	2														
	3														
	4														

Photographic Log:

Photo file name	Date	Initials	Subject of Photo
CI-SD05-0-1	**5/28/09**	**RC**	

Sample Summary (check boxes for analysis):

Sample ID	Exp Residue/Perchlorate/Total Metals	TOC	GS	Interval sampled	Time
CI-SD05-0509	**X**	**X**	**X**	**0-1'**	**1018**
CI-SD05D-0509	**X**	**X**	**X**	**0-1'**	**1018**

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Reviewed by: T. Himmer/BOS Date: 5/28/09

CH2MHILL

Site Name: Cat Island Former Bomb Target
Project Name: Site Inspection for Former Cat Island Bomb Target (BT-2) and Surface Danger Zone
Project Number: 362275
Survey Duration: 5/26/09-5/29/09

Station ID:	CI-SD06	**Northing:**	346739.37		**Attempt 1**
Sampler(s):	T. Himmer	**Easting:**	2616085.72	**Penetration (ft):**	4.0'
	R. Clore	**Datum:**	NC State Plane	**Recovery (ft)**	3.4'
Survey Crew:	Athena	**Depth:**	2.2'	**Time:**	1042 5/27/09
		Tide:	N/A		**Attempt 2**
		St. Arrival:	1035	**Penetration (ft):**	NA
Vessel:	Pontoon VC Boat	**St.Depart**	1054	**Recovery (ft)**	NA
Collection:	Vibracore	**Logged by:**	R. Clore	**Time:**	NA

Weather:
Hot humid, party cloudy

Depth below water surface (ft)	Depth below mudline (ft)	Lithology	Type	Color (Munsell)	Consistency/ Density	Cementation/ Plasticity	Structure	Moisture Content	Maximum particle size	Odor	% gravel	% sand	% fines	Sample interval	Comments
			SP	5Y2.5/1 5Y4/1	F	N	M	SM	FS	N	0	95	5	0-1	
	1														
	2														
	3														
	4														

Photographic Log:

Photo file name	Date	Initials	Subject of Photo
CI-SD06-0-1	**5/28/09**	**RC**	

Sample Summary (check boxes for analysis):

Sample ID	Exp Residue/Perchlorate/Total Metals	TOC	GS	Interval sampled	Time
CI-SD06-0509	**X**	**X**	**X**	**0-1'**	**1042**

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Reviewed by: T. Himmer/BOS Date: 5/28/09

CH2MHILL

Site Name: Cat Island Former Bomb Target
Project Name: Site Inspection for Former Cat Island Bomb Target (BT-2) and Surface Danger Zone
Project Number: 362275
Survey Duration: 5/26/09-5/29/09

Station ID:	CI-SD07	**Northing:**	346904.79		**Attempt 1**
Sampler(s):	T. Himmer	**Easting:**	2615807.78	**Penetration (ft):**	4.0'
	R. Clore	**Datum:**	NC State Plane	**Recovery (ft)**	3.4'
Survey Crew:	Athena	**Depth:**	1.8'	**Time:**	1100 5/27/09
		Tide:	N/A		**Attempt 2**
		St. Arrival:	1059	**Penetration (ft):**	NA
Vessel:	Pontoon VC Boat	**St.Depart**	1115	**Recovery (ft)**	NA
Collection:	Vibracore	**Logged by:**	RC	**Time:**	NA

Weather:
Sunny, hot humid, party cloudy

Depth below water surface (ft)	Depth below mudline (ft)	Lithology	Type	Color (Munsell)	Consistency/ Density	Cementation/ Plasticity	Structure	Moisture Content	Maximum particle size	Odor	% gravel	% sand	% fines	Sample interval	Comments
			SP	5Y3/1	F	N	M	SM	FS	N	0	95	5	0-1	Small amounts of organic matter
			↓	5Y3/3	H	↓	↓	↓	↓	↓	↓	75	25		
	1														
	2														
	3														
	4														

Photographic Log:

Photo file name	Date	Initials	Subject of Photo
CI-SD07-0-1	**5/28/09**	**RC**	

Sample Summary (check boxes for analysis):

Sample ID	Exp Residue/Perchlorate/Total Metals	TOC	GS	Interval sampled	Time
CI-SD07-0509	**X**	**X**	**X**	**0-1'**	**1100**

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Reviewed by: T. Himmer/BOS Date: 5/28/09

CH2MHILL

Site Name: Cat Island Former Bomb Target
Project Name: Site Inspection for Former Cat Island Bomb Target (BT-2) and Surface Danger Zone
Project Number: 362275
Survey Duration: 5/26/09-5/29/09

Station ID:	CI-SD08	**Northing:**	347032.00		**Attempt 1**
Sampler(s):	T. Himmer	**Easting:**	2615495.98	**Penetration (ft):**	4.0'
	R. Clore	**Datum:**	NC State Plane	**Recovery (ft)**	3.1'
Survey Crew:	Athena	**Depth:**	2.2'	**Time:**	1124 5/27/09
		Tide:	N/A		**Attempt 2**
		St. Arrival:	1120	**Penetration (ft):**	NA
Vessel:	Pontoon VC Boat	**St.Depart**	1137	**Recovery (ft)**	NA
Collection:	Vibracore	**Logged by:**	RC	**Time:**	NA

Weather:
Hot, humid, party cloudy

Depth below water surface (ft)	Depth below mudline (ft)	Lithology	Type	Color (Munsell)	Consistency/ Density	Cementation/ Plasticity	Structure	Moisture Content	Maximum particle size	Odor	% gravel	% sand	% fines	Sample interval	Comments
	1		SP	5Y2.5/1 5Y3/2	F	N	M	SM	FS	N	0	90	10	0-1	Vegetation on top (green grasses) roots extend to 0.3'
	2														
	3														
	4														

Photographic Log:

Photo file name	Date	Initials	Subject of Photo
CI-SD08-0-1	**5/28/09**	**RC**	

Sample Summary (check boxes for analysis):

Sample ID	Exp Residue/Perchlorate/Total Metals	TOC	GS	Interval sampled	Time
CI-SD08-0509	**X**	**X**	**X**	**0-1'**	**1124**

Reviewed by: T. Himmer/BOS Date: 5/28/09

CH2MHILL

Site Name: Cat Island Former Bomb Target
Project Name: Site Inspection for Former Cat Island Bomb Target (BT-2) and Surface Danger Zone
Project Number: 362275
Survey Duration: 5/26/09-5/29/09

Station ID:	CI-SD09	**Northing:**	349036.87		**Attempt 1**
Sampler(s):	T. Himmer	**Easting:**	2616299.54	**Penetration (ft):**	4.0'
	R. Clore	**Datum:**	NC State Plane	**Recovery (ft)**	3.0'
Survey Crew:	Athena	**Depth:**	1.8'	**Time:**	1148 5/27/09
		Tide:	N/A		**Attempt 2**
		St. Arrival:	1140	**Penetration (ft):**	NA
Vessel:	Pontoon VC Boat	**St.Depart**	1200	**Recovery (ft)**	NA
Collection:	Vibracore	**Logged by:**	R. Clore/T. Himmer	**Time:**	NA

Weather:
Rainy, hot humid, party cloudy

Depth below water surface (ft)	Depth below mudline (ft)	Lithology	Type	Color (Munsell)	Consistency/ Density	Cementation/ Plasticity	Structure	Moisture Content	Maximum particle size	Odor	% gravel	% sand	% fines	Sample interval	Comments
	1		SP	5Y3/2 5Y4/2	S F	N	H	SM	FS	N	0	95	5	0-1	Collected second smaller core for additional volume for MS/MSD. 0.8' recovery from 1.6' penetration core
	2														
	3														
	4														

Photographic Log:

Photo file name	Date	Initials	Subject of Photo
CI-SD09-0-1	**5/28/09**	**RC**	

Sample Summary (check boxes for analysis):

Sample ID	Exp Residue/Perchlorate/Total Metals	TOC	GS	Interval sampled	Time
CI-SD09-0509	**X**	**X**	**X**	**0-1'**	**1148**
CI-SD09-0509-MS	**X**			**0-1'**	**1148**
CI-SD09-0509-SD	**X**			**0-1'**	**1148**

Reviewed by: T. Himmer/BOS Date: 5/28/09

CH2MHILL

Site Name: Cat Island Former Bomb Target
Project Name: Site Inspection for Former Cat Island Bomb Target (BT-2) and Surface Danger Zone
Project Number: 362275
Survey Duration: 5/26/09-5/29/09

Station ID:	CI-SD10	**Northing:**	349036.87		**Attempt 1**
Sampler(s):	T. Himmer	**Easting:**	2616299.54	**Penetration (ft):**	4.0'
	R. Clore	**Datum:**	NC State Plane	**Recovery (ft)**	3.0'
Survey Crew:	Athena	**Depth:**	1.8'	**Time:**	940 5/27/09
		Tide:	N/A		**Attempt 2**
		St. Arrival:	0854	**Penetration (ft):**	NA
Vessel:	Pontoon VC Boat	**St.Depart**	0950	**Recovery (ft)**	NA
Collection:	Vibracore	**Logged by:**	R. Clore	**Time:**	NA

Weather:
Rainy, hot humid, party cloudy

Depth below water surface (ft)	Depth below mudline (ft)	Lithology	Type	Color (Munsell)	Consistency/ Density	Cementation/ Plasticity	Structure	Moisture Content	Maximum particle size	Odor	% gravel	% sand	% fines	Sample interval	Comments
	1	ΩΩΩ ΩΩΩ	SP	5Y2.5/1	F	N	M	M	FS	N	0	80	20	0-1	Vegetation on top (green grasses) roots extend to 0.5' Shell fragments from 0.5 to 1.0'
	2														
	3														
	4														

Photographic Log:

Photo file name	Date	Initials	Subject of Photo
CI-SD10-0-1	**5/28/09**	**RC**	

Sample Summary (check boxes for analysis):

Sample ID	Exp Residue/Perchlorate/Total Metals	TOC	GS	Interval sampled	Time
CI-SD10-0509	**X**	**X**	**X**	**0-1'**	**0940**

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Reviewed by: T. Himmer/BOS Date: 5/28/09

CH2MHILL

Site Name: Cat Island Former Bomb Target
Project Name: Site Inspection for Former Cat Island Bomb Target (BT-2) and Surface Danger Zone
Project Number: 362275
Survey Duration: 5/26/09-5/29/09

Station ID:	CI-SD11	**Northing:**	344074.36		**Attempt 1**
Sampler(s):	T. Himmer	**Easting:**	2598437.66	**Penetration (ft):**	4.0'
	R. Clore	**Datum:**	NC State Plane	**Recovery (ft)**	3.3'
Survey Crew:	Athena	**Depth:**	2.8'	**Time:**	1505 5/27/09
		Tide:	N/A		**Attempt 2**
		St. Arrival:	1503	**Penetration (ft):**	NA
Vessel:	Pontoon VC Boat	**St.Depart**	1507	**Recovery (ft)**	NA
Collection:	Vibracore	**Logged by:**	R. Clore	**Time:**	NA

Weather:
Hot humid, party cloudy

Depth below water surface (ft)	Depth below mudline (ft)	Lithology	Type	Color (Munsell)	Consistency/ Density	Cementation/ Plasticity	Structure	Moisture Content	Maximum particle size	Odor	% gravel	% sand	% fines	Sample interval	Comments
	1	ΩΩΩ	SM	5Y2.5/1	F	N	H	M	FS	N	0	40	60	0-1	large shell pieces from 0.6 to 1'
	2														
	3														
	4														

Photographic Log:

Photo file name	Date	Initials	Subject of Photo
CI-SD11-0-1	**5/28/09**	**RC**	

Sample Summary (check boxes for analysis):

Sample ID	Exp Residue/Perchlorate/Total Metals	TOC	GS	Interval sampled	Time
CI-SD11-0509	**X**	**X**	**X**	**0-1'**	**1505**

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Reviewed by: T. Himmer/BOS Date: 5/28/09

CH2MHILL

Site Name: Cat Island Former Bomb Target
Project Name: Site Inspection for Former Cat Island Bomb Target (BT-2) and Surface Danger Zone
Project Number: 362275
Survey Duration: 5/26/09-5/29/09

Station ID:	CI-SD12	**Northing:**	353751.04		**Attempt 1**
Sampler(s):	T. Himmer	**Easting:**	2630691.2	**Penetration (ft):**	2.7'
	R. Clore	**Datum:**	NC State Plane	**Recovery (ft)**	2.2'
Survey Crew:	Athena	**Depth:**	5.6'	**Time:**	1351 5/27/09
		Tide:	N/A		**Attempt 2**
		St. Arrival:	1345	**Penetration (ft):**	NA
Vessel:	Pontoon VC Boat	**St.Depart**	1357	**Recovery (ft)**	NA
Collection:	Vibracore	**Logged by:**	R. Clore	**Time:**	NA

Weather:
Hot, humid, party cloudy

Depth below water surface (ft)	Depth below mudline (ft)	Lithology	Type	Color (Munsell)	Consistency/ Density	Cementation/ Plasticity	Structure	Moisture Content	Maximum particle size	Odor	% gravel	% sand	% fines	Sample interval	Comments
	1	ΩΩΩ ΩΩΩ	SP	5Y2.5/1	F	N	H	SM	FS	N	0	95	5	0-1	Large shell fragments from 0.5 to 1'
	2														
	3														
	4														

Photographic Log:

Photo file name	Date	Initials	Subject of Photo
CI-SD12-0-1	**5/28/09**	**RC**	

Sample Summary (check boxes for analysis):

Sample ID	Exp Residue/Perchlorate/Total Metals	TOC	GS	Interval sampled	Time
CI-SD12-0509	**X**	**X**	**X**	**0-1'**	**1505**

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Reviewed by: T. Himmer/BOS Date: 5/28/09

MAJOR DIVISIONS			GRAPHIC SYMBOL	GROUP SYMBOL	DESCRIPTION
COARSE-GRAINED MATERIAL	GRAVELS	CLEAN GRAVELS		GW	Well-graded gravel Well-graded gravel with sand
				GP	Poorly graded gravel Poorly graded gravel with sand
		GRAVELS WITH FINES		GW-GM	Well-graded gravel with silt Well-graded gravel with silt and sand
				GW-GC	Well-graded gravel with clay Well graded gravel with clay and sand
				GP-GM	Poorly graded gravel with silt Poorly graded gravel with silt and sand
				GP-GC	Poorly graded gravel with clay Poorly graded gravel with clay and sand
				GM	Silty gravel Silty gravel with sand
				GC	Clayey gravel Clayey gravel with sand
	SANDS	CLEAN SANDS		SW	Well-graded sands Well-graded sand and gravel
				SP	Poorly-graded sands Poorly graded sand with gravel
		SANDS WITH FINES		SW-SM	Well-graded sand with silt Well-graded sand with silt and gravel
				SW-SC	Well-graded sand with clay Well-graded sand with clay and gravel
				SP-SM	Poorly-graded sand with silt Poorly-graded sand with silt and gravel
				SP-SC	Poorly-graded sand with clay Poorly-graded sand with clay and gravel
				SM	Silty sand Silty sand and with gravel
				SC	Clayey sand Clayey sand and with gravel
FINE-GRAINED MATERIALS	SILTS AND CLAYS			CL	Lean clay * Lean clay with sand or gravel * Sandy lean clay * Sandy lean clay with gravel * Gravelly lean clay * Gravelly lean clay with sand
				ML	Silt * Silty with sand or gravel * Sandy silt * Sandy silt with gravel * Gravelly silt * Gravelly silt with sand
				CH	Fat clay * Fat clay with sand or gravel * Sandy fat clay * Gravelly fat clay * Gravelly fat clay with sand
				MH	Elastic silt * Elastic silt with sand or gravel * Sandy elastic silt * Sandy elastic silt with gravel * Gravelly elastic silt * Gravelly elastic silt with sand
				OL/OH	Organic silt * Organic silt with sand or gravel * Sandy organic silt * Sandy organic soil with gravel * Gravelly organic soil * Gravelly organic soil with sand

Ω Shell hash

λλλλ Peat/organic matter

CONSISTENCY

Penetration of thumb:

<0.25 cm = hard (H)

0.25 - 2.0 cm = firm (F)

2.0 - 4.0 cm = soft (S)

>4.0 cm = very soft (VS

CEMENTION

N = not cemented

W = weakly cemented

M = Moderately cemented

S = Strongly cemented

STRUCTURE

H = Homogeneous

S = Stratified

L = Laminated

M = Mottled

HCl REACTION

N = None

W = Weak

S = Strong

MAXIMUM PARTICLE SIZE

SC = Small Cobble

CP = Coarse Pebble

MP = Medium Pebble

SP = Small Pebble

CS = Coarse Sand

MS = Medium Sand

FS = Fine Sand

VFS = Very Fine Sand

Z = Silt

SA = Sub-angular

VA = Very angular

ODOR

N = None

H = Hydrocarbon

S or HS =Sulfide

COLOR

from munsell chart

DILATANCY

N = None

S = Slow

R = Rapid

TOUGHNESS

L = Low

M = Medium

H = High

MOISTURE CONTENT

W = wet

M = moist

SM = slightly moist

D = dry

Appendix D
Raw Analytical Data

Cherry Point - Cat Island BT-2
CTO-201
Final Surface Soil Samples Raw Analytical Data Tables
March 2009

Station ID	CI-SS01	CI-SS02	CI-SS03		CI-SS04	CI-SS05	CI-SS06
Sample ID	CI-SS01-0309	CI-SS02-0309	CI-SS03-0309	CI-SS03-D-0309	CI-SS04-0309	CI-SS05-0309	CI-SS06-0309
Sample Date	03/03/09	03/03/09	03/03/09	03/03/09	03/03/09	03/03/09	03/03/09
Chemical Name							
Explosives (UG/KG)							
1,3,5-Trinitrobenzene	250 U	250 U	250 U	250 U	250 U	250 U	250 U
1,3-Dinitrobenzene	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,4,6-Trinitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,4-Dinitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,6-Dinitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2-Amino-4,6-dinitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2-Nitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U
3-Nitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U
4-Amino-2,6-dinitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U
4-Nitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U
HMX	250 U	250 U	250 U	250 U	250 U	250 U	250 U
Nitrobenzene	250 U	250 U	250 U	250 U	250 U	250 U	250 U
Nitroglycerin	650 U	650 U	650 U	650 U	650 U	650 U	650 U
Perchlorate	1.6 U	1.9 U	1.4 U	1.5 U	1.8 U	1.2 U	1.8 U
PETN	1,000 U	1,000 U	1,000 U	1,000 U	1,000 U	1,000 U	1,000 U
RDX	250 U	250 U	250 U	250 U	250 U	250 U	250 U
Tetryl	250 U	250 U	250 U	250 U	250 U	250 U	250 U
Total Metals (MG/KG)							
Aluminum	425	3,670	1,150	1,080	4,320	186	4,060
Antimony	3.3 U	4.2 U	3.6 U	3.8 U	4.9 U	3.4 U	3.9 U
Arsenic	2.2 U	3	1 J	1.3 J	3.1 J	2.3 U	3.1
Barium	1.6 J	6.3 J	6.5 J	5.6 J	6.9 J	9 U	6.6 J
Beryllium	1.1 U	1.4 U	1.2 U	1.3 U	1.6 U	1.1 U	1.3 U
Cadmium	1.1 U	1.4 U	0.24 J	1.3 U	1.6 U	1.1 U	1.3 U
Calcium	278 J	1,040 J	16,500	14,400	811 J	1,130 U	620 J
Chromium	2.7	11.3	3.2	3.4	12.6	0.78 J	11.1
Cobalt	3.3 U	4.2 U	3.6 U	3.8 U	4.9 U	3.4 U	3.9 U
Copper	2.2 U	3.2	7.6	5.4	3.1 J	2.3 U	3.2
Iron	1,020	3,970	1,510	1,440	4,940	247	5,850
Lead	1.4	9	5.5	5	16.4	2.5	5.5
Magnesium	272 J	1,540	1,090 J	958 J	1,810	1,130 U	1,890
Manganese	2 J	19.2	22.6	21.3	24.4	2 J	20.8
Mercury	0.037 U	0.053 U	0.026 J	0.041 U	0.055 U	0.036 U	0.042 U
Nickel	2.2 U	2.9	0.88 J	0.84 J	3.2	2.3 U	3
Potassium	1,100 U	720 J	245 J	1,280 U	901	1,130 U	849 J
Selenium	1.1 U	1.4 U	1.3	1.3	1.1	1.1 U	0.99 J
Silver	2.2 U	2.8 U	2.4 U	2.6 U	3.3 U	2.3 U	2.6 U
Sodium	967 J	2,220	1,600	1,410	3,230	636 J	4,280
Thallium	2.2 U	2.8 U	2.4 U	2.6 U	3.3 U	2.3 U	2.6 U
Vanadium	1.2 J	11.9	4.4	3.7 J	14.1	3.4 U	13
Zinc	2.2 J	14.7	61.7	55.2	15	4.5 U	13.8

Notes:

Shading indicates detections
NA - Not analyzed
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
MG/KG - Milligrams per kilogram
UG/KG - Micrograms per kilogram

Cherry Point - Cat Island BT-2
CTO-201
Final Sediment Samples Raw Analytical Data Tables
May 2009

Station ID	CI-SD01	CI-SD02	CI-SD03		CI-SD04	CI-SD05		CI-SD06	CI-SD07	CI-SD08	CI-SD09	CI-SD10	CI-SD11	CI-SD12
Sample ID	CI-SD01-0509	CI-SD02-0509	CI-SD03-0509	CI-SD03-P-0509	CI-SD04-0509	CI-SD05-0509	CI-SD05-P-0509	CI-SD06-0509	CI-SD07-0509	CI-SD08-0509	CI-SD09-0509	CI-SD10-0509	CI-SD11-0509	CI-SD12-0509
Sample Date	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09
Chemical Name														
Explosives (UG/KG)														
1,3,5-Trinitrobenzene	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
1,3-Dinitrobenzene	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,4,6-Trinitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,4-Dinitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2,6-Dinitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2-Amino-4,6-dinitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
2-Nitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
3-Nitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
4-Amino-2,6-dinitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
4-Nitrotoluene	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
HMX	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
Nitrobenzene	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
Nitroglycerin	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U
Perchlorate	2.7 U	0.48 J	2.6 U	2.4 U	2.5 U	2.8 U	2.7 U	2.5 U	3.6 U	1.8 J	0.74 J	2.6 U	2.7 U	2.5 U
PETN	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U	2,500 U
RDX	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
Tetryl	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U	250 U
Total Metals (MG/KG)														
Aluminum	1,030 J	484 J	490 J	741 J	649 J	2,690 J	1,720 J	747 J	688 J	986 J	620 J	1,410 J	3,650 J	1,100 J
Antimony	3.9 U	3.5 U	3.4 U	3.7 U	3.5 U	3.6 U	3.8 U	4 U	3.6 U	3.6 U	3.7 U	3.7 U	3.8 U	3.4 U
Arsenic	1.2 J	2.4 U	2.3 U	2.5 U	2.3 U	1.4 J	0.97 J	0.92 J	2.4 U	1.1 J	2.5 U	1.7 J	3.2	1.7 J
Barium	2 J	9.4 U	9.1 U	1.5 J	1.4 J	4.4 J	3 J	1.6 J	1.6 J	1.9 J	1.4 J	2.6 J	5.7 J	2.5 J
Beryllium	1.3 U	1.2 U	1.1 U	1.2 U	1.2 U	1.2 U	1.3 U	1.3 U	1.2 U	1.2 U	1.2 U	1.2 U	1.3 U	1.1 U
Cadmium	1.3 U	1.2 U	1.1 U	1.2 U	1.2 U	1.2 U	1.3 U	1.3 U	1.2 U	1.2 U	1.2 U	1.2 U	1.3 U	1.1 U
Calcium	448 J	290 J	524 J	460 J	494 J	1,360	678 J	835 J	488 J	624 J	474 J	1,080 J	10,800	842 J
Chromium	4.3	1.9 J	2.6	3	3.4	10	7	4	3.9	4.1	3.2	6	12.2	5.3
Cobalt	3.9 U	3.5 U	3.4 U	3.7 U	3.5 U	3.6 U	3.8 U	4 U	3.6 U	3.6 U	3.7 U	3.7 U	3.8 U	3.4 U
Copper	2.6 U	2.4 U	2.3 U	2.5 U	2.3 U	2.4 U	2.5 U	2.6 U	2.4 U	2.4 U	2.5 U	2.5 U	1.9 J	2.3 U
Iron	1,270 J	734 J	734 J	1,130 J	917 J	2,540 J	1,780 J	1,370 J	1,020 J	1,300 J	761 J	2,160 J	5,180 J	1,900 J
Lead	1.7	2.8	1.1	1.6	0.78	2.2	1.8	1.4	3.8	1.8	1.7	1.5	4.2	1.4
Magnesium	726 J	468 J	499 J	616 J	558 J	1,170 J	903 J	495 J	683 J	777 J	498 J	1,160 J	2,040	1,110 J
Manganese	6.4	3.5 J	3.3 J	5.5	4	13.4	9	6.2	3.9	7.2	3.9	11.8	27.2	10.1
Mercury	0.045 U	0.038 U	0.041 U	0.041 U	0.039 U	0.043 U	0.042 U	0.043 U	0.046 U	0.04 U	0.04 U	0.04 U	0.045 U	0.04 U
Nickel	0.92 J	2.4 U	2.3 U	2.5 U	0.73 J	1.9 J	1.4 J	0.82 J	0.79 J	0.96 J	2.5 U	1.4 J	2.9	1.1 J
Selenium	1.3 U	1.2 U	1.1 U	1.2 U	1.2 U	1.2 U	1.3 U	1.3 U	1.2 U	1.2 U	1.2 U	1.2 U	1.3 U	1.1 U
Silver	2.6 U	2.4 U	2.3 U	2.5 U	2.3 U	2.4 U	2.5 U	2.6 U	2.4 U	2.4 U	2.5 U	2.5 U	2.6 U	2.3 U
Sodium	2,850 U	2,200 U	2,340 U	2,520 U	2,540 U	3,320 U	3,230 U	1,320 U	3,190 U	3,090 U	2,430 U	3,200 U	4,150 U	2,850 U
Thallium	2.6 U	2.4 U	2.3 U	2.5 U	2.3 U	2.4 U	2.5 U	2.6 U	2.4 U	2.4 U	2.5 U	2.5 U	2.6 U	2.3 U
Vanadium	4.4	2.5 J	2 J	2.4 J	2.9 J	7.9	5.8	2.7 J	3.1 J	4	2.3 J	5.9	10.9	4.6
Zinc	5.2 U	4.7 U	4.6 U	4.9 U	4.6 U	8.9	5 U	5.3 U	4.9 U	4.9 U	5 U	5.5 U	13	4.8 U

Notes:

Shading indicates detections
NA - Not analyzed
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
MG/KG - Milligrams per kilogram
UG/KG - Micrograms per kilogram

Cherry Point
CTO-201 Cat Island
Sediment Samples Raw Analytical Grain Size and TOC Data Tables
May 2009

Station ID	CI-SD01	CI-SD02	CI-SD03		CI-SD04	CI-SD05		CI-SD06	CI-SD07	CI-SD08	CI-SD09	CI-SD10	CI-SD11	CI-SD12
Sample ID	CI-SD01-0509	CI-SD02-0509	CI-SD03-0509	CI-SD03-P-0509	CI-SD04-0509	CI-SD05-0509	CI-SD05-P-0509	CI-SD06-0509	CI-SD07-0509	CI-SD08-0509	CI-SD09-0509	CI-SD10-0509	CI-SD11-0509	CI-SD12-0509
Sample Date	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09	05/27/09
Chemical Name														
Wet Chemistry														
TOC (mg/kg)	4,210	706 J	1,220 J	1,150 J	2,290	2,900	2,810	1,010 J	5,730	4,170	1,450 J	2,910	4,860	1,210 J
Geotechnical (PCT)														
Gravel	0	0	0	1	0	0	0	1	0	0	0	1	1	3
Clay	6	4	6	6	3	9	5	6	4	5	5	9	11	5
Sand	94	94	94	92	94	89	63	93	95	92	93	87	81	91
Silt	0	2	0	0	3	2	32	1	1	3	2	4	7	1

Notes:

Shading indicates detections

NA - Not analyzed

J - Analyte present, value may or may not be accurate or precise

MG/KG - Milligrams per kilogram

PCT - Percent

Cherry Point - Cat Island BT-2
CTO-201
Final Surface Water Samples Raw Analytical Data Tables
March and May 2009

Station ID	CI-SW01	CI-SW02		CI-SW03	CI-SW04	CI-SW05		CI-SW06
Sample ID	CI-SW01-0509	CI-SW02-0509	CI-SW02-P-0509	CI-SW03-0509	CI-SW04-0309	CI-SW05-0309	CI-SW05-D-0309	CI-SW06-0509
Sample Date	05/28/09	05/28/09	05/28/09	05/28/09	03/03/09	03/04/09	03/04/09	05/28/09
Chemical Name								
Explosives (UG/L)								
1,3,5-Trinitrobenzene	0.2 U	0.062 J	0.078 J	0.18 U	0.2 U	0.2 U	0.2 U	0.18 U
1,3-Dinitrobenzene	0.2 U	0.19 U	0.2 U	0.18 U	0.2 U	0.2 U	0.2 U	0.18 U
2,4,6-Trinitrotoluene	0.2 U	0.19 U	0.2 U	0.18 U	0.2 U	0.2 U	0.2 U	0.18 U
2,4-Dinitrotoluene	0.2 U	0.19 U	0.2 U	0.18 U	0.2 U	0.2 U	0.2 U	0.18 U
2,6-Dinitrotoluene	0.2 U	0.19 U	0.2 U	0.18 U	0.2 U	0.12 J	0.2 U	0.073 J
2-Amino-4,6-dinitrotoluene	0.2 U	0.19 U	0.2 U	0.18 U	0.2 U	0.2 U	0.2 U	0.18 U
2-Nitrotoluene	0.2 U	0.073 J	0.2 U	0.18 U	0.2 U	0.2 U	0.2 U	0.18 U
3-Nitrotoluene	0.2 U	0.19 U	0.2 U	0.18 U	0.2 U	0.2 U	0.2 U	0.18 U
4-Amino-2,6-dinitrotoluene	0.2 U	0.19 U	0.2 U	0.18 U	0.2 U	0.2 U	0.2 U	0.18 U
4-Nitrotoluene	0.2 U	0.19 J	0.2 J	0.18 U	0.2 U	0.2 U	0.2 U	0.18 U
HMX	0.2 U	0.19 U	0.2 U	0.18 U	0.22 U	0.2 U	0.2 U	0.18 U
Nitrobenzene	0.2 U	0.19 U	0.2 U	0.18 U	0.2 U	0.2 U	0.2 U	0.18 U
Nitroglycerin	2 U	1.9 U	2 U	1.8 U	0.51 U	0.52 U	0.51 U	1.8 U
Perchlorate	0.2 U	0.2 U	0.2 U	0.2 U	0.08 U	0.08 U	0.08 U	0.2 U
PETN	2 U	1.9 U	2 U	1.8 U	0.79 U	0.8 U	0.78 U	1.8 U
RDX	0.2 U	0.076 J	0.2 U	0.18 U	2.3	0.2 U	0.2 U	0.18 U
Tetryl	0.2 U	0.19 U	0.2 U	0.18 U	0.2 U	0.2 U	0.2 U	0.18 U
Total Metals (UG/L)								
Aluminum	332 J	394 J	436 J	608 J	200 U	200 U	1,040	669 J
Antimony	15 U	15 U	15 U	15 U	15 U	15 U	15 U	15 U
Arsenic	10 U	10 U	10 U	10 U	50 U	5.5 J	3.5 J	10 U
Barium	14.4 J	14.8 J	14.3 J	15.2 J	14 J	16.8 J	19.5 J	15.3 J
Beryllium	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Cadmium	2.2 J	2.1 J	2.3 J	2.4 J	10.6 J	2.4 J	2.6 J	2.4 J
Calcium	399,000	397,000	385,000	409,000	358,000	358,000	347,000	406,000
Chromium	10 U	10 U	10 U	10 U	50 U	50 U	50 U	10 U
Cobalt	15 U	15 U	15 U	15 U	15 U	15 U	15 U	15 U
Copper	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Iron	230 J	290 J	302 J	500 J	60.6 J	141 J	1,500 J	491 J
Lead	15 U	15 U	15 U	15 U	15 U	3 U	15 U	15 U
Magnesium	1,150,000	1,130,000	1,110,000	1,150,000	1,190,000	1,050,000	1,020,000	1,160,000
Manganese	75 U	75 U	75 U	17.7 J	7.2 J	16.9	23.6	75 U
Mercury	0.2 U	0.2 U	0.2 U	0.2 U	0.2 UJ	0.2 U	0.2 U	0.2 U
Nickel	5.2 J	5.5 J	5.2 J	4.9 J	10 U	10 U	10 U	4.7 J
Potassium	NA	NA	NA	NA	463,000	420,000	403,000	NA
Selenium	3.3 J	3.4 J	5.8 J	6.5 J	17.5 J	5.3	8.4	4.4 J
Silver	1.5 J	1.3 J	1.1 J	1.6 J	50 U	1.2 J	1.2 J	1.7 J
Sodium	9,490,000	9,440,000	9,110,000	9,780,000	10,400,000	8,590,000	8,120,000	9,760,000
Thallium	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Vanadium	15 U	5.3 J	5.3 J	5.7 J	15 U	15 U	5.6 J	5.4 J
Zinc	100 U	100 U	100 U	100 U	20 U	20 U	20 U	100 U

Cherry Point - Cat Island BT-2
CTO-201
Final Surface Water Samples Raw Analytical Data Tables
March and May 2009

Station ID	CI-SW01	CI-SW02		CI-SW03	CI-SW04	CI-SW05		CI-SW06
Sample ID	CI-SW01-0509	CI-SW02-0509	CI-SW02-P-0509	CI-SW03-0509	CI-SW04-0309	CI-SW05-0309	CI-SW05-D-0309	CI-SW06-0509
Sample Date	05/28/09	05/28/09	05/28/09	05/28/09	03/03/09	03/04/09	03/04/09	05/28/09
Chemical Name								
Dissolved Metals (UG/L)								
Aluminum, Dissolved	200 U	200 U	200 U	200 U	511 J	391 J	415 J	200 U
Antimony, Dissolved	15 U	15 U	15 U	15 U	15 U	15 U	15 U	15 U
Arsenic, Dissolved	10 U	10 U	10 U	10 U	10 U	9.8 J	3.4 J	10 U
Barium, Dissolved	14.2 J	13.8 J	13.9 J	13.8 J	13.6 J	15.5 J	15.1 J	14 J
Beryllium, Dissolved	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Cadmium, Dissolved	2.5 J	2.5 J	2.4 J	2.1 J	2.3 J	2.3 J	2.6 J	2.4 J
Calcium, Dissolved	393,000	387,000	392,000	392,000	376,000	362,000	348,000	402,000
Chromium, Dissolved	10 U	10 U	10 U	10 U	50 U	50 U	50 U	10 U
Cobalt, Dissolved	15 U	15 U	15 U	15 U	15 U	15 U	15 U	15 U
Copper, Dissolved	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Iron, Dissolved	500 U	500 U	500 U	500 U	100 U	100 U	100 U	500 U
Lead, Dissolved	15 U	15 U	15 U	15 U	15 U	15 U	13.5 J	15 U
Magnesium, Dissolved	1,310,000	1,310,000	1,300,000	1,310,000	1,250,000	1,060,000	1,020,000	1,310,000
Manganese, Dissolved	75 U	75 U	75 U	75 U	6.7 J	15.7	15.8	75 U
Mercury, Dissolved	0.2 U	0.2 U	0.2 U	0.2 U	0.2 UJ	0.2 UJ	0.2 UJ	0.2 U
Nickel, Dissolved	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Potassium, Dissolved	443,000	442,000	438,000	445,000	470,000	419,000	408,000	445,000
Selenium, Dissolved	6.4 J	4.7 J	5 J	5 U	5 U	5 U	5.3 J	5.1 J
Silver, Dissolved	1.1 J	1.2 J	1.3 J	1.4 J	1.4 J	1.5 J	1.1 J	1.3 J
Sodium, Dissolved	10,100,000	9,890,000	10,100,000	10,300,000	10,800,000	8,570,000	8,280,000	10,300,000
Thallium, Dissolved	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Vanadium, Dissolved	15 U	15 U	15 U	15 U	15 U	15 U	15 U	15 U
Zinc, Dissolved	100 U	100 U	100 U	29.6 J	20 U	20 U	20 U	100 U

Notes:

Shading indicates detections
NA - Not analyzed
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
UJ - Analyte not detected, quantitation limit may be inaccurate
UG/L - Micrograms per liter

Cherry Point - Cat Island BT-2
CTO-201
IDW Results
Raw Analytical Data Tables
May 2009

Station ID	CI-IDW
Sample ID	CI-IDW-SD-052909
Sample Date	05/29/09
Chemical Name	
TCLP Volatile Organic Compounds (MG/L)	
1,1-Dichloroethene	0.01 U
1,2-Dichloroethane	0.01 U
1,4-Dichlorobenzene	0.01 U
2-Butanone	0.1 U
Benzene	0.01 U
Carbon tetrachloride	0.01 U
Chlorobenzene	0.01 U
Chloroform	0.0012 J
Tetrachloroethene	0.01 U
Trichloroethene	0.01 U
Vinyl chloride	0.02 U
TCLP Semivolatile Organic Compounds (MG/L)	
2,4,5-Trichlorophenol	0.05 U
2,4,6-Trichlorophenol	0.05 U
2,4-Dinitrotoluene	0.05 U
2-Methylphenol	0.05 U
3-Methylphenol	0.05 U
4-Methylphenol	0.05 U
Hexachlorobenzene	0.05 U
Hexachlorobutadiene	0.05 U
Hexachloroethane	0.05 U
Nitrobenzene	0.05 U
Pentachlorophenol	0.2 U
Pyridine	0.2 U
TCLP Pesticides/Polychlorinated Biphenyls (MG/L)	
Endrin	1.00E-04 U
gamma-BHC (Lindane)	1.00E-04 U
gamma-Chlordane	5.00E-04 U
Heptachlor	1.00E-04 U
Heptachlor epoxide	1.00E-04 U
Methoxychlor	1.00E-04 U
Toxaphene	0.01 U
TCLP Herbicides (MG/L)	
2,4,5-TP (Silvex)	5.00E-04 U
2,4-D	0.005 U
TCLP Metals (UG/L)	
Arsenic	100 U
Barium	166 J
Cadmium	50 U
Chromium	100 U
Lead	16.6 J
Selenium	50 U
Silver	100 U
Mercury	2 U

Notes:

Shading indicates detections
NA - Not analyzed
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
MG/L - Milligrams per liter
UG/L - Micrograms per liter

Cherry Point - Cat Island BT-2
CTO-201
IDW Wet Chemistry Results
Raw Analytical Data Tables
May 2009

Station ID	CI-IDW
Sample ID	CI-IDW-SD-052909
Sample Date	05/29/09
Chemical Name	
Total Metals (MG/KG)	
Cyanide	0.25 U
Wet Chemistry	
Ignitability (DEG/F)	158
PH	7.66
Reactivity (MG/KG)	
Reactive Sulfide	57 U

Notes:

Shading indicates detections
NA - Not analyzed
U - The material was analyzed for, but not detected
DEG/F - Degrees Fahrenheit
MG/KG - Milligrams per kilogram
PH - pH units

Appendix E
Human Health Risk Screening Tables

TABLE 2.1
Occurrence, Distribution and Selection of Chemicals of Poetntial Concern
Former Cat Island Bomb Target BT-2 and Surface Danger Zone
MCAS Cherry Point, North Carolina

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum [1] Concentration Qualifier	Maximum [1] Concentration Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration [2] Used for Screening	Background [3] Value	Screening [4] Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for [5] Contaminant Deletion or Selection
Surface Soil	121-14-2	2,4-Dinitrotoluene	ND	ND	MG/KG		0/6	0.25 - 0.25	2.5E-01	N/A	1.6E+00 C*	N/A	N/A	NO	DLBSL
	606-20-2	2,6-Dinitrotoluene	ND	ND	MG/KG		0/6	0.25 - 0.25	2.5E-01	N/A	6.1E+00 N	N/A	N/A	NO	DLBSL
	98-95-3	Nitrobenzene	ND	ND	MG/KG		0/6	0.25 - 0.25	2.5E-01	N/A	4.8E+00 C*	N/A	N/A	NO	DLBSL
	99-35-4	1,3,5-Trinitrobenzene	ND	ND	MG/KG		0/6	0.25 - 0.25	2.5E-01	N/A	2.2E+02 N	N/A	N/A	NO	DLBSL
	99-65-0	1,3-Dinitrobenzene	ND	ND	MG/KG		0/6	0.25 - 0.25	2.5E-01	N/A	6.1E-01 N	N/A	N/A	NO	DLBSL
	118-96-7	2,4,6-Trinitrotoluene	ND	ND	MG/KG		0/6	0.25 - 0.25	2.5E-01	N/A	3.6E+00 C**	N/A	N/A	NO	DLBSL
	35572-78-2	2-Amino-4,6-dinitrotoluene	ND	ND	MG/KG		0/6	0.25 - 0.25	2.5E-01	N/A	1.5E+01 N	N/A	N/A	NO	DLBSL
	88-72-2	2-Nitrotoluene	ND	ND	MG/KG		0/6	0.25 - 0.25	2.5E-01	N/A	2.9E+00 C*	N/A	N/A	NO	DLBSL
	99-08-1	3-Nitrotoluene	ND	ND	MG/KG		0/6	0.25 - 0.25	2.5E-01	N/A	6.1E-01 N	N/A	N/A	NO	DLBSL
	19406-51-0	4-Amino-2,6-dinitrotoluene	ND	ND	MG/KG		0/6	0.25 - 0.25	2.5E-01	N/A	1.5E+01 N	N/A	N/A	NO	DLBSL
	99-99-0	4-Nitrotoluene	ND	ND	MG/KG		0/6	0.25 - 0.25	2.5E-01	N/A	2.4E+01 C**	N/A	N/A	NO	DLBSL
	2691-41-0	HMX	ND	ND	MG/KG		0/6	0.25 - 0.25	2.5E-01	N/A	3.8E+02 N	N/A	N/A	NO	DLBSL
	55-63-0	Nitroglycerin	ND	ND	MG/KG		0/6	0.65 - 0.65	6.5E-01	N/A	6.1E-01 N	N/A	N/A	YES	DLASL
	14797-73-0	Perchlorate	ND	ND	MG/KG		0/6	0.0023 - 0.0038	3.8E-03	N/A	5.5E+00 N	N/A	N/A	NO	DLBSL
	78-11-5	PETN	ND	ND	MG/KG		0/6	0.001 - 1	1.0E+00	N/A	N/A	N/A	N/A	NO	NTX
	121-82-4	RDX	ND	ND	MG/KG		0/6	0.25 - 0.25	2.5E-01	N/A	5.5E+00 C*	N/A	N/A	NO	DLBSL
	479-45-8	Tetryl	ND	ND	MG/KG		0/6	0.25 - 0.25	2.5E-01	N/A	2.4E+01 N	N/A	N/A	NO	DLBSL
	7429-90-5	Aluminum	1.9E+02	4.3E+03	MG/KG	CI-SS04-0309	6/6	43.9 - 65.9	4.3E+03	N/A	7.7E+03 N	N/A	N/A	NO	BSL
	7440-36-0	Antimony	ND	ND	MG/KG		0/6	3.3 - 4.9	4.9E+00	N/A	3.1E+00 N	N/A	N/A	YES	DLASL
	7440-38-2	**Arsenic**	**1.3E+00 J**	**3.1E+00**	**MG/KG**	**CI-SS04-0309 : CI-SS06-0309**	**4/6**	**2.2 - 3.3**	**3.1E+00**	**N/A**	**3.9E-01 C***	**5.8E+00**	**Csoil**	**YES**	**ASL**
	7440-39-3	Barium	1.6E+00 J	6.9E+00 J	MG/KG	CI-SS04-0309	5/6	8.8 - 13.2	6.9E+00	N/A	1.5E+03 N	5.8E+02	Csoil	NO	BSL
	7440-41-7	Beryllium	ND	ND	MG/KG		0/6	1.1 - 1.6	1.6E+00	N/A	1.6E+01 N	N/A	N/A	NO	DLBSL
	7440-43-9	Cadmium	2.4E-01 J	2.4E-01 J	MG/KG	CI-SS03-0309	1/6	1.1 - 1.6	2.4E-01	N/A	7.0E+00 N	3.0E+00	N/A	NO	BSL
	7440-70-2	Calcium	2.8E+02 J	1.7E+04	MG/KG	CI-SS03-0309	5/6	1100 - 1650	1.7E+04	N/A	N/A	N/A	N/A	NO	NUT
	7440-47-3	**Chromium**	**7.8E-01 J**	**1.3E+01**	**MG/KG**	**CI-SS04-0309**	**6/6**	**2.2 - 3.3**	**1.3E+01**	**N/A**	**2.9E-01 C**	**3.8E+00**	**Csoil**	**YES**	**ASL**
	7440-48-4	Cobalt	ND	ND	MG/KG		0/6	3.3 - 4.9	4.9E+00	N/A	2.3E+00 N	N/A	N/A	YES	DLASL
	7440-50-8	Copper	3.1E+00 J	7.6E+00	MG/KG	CI-SS03-0309	4/6	2.2 - 3.3	7.6E+00	N/A	3.1E+02 N	7.0E+02	Csoil	NO	BSL
	7439-89-6	**Iron**	**2.5E+02**	**5.9E+03**	**MG/KG**	**CI-SS06-0309**	**6/6**	**22 - 33**	**5.9E+03**	**N/A**	**5.5E+03 N**	**1.5E+02**	**Csoil**	**YES**	**ASL**
	7439-92-1	Lead	1.4E+00	1.6E+01	MG/KG	CI-SS04-0309	6/6	0.66 - 0.99	1.6E+01	N/A	4.0E+02 NL	2.7E+02	Csoil	NO	BSL
	7439-95-4	Magnesium	2.7E+02 J	1.9E+03	MG/KG	CI-SS06-0309	5/6	1100 - 1650	1.9E+03	N/A	N/A	N/A	N/A	NO	NUT
	7439-96-5	Manganese	2.0E+00 J	2.4E+01	MG/KG	CI-SS04-0309	6/6	3.3 - 4.9	2.4E+01	N/A	1.8E+02 N	N/A	N/A	NO	BSL
	7439-97-6	Mercury	2.6E-02 J	2.6E-02 J	MG/KG	CI-SS03-0309	1/6	0.036 - 0.055	2.6E-02	N/A	2.3E+00 N	1.0E+00	Csoil	NO	BSL
	7440-02-0	Nickel	8.8E-01 J	3.2E+00	MG/KG	CI-SS04-0309	4/6	2.2 - 3.3	3.2E+00	N/A	1.5E+02 N	1.3E+02	Csoil	NO	BSL
	7440-09-7	Potassium	2.5E+02 J	9.0E+02	MG/KG	CI-SS04-0309	4/6	1100 - 1650	9.0E+02	N/A	N/A	N/A	N/A	NO	NUT
	7782-49-2	Selenium	9.9E-01 J	1.3E+00	MG/KG	CI-SS03-0309 : CI-SS03-D-0309	3/6	1.1 - 1.6	1.3E+00	N/A	3.9E+01 N	2.1E+00	Csoil	NO	BSL
	7440-22-4	Silver	ND	ND	MG/KG		0/6	2.2 - 3.3	3.3E+00	N/A	3.9E+01 N	3.4E+00	Csoil	NO	DLBSL

TABLE 2.1
Occurrence, Distribution and Selection of Chemicals of Poetntial Concern
Former Cat Island Bomb Target BT-2 and Surface Danger Zone
MCAS Cherry Point, North Carolina

Scenario Timeframe: Current/Future
Medium: Surface Soil
Exposure Medium: Surface Soil

Exposure Point	CAS Number	Chemical	Minimum [1] Concentration Qualifier	Maximum [1] Concentration Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration [2] Used for Screening	Background [3] Value	Screening [4] Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for [5] Contaminant Deletion or Selection
	7440-23-5	Sodium	6.4E+02 J	4.3E+03	MG/KG	CI-SS06-0309	6/6	1100 - 1650	4.3E+03	N/A	N/A	N/A	N/A	NO	NUT
	7440-28-0	Thallium	ND	ND	MG/KG		0/6	2.2 - 3.3	3.3E+00	N/A	N/A	N/A	N/A	NO	NTX
	7440-62-2	Vanadium	1.2E+00 J	1.4E+01	MG/KG	CI-SS04-0309	5/6	3.3 - 4.9	1.4E+01	N/A	3.9E+01 N	N/A	N/A	NO	BSL
	7440-66-6	Zinc	2.2E+00 J	6.2E+01	MG/KG	CI-SS03-0309	5/6	4.4 - 6.6	6.2E+01	N/A	2.3E+03 N	1.2E+03	Csoil	NO	BSL

[1] Minimum/Maximum detected concentrations.
[2] Maximum concentration is used for screening.
[3] Background values not available.
[4] Oak Ridge National Laboratory (ORNL).May 2010. Residential Regional Screening Levels for Chemical Contaminants at Superfund Sites (based on 10-6 for carcinogens and HQ of 0.1 for noncarcinogens). [Online]. Available: http://epa-prgs.ornl.gov/chemicals/index.shtml
The soil value of 400 mg/kg for lead is from the Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, USEPA, July 14, 1994.
RSL value for Chromium(VI) used as surrogate for chromium.
RSL value for manganese (water) used for manganese.
RSL value for mercury (inorganic salts) used for mercury.
[5] Rationale Codes

Selection Reason: Above Screening Levels (ASL)
Detection Limit Above Screening Levels (DLASL)
Deletion Reason: No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)
Detection Limit Below Screening Level (DLBSL)

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
J = Estimated Value
N/A = Not Applicable/Not Available
ND = Not Detected
NL = Noncarcinogenic lead residential soil RSL not adjusted by dividing by 10.
C = Carcinogenic
N = Noncarcinogenic
C* = N screening level < 100x C screening level, therefore N screening value/10 used as screening level
C** = N screening level < 10x C screening level, therefore N screening value/10 used as screening level
S = concentration exceeds Csat, used Csat as screening value
Csoil = Federal Remediation Branch Target Screening Values, calculated source concentration for soil which is protective of groundwater, January 2010

TABLE 2.1a

Step 2 Surface Soil Screening - Risk Ratio, Maximum Detected Concentration

Former Cat Island Bomb Target BT-2 and Surface Danger Zone

MCAS Cherry Point, North Carolina

Analyte	Detection Frequency	Maximum Detected Concentration (Qualifier)	Sample Location of Maximum Detected Concentration	Residential Soil RSL	Acceptable Risk Level	Corresponding Hazard Index[a]	Corresponding Cancer Risk[b]	Target Organ
Metals (mg/kg)								
Arsenic	4 / 6	3.1E+00	CI-SS04-0309 : CI-SS06-0309	3.9E-01	1.0E-06	NA	8.E-06	NA
Chromium	6 / 6	1.3E+01	CI-SS04-0309	2.9E-01	1.0E-06	NA	4.E-05	NA
Iron	6 / 6	5.9E+03	CI-SS06-0309	5.5E+04	1	0.1	NA	Gastrointestinal
Cumulative Corresponding Hazard Index[c]						**0.1**		
Cumulative Corresponding Cancer Risk[d]							**5.E-05**	
							Total Gastrointestinal HI =	0.1

Notes:

[a] Corresponding Hazard Index equals maximum detected concentration divided by the RSL divided by the acceptable risk level.

[b] Corresponding Cancer Risk equals maximum detected concentration divided by the RSL divided by the acceptable risk level.

[c] Cumulative Corresponding Hazard Index equals sum of Corresponding Hazard Indices for each constituent.

[d] Cumulative Corresponding Cancer Risk equals sum of Corresponding Cancer Risks for each constituent.

Constituent selected as COPC if it contributes to an overall Hazard Index by target organ greater than 0.5 or Cumulative Corresponding Cancer Risk greater than 5E-05, otherwise, constituent not selected as COPC.

Constituents selected as COPCs are indicated by shading.

COPC = Constituent of Potential Concern

HI = Hazard Index

mg/kg = milligrams per kilogram

NA = Not available/not applicable.

TABLE 2.2
Occurrence, Distribution and Selection of Chemicals of Poetntial Concern
Former Cat Island Bomb Target BT-2 and Surface Danger Zone
MCAS Cherry Point, North Carolina

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water

Exposure Point	CAS Number	Chemical	Minimum [1] Concentration Qualifier	Maximum [1] Concentration Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration [2] Used for Screening	Background [3] Value	Screening [4] Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for [5] Contaminant Deletion or Selection
Surface Water	121-14-2	2,4-Dinitrotoluene	ND	ND	UG/L		0/5	0.18 - 0.2	2.0E-01	ND	3.4E+00 NA	9.9E-02	R-c	NO	DLBSL
	606-20-2	2,6-Dinitrotoluene	1.2E-01 J	1.2E-01 J	UG/L	CI-SW05-0309	1/5	0.18 - 0.2	1.2E-01	7.3E-02	7.1E-01 N	3.7E+00	R-n	NO	BSL
	98-95-3	Nitrobenzene	ND	ND	UG/L		0/5	0.18 - 0.2	2.0E-01	ND	3.0E+01 NA	1.2E-01	R-c	NO	DLBSL
	99-35-4	1,3,5-Trinitrobenzene	7.8E-02 J	7.8E-02 J	UG/L	CI-SW02-P-0509	1/5	0.18 - 0.2	7.8E-02	ND	7.5E+04 N	1.1E+02	R-n	NO	BSL
	99-65-0	1,3-Dinitrobenzene	ND	ND	UG/L		0/5	0.18 - 0.2	2.0E-01	ND	1.4E+02 N	3.7E-01	R-n	NO	DLBSL
	118-96-7	2,4,6-Trinitrotoluene	ND	ND	UG/L		0/5	0.18 - 0.2	2.0E-01	ND	3.9E+01 N	2.2E+00	R-c**	NO	DLBSL
	35572-78-2	2-Amino-4,6-dinitrotoluene	ND	ND	UG/L		0/5	0.18 - 0.2	2.0E-01	ND	1.5E+02 N	7.3E+00	R-n	NO	DLBSL
	88-72-2	2-Nitrotoluene	7.3E-02 J	7.3E-02 J	UG/L	CI-SW02-0509	1/5	0.18 - 0.2	7.3E-02	ND	1.5E+00 N	3.1E-01	R-c	NO	BSL
	99-08-1	3-Nitrotoluene	ND	ND	UG/L		0/5	0.18 - 0.2	2.0E-01	ND	5.3E+03 N	3.7E-01	R-n	NO	DLBSL
	19406-51-0	4-Amino-2,6-dinitrotoluene	ND	ND	UG/L		0/5	0.18 - 0.2	2.0E-01	ND	1.5E+02 N	7.3E+00	R-n	NO	DLBSL
	99-99-0	4-Nitrotoluene	2.0E-01 J	2.0E-01 J	UG/L	CI-SW02-P-0509	1/5	0.18 - 0.2	2.0E-01	ND	1.8E+01 N	4.2E+00	R-c*	NO	BSL
	2691-41-0	HMX	ND	ND	UG/L		0/5	0.18 - 0.2	2.0E-01	ND	6.3E+04 N	1.8E+02	R-n	NO	DLBSL
	55-63-0	Nitroglycerin	ND	ND	UG/L		0/5	0.51 - 2	2.0E+00	ND	6.7E+01 N	3.7E-01	R-n	NO	DLBSL
	14797-73-0	Perchlorate	ND	ND	UG/L		0/5	0.2 - 0.2	2.0E-01	ND	2.8E+00 N	2.6E+00	R-n	NO	DLBSL
	78-11-5	PETN	ND	ND	UG/L		0/5	0.78 - 2	2.0E+00	ND	N/A	N/A	N/A	NO	NTX
	121-82-4	RDX	7.6E-02 J	2.3E+00	UG/L	CI-SW04-0309	2/5	0.18 - 0.2	2.3E+00	ND	1.1E+01 N	6.1E-01	R-c	NO	BSL
	479-45-8	Tetryl	ND	ND	UG/L		0/5	0.18 - 0.2	2.0E-01	ND	4.3E+03 N	1.5E+01	R-n	NO	DLBSL
	7429-90-5	Aluminum	3.3E+02 J	1.0E+03	UG/L	CI-SW05-D-0309	4/5	200 - 200	1.0E+03	6.7E+02	8.0E+03 N	3.7E+03	R-n	NO	BSL
	7440-36-0	Antimony	ND	ND	UG/L		0/5	15 - 15	1.5E+01	ND	6.4E+02 NA	1.5E+00	R-n	NO	DLBSL
	7440-38-2	Arsenic	5.5E+00 J	5.5E+00 J	UG/L	CI-SW05-0309	1/5	10 - 50	5.5E+00	ND	1.0E+01 N	1.4E-01	A	NO	BSL
	7440-39-3	Barium	1.4E+01 J	2.0E+01 J	UG/L	CI-SW05-D-0309	5/5	40 - 40	2.0E+01	1.5E+01	2.0E+05 N	7.3E+02	R-n	NO	BSL
	7440-41-7	Beryllium	ND	ND	UG/L		0/5	5 - 5	5.0E+00	ND	7.3E+00 R-n	N/A	N/A	NO	DLBSL
	7440-43-9	**Cadmium**	**2.2E+00 J**	**1.1E+01 J**	**UG/L**	**CI-SW04-0309**	**5/5**	**5 - 25**	**1.1E+01**	**2.4E+00**	**1.8E+00 R-n**	**N/A**	**N/A**	**YES**	**ASL**
	7440-70-2	Calcium	3.6E+05	4.1E+05	UG/L	CI-SW03-0509	5/5	5000 - 5000	4.1E+05	4.1E+05	N/A	N/A	N/A	NO	NUT
	7440-47-3	Chromium	ND	ND	UG/L		0/5	10 - 50	5.0E+01	ND	4.3E-02 R-c	N/A	N/A	YES	DLASL
	7440-48-4	Cobalt	ND	ND	UG/L		0/5	15 - 15	1.5E+01	ND	4.0E+00 N	2.3E+00	R-n	YES	DLASL
	7440-50-8	Copper	ND	ND	UG/L		0/5	10 - 10	1.0E+01	ND	1.5E+02 R-n	N/A	N/A	NO	DLBSL
	7439-89-6	Iron	6.1E+01 J	1.5E+03 J	UG/L	CI-SW05-D-0309	5/5	100 - 500.01	1.5E+03	4.9E+02	2.6E+03 R-n	N/A	N/A	NO	BSL
	7439-92-1	Lead	ND	ND	UG/L		0/5	3 - 15	1.5E+01	ND	1.5E+01 M	N/A	N/A	YES	DLASL
	7439-95-4	Magnesium	1.1E+06	1.2E+06	UG/L	CI-SW04-0309	5/5	25000 - 25000	1.2E+06	1.2E+06	N/A	N/A	N/A	NO	NUT
	7439-96-5	Manganese	7.2E+00 J	2.4E+01	UG/L	CI-SW05-D-0309	3/5	15 - 75	2.4E+01	ND	1.0E+02 A	8.8E+01	R-n	NO	BSL
	7439-97-6	Mercury	ND	ND	UG/L		0/5	0.2 - 0.2	2.0E-01	ND	1.0E+00 R-n	N/A	N/A	NO	DLBSL
	7440-02-0	Nickel	4.9E+00 J	5.5E+00 J	UG/L	CI-SW02-0509	3/5	10 - 10	5.5E+00	4.7E+00	4.6E+03 A	7.3E+01	R-n	NO	BSL
	7440-09-7	Potassium	4.2E+05	4.6E+05	UG/L	CI-SW04-0309	2/2	25000 - 25000	4.6E+05	NS	N/A	N/A	N/A	NO	NUT
	7782-49-2	Selenium	3.3E+00 J	1.8E+01 J	UG/L	CI-SW04-0309	5/5	5 - 25	1.8E+01	4.4E+00	4.2E+03 A	1.8E+01	R-n	NO	BSL
	7440-22-4	Silver	1.2E+00 J	1.6E+00 J	UG/L	CI-SW03-0509	4/5	10 - 50	1.6E+00	1.7E+00	1.8E+01 R-n	N/A	N/A	NO	BSL

TABLE 2.2
Occurrence, Distribution and Selection of Chemicals of Poetntial Concern
Former Cat Island Bomb Target BT-2 and Surface Danger Zone
MCAS Cherry Point, North Carolina

Scenario Timeframe: Current/Future
Medium: Surface Water
Exposure Medium: Surface Water

Exposure Point	CAS Number	Chemical	Minimum [1] Concentration Qualifier	Maximum [1] Concentration Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration [2] Used for Screening	Background [3] Value	Screening [4] Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for [5] Contaminant Deletion or Selection
	7440-23-5	Sodium	8.6E+06	1.0E+07	UG/L	CI-SW04-0309	5/5	125000 - 250000	1.0E+07	9.8E+06	N/A	N/A	N/A	NO	NUT
	7440-28-0	Thallium	ND	ND	UG/L		0/5	10 - 10	1.0E+01	ND	4.7E-01 NA	2.4E-01	A	YES	DLASL
	7440-62-2	Vanadium	5.3E+00 J	5.7E+00 J	UG/L	CI-SW03-0509	3/5	15 - 15	5.7E+00	5.4E+00	1.8E+01 R-n	N/A	N/A	NO	BSL
	7440-66-6	Zinc	ND	ND	UG/L		0/5	20 - 100	1.0E+02	ND	1.1E+03 R-n	N/A	N/A	NO	DLBSL

[1] Minimum/Maximum detected concentrations.
[2] Maximum concentration is used for screening.
[3] Background values are from background sample CI-SW06-0509.
[4] North Carolina WQS for Human Health followed by Federal Ambient Water Quality Criteria, Consumption of Organisms.
Where North Carolina WQS or Federal Ambient Water Quality Criteria are not available, used the Tap Water RSL, May 2010, (based on $1x10^{-6}$ for carcinogens and HQ of 0.1 for noncarcinogens).
[5] Rationale Codes

Selection Reason: Above Screening Levels (ASL)
Detection Limit Above Screening Levels (DLASL)
Deletion Reason: No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)
Detection Limit Below Screening Level (DLBSL)

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
J = Estimated Value
K = Biased High
L = Biased Low
N = North Carolina 15A NCAC 2B Human Health, Amended Feb. 2010.
NA = Where North Carolina 15A NCAC 2B Human Health, Amended Feb. 2010. references Federal Ambient Water Quality Criteria, Consumption of Organisms
A= Federal Ambient Water Quality Criteria, Consumption of Organisms
M = Action level for lead from Federal Drinking Water MCLs
R-n = USEPA Regional Screening Level, noncarcinogenic (therefore, RSL divided by 10, see text)
R-c = USEPA Regional Screening Level, Carcinogenic
R-c* = R-n screening level < 100x R-c screening level, therefore R-n screening value/10 used as screening level
R-c** = R-n screening level < 10x R-c screening level, therefore R-n screening value/10 used as screening level
N/A = Not available
M = Action level for lead from Federal Drinking Water MCLs
ND = Not Detected

TABLE 2.2a

Step 2 Surface Water Screening - Risk Ratio, Maximum Detected Concentration

Former Cat Island Bomb Target BT-2 and Surface Danger Zone

MCAS Cherry Point, North Carolina

Analyte	Detection Frequency	Maximum Detected Concentration (Qualifier)	Sample	Screening Level	Acceptable Risk Level	Corresponding Hazard Index[a]	Corresponding Cancer Index[b]	Target Organ
Metals (ug/L)								
Cadmium	5 / 5	1.1E+01 J	CI-SW04-0309	1.8E+01	1	0.6	NA	Blood
Iron	5 / 5	1.5E+03 J	CI-SW05-D-0309	2.6E+04	1	0.1	NA	Gastrointestinal
Cumulative Corresponding Hazard Index[c]						**0.6**		
Cumulative Corresponding Cancer Risk[d]							**NA**	
						Total Blood HI =		0.6
						Total Gastrointestinal HI =		0.1

Screening level used for Step 2, risk ratio evaluation is the Tap Water RSL, May 2010. The North Carolina WQS for Human Health fand Federal Ambient Water Quality Criteria are not risk-based, and are not appropriate for use in Step 2.

[a] Corresponding Hazard Index equals maximum detected concentration divided by the SL divided by the acceptable risk level.

[b] Corresponding Cancer Risk equals maximum detected concentration divided by the SL divided by the acceptable risk level.

[c] Cumulative Corresponding Hazard Index equals sum of Corresponding Hazard Indices for each constituent.

[d] Cumulative Corresponding Cancer Risk equals sum of Corresponding Cancer Risks for each constituent.

Constituent selected as COPC if it contributes to an overall Hazard Index by target organ greater than 0.5 or Cumulative Corresponding Cancer Risk greater than 5E-05, otherwise, constituent not selected as COPC.

Constituents selected as COPCs are indicated by shading.

COPC = Constituent of Potential Concern

HI = Hazard Index

mg/kg = milligrams per kilogram

TABLE 2.2b
Step 3 Surface Water Screening - Risk Ratio, Maximum Detected Concentration
Former Cat Island Bomb Target BT-2 and Surface Danger Zone
MCAS Cherry Point, North Carolina

Analyte	Detection Frequency	95% UCL		95% UCL Rationale	Screening Level	Acceptable Risk Level	Corresponding Hazard Index[a]	Corresponding Cancer Risk[b]	Target Organ
Metals (ug/L)									
Cadmium	5 / 5	1.1E+01	Max	5, 6	1.8E+01	1	0.6		Blood
Cumulative Corresponding Hazard Index[c]							**0.6**		
Cumulative Corresponding Cancer Risk[d]								**NA**	
								Total Blood HI =	0.6

[a] Corresponding Hazard Index equals 95% UCL divided by the RSL divided by the acceptable risk level.
[b] Corresponding Cancer Risk equals 95% UCL divided by the RSL divided by the acceptable risk level.
[c] Cumulative Corresponding Hazard Index equals sum of Corresponding Hazard Indices for each constituent.
[d] Cumulative Corresponding Cancer Risk equals sum of Corresponding Cancer Risks for each constituent
Constituent selected as COPC if it contributes to an overall Hazard Index by target organ greater than 0.5 or Cumulative Corresponding Cancer Risk greater than 5E-05
Constituents selected as COPCs are indicated by shading.
mg/kg = milligrams per kilogram
HI = Hazard Index

ProUCL, Version 4.00.04 used to determine distribution of data and calculate 95% UCL, following recommendations in users guide (USEPA.February 2009. ProUCL, Version 4.0. Prepared by Lockheed Martin Environmental Services).
Options: Maximum Detected Value (M); 95% Student's-T test UCL (95% Stud-t)

UCL Rationale:
(1) Shapiro-Wilk W Test/Lilliefors test indicates data are log-normally distributed.
(2) Shapiro-Wilk W Test/Lilliefors indicates data are normally distributed.
(3) Anderson-Darling Test indicates data are gamma distributed.
(4) Kolmogorov-Smirnov Test indicates data are gamma distributed.
(5) Distribution tests are inconclusive (data are not normal, log-normal, or gamma-distributed).
(6) Maximum value used because calculated 95% UCL exceeds maximum concentration.

TABLE 2.3
Occurrence, Distribution and Selection of Chemicals of Poetntial Concern
Former Cat Island Bomb Target BT-2 and Surface Danger Zone
MCAS Cherry Point, North Carolina

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	CAS Number	Chemical	Minimum [1] Concentration Qualifier	Maximum [1] Concentration Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration [2] Used for Screening	Background [3] Value	Screening [4] Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for [5] Contaminant Deletion or Selection
Sediment	121-14-2	2,4-Dinitrotoluene	ND	ND	MG/KG		0/10	0.25 - 0.25	2.5E-01	ND	1.6E+00 C*			NO	DLBSL
	606-20-2	2,6-Dinitrotoluene	ND	ND	MG/KG		0/10	0.25 - 0.25	2.5E-01	ND	6.1E+00 N			NO	DLBSL
	98-95-3	Nitrobenzene	ND	ND	MG/KG		0/10	0.25 - 0.25	2.5E-01	ND	4.8E+00 C*			NO	DLBSL
	99-35-4	1,3,5-Trinitrobenzene	ND	ND	MG/KG		0/10	0.25 - 0.25	2.5E-01	ND	2.2E+02 N			NO	DLBSL
	99-65-0	1,3-Dinitrobenzene	ND	ND	MG/KG		0/10	0.25 - 0.25	2.5E-01	ND	6.1E-01 N			NO	DLBSL
	118-96-7	2,4,6-Trinitrotoluene	ND	ND	MG/KG		0/10	0.25 - 0.25	2.5E-01	ND	3.6E+00 C**			NO	DLBSL
	35572-78-2	2-Amino-4,6-dinitrotoluene	ND	ND	MG/KG		0/10	0.25 - 0.25	2.5E-01	ND	1.5E+01 N			NO	DLBSL
	88-72-2	2-Nitrotoluene	ND	ND	MG/KG		0/10	0.25 - 0.25	2.5E-01	ND	2.9E+00 C*			NO	DLBSL
	99-08-1	3-Nitrotoluene	ND	ND	MG/KG		0/10	0.25 - 0.25	2.5E-01	ND	6.1E-01 N			NO	DLBSL
	19406-51-0	4-Amino-2,6-dinitrotoluene	ND	ND	MG/KG		0/10	0.25 - 0.25	2.5E-01	ND	1.5E+01 N			NO	DLBSL
	99-99-0	4-Nitrotoluene	ND	ND	MG/KG		0/10	0.25 - 0.25	2.5E-01	ND	2.4E+01 C**			NO	DLBSL
	2691-41-0	HMX	ND	ND	MG/KG		0/10	0.25 - 0.25	2.5E-01	ND	3.8E+02 N			NO	DLBSL
	55-63-0	Nitroglycerin	ND	ND	MG/KG		0/10	2.5 - 2.5	2.5E+00	ND	6.1E-01 N			YES	DLASL
	14797-73-0	Perchlorate	4.8E-04 J	1.8E-03 J	MG/KG	CI-SD08-0509	3/10	0.0024 - 0.0036	1.8E-03	ND	5.5E+00 N			NO	BSL
	78-11-5	PETN	ND	ND	MG/KG		0/10	2.5 - 2.5	2.5E+00	ND	N/A			NO	NTX
	121-82-4	RDX	ND	ND	MG/KG		0/10	0.25 - 0.25	2.5E-01	ND	5.5E+00 C*			NO	DLBSL
	479-45-8	Tetryl	ND	ND	MG/KG		0/10	0.25 - 0.25	2.5E-01	ND	2.4E+01 N			NO	DLBSL
	7429-90-5	Aluminum	4.8E+02 J	2.7E+03 J	MG/KG	CI-SD05-0509	10/10	45.6 - 52.8	2.7E+03	1.1E+03	7.7E+03 N			NO	BSL
	7440-36-0	Antimony	ND	ND	MG/KG		0/10	3.4 - 4	4.0E+00	ND	3.1E+00 N			YES	DLASL
	7440-38-2	**Arsenic**	**9.2E-01 J**	**1.7E+00 J**	**MG/KG**	**CI-SD10-0509**	**5/10**	**2.3 - 2.6**	**1.7E+00**	**1.7E+00**	**3.9E-01 C***			**YES**	**ASL**
	7440-39-3	Barium	1.4E+00 J	4.4E+00 J	MG/KG	CI-SD05-0509	9/10	9.1 - 10.6	4.4E+00	2.5E+00	1.5E+03 N			NO	BSL
	7440-41-7	Beryllium	ND	ND	MG/KG		0/10	1.1 - 1.3	1.3E+00	ND	1.6E+01			NO	DLBSL
	7440-43-9	Cadmium	ND	ND	MG/KG		0/10	1.1 - 1.3	1.3E+00	ND	7.0E+00 N			NO	DLBSL
	7440-70-2	Calcium	2.9E+02 J	1.4E+03	MG/KG	CI-SD05-0509	10/10	1140 - 1320	1.4E+03	8.4E+02	N/A			NO	NUT
	7440-47-3	**Chromium**	**1.9E+00 J**	**1.0E+01**	**MG/KG**	**CI-SD05-0509**	**10/10**	**2.3 - 2.6**	**1.0E+01**	**5.3E+00**	**2.9E-01 C**			**YES**	**ASL**
	7440-48-4	Cobalt	ND	ND	MG/KG		0/10	3.4 - 4	4.0E+00	ND	2.3E+00 N			YES	DLASL
	7440-50-8	Copper	ND	ND	MG/KG		0/10	2.3 - 2.6	2.6E+00	1.9E+00	3.1E+02 N			NO	DLBSL
	7439-89-6	Iron	7.3E+02 J	2.5E+03 J	MG/KG	CI-SD05-0509	10/10	22.8 - 26.4	2.5E+03	1.9E+03	5.5E+03 N			NO	BSL
	7439-92-1	Lead	7.8E-01	3.8E+00	MG/KG	CI-SD07-0509	10/10	0.68 - 0.79	3.8E+00	1.4E+00	4.0E+02 NL			NO	BSL
	7439-95-4	Magnesium	4.7E+02 J	1.2E+03 J	MG/KG	CI-SD05-0509	10/10	1140 - 1320	1.2E+03	1.1E+03	N/A			NO	NUT
	7439-96-5	Manganese	3.5E+00 J	1.3E+01	MG/KG	CI-SD05-0509	10/10	3.4 - 4	1.3E+01	1.0E+01	1.8E+02 N			NO	BSL
	7439-97-6	Mercury	ND	ND	MG/KG		0/10	0.038 - 0.046	4.6E-02	ND	2.3E+00 N			NO	DLBSL
	7440-02-0	Nickel	7.3E-01 J	1.9E+00 J	MG/KG	CI-SD05-0509	7/10	2.3 - 2.6	1.9E+00	1.1E+00	1.5E+02 N			NO	BSL
	7782-49-2	Selenium	ND	ND	MG/KG		0/10	1.1 - 1.3	1.3E+00	ND	3.9E+01 N			NO	DLBSL
	7440-22-4	Silver	ND	ND	MG/KG		0/10	2.3 - 2.6	2.6E+00	ND	3.9E+01 N			NO	DLBSL
	7440-23-5	Sodium	ND	ND	MG/KG		0/10	1140 - 1320	1.3E+03	ND	N/A			NO	NUT

TABLE 2.3
Occurrence, Distribution and Selection of Chemicals of Poetntial Concern
Former Cat Island Bomb Target BT-2 and Surface Danger Zone
MCAS Cherry Point, North Carolina

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Point	CAS Number	Chemical	Minimum [1] Concentration Qualifier	Maximum [1] Concentration Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration [2] Used for Screening	Background [3] Value	Screening [4] Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for [5] Contaminant Deletion or Selection
	7440-28-0	Thallium	ND	ND	MG/KG		0/10	2.3 - 2.6	2.6E+00	ND	N/A			NO	NTX
	7440-62-2	Vanadium	2.3E+00 J	7.9E+00	MG/KG	CI-SD05-0509	10/10	3.4 - 4	7.9E+00	4.6E+00	3.9E+01 N			NO	BSL
	7440-66-6	Zinc	8.9E+00	8.9E+00	MG/KG	CI-SD05-0509	1/10	4.6 - 5.3	8.9E+00	1.3E+01	2.3E+03 N			NO	BSL

[1] Minimum/Maximum detected concentrations.
[2] Maximum concentration is used for screening.
[3] Background values are the lower concentration from background samples CI-SD11-0509 and CI-SD12-0509.
[4] Oak Ridge National Laboratory (ORNL). May 2010. Regional Screening Levels for Chemical Contaminants at Superfund Sites. [Online].
Available: http://epa-prgs.ornl.gov/chemicals/index.shtml. Residential soil RSL (based on 1x10-6 for carcinogens and HQ of 0.1 for noncarcinogens).
The soil value of 400 mg/kg for lead is from the Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities, USEPA, July 14, 1994.
RSL value for Manganese (water) used as surrogate for manganese.
RSL value for Mercury (inorganic salts) used as surrogate for mercury.
[5] Rationale Codes

Selection Reason: Above Screening Levels (ASL)
Detection Limit Above Screening Levels (DLASL)
Deletion Reason: No Toxicity Information (NTX)
Essential Nutrient (NUT)
Below Screening Level (BSL)
Detection Limit Below Screening Level (DLBSL)

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
J = Estimated Value
K = Biased High
L = Biased Low
C = Carcinogenic
C* = N screening level < 100 x C screening level, C screening level used
C** = N screening level < 10 x C screening level, N/10 screening level used
N = Noncarcinogenic
NL = Noncarcinogenic, lead RSL not divided by 10.
ND = Not Detected
N/A = Not Available

TABLE 2.3a

Step 2 Sediment Screening - Risk Ratio, Maximum Detected Concentration

Former Cat Island Bomb Target BT-2 and Surface Danger Zone

MCAS Cherry Point, North Carolina

Analyte	Detection Frequency		Maximum Detected Concentration (Qualifier)		Sample	Screening Level	Acceptable Risk Level	Corresponding Hazard Index[a]	Corresponding Cancer Index[b]	Target Organ
METAL (mg/kg)										
Arsenic	5 /	10	1.7E+00	J	CI-SD10-0509	3.9E-01	1.0E-06		4.E-06	
Chromium	10 /	10	1.0E+01		CI-SD05-0509	2.9E-01	1.0E-06	NA	3.E-05	NA
Cumulative Corresponding Hazard Index[c]										
Cumulative Corresponding Cancer Risk[d]									**4.E-05**	

[a] Corresponding Hazard Index equals maximum detected concentration divided by the SL divided by the acceptable risk level.

[b] Corresponding Cancer Risk equals maximum detected concentration divided by the SL divided by the acceptable risk level.

[c] Cumulative Corresponding Hazard Index equals sum of Corresponding Hazard Indices for each constituent.

[d] Cumulative Corresponding Cancer Risk equals sum of Corresponding Cancer Risks for each constituent.

Constituent selected as COPC if it contributes to an overall Hazard Index by target organ greater than 0.5 or Cumulative Corresponding Cancer Risk greater than 5E-05, otherwise, constituent not selected as COPC.

Constituents selected as COPCs are indicated by shading.

COPC = Constituent of Potential Concern

HI = Hazard Index

mg/kg = milligrams per kilogram

J = Estimated Value

Appendix F
Ecological Risk Screening Tables

Table F-1
Surface Soil Screening
Former Cat Island Bomb Target BT-2 and Surface Danger Zone
MCAS Cherry Point, North Carolina

Parameter Class	Chemical	Maximum Concentration (mg/kg)		Location of Maximum Concentration	Average Concentration (mg/kg)	Detection Ratio	Ecological Screening Value (ESV) (mg/kg)	Frequency of Exceedance of ESV	Cherry Point Background SS 2X Mean (mg/kg)	Frequency of Exceedance of 2X Mean Background	Detection Limit Range for Non Detects (mg/kg)	Hazard Quotient (Max/ESV)	Hazard Quotient (Avg/ESV)	Ratio of Site Max to 2X Mean Background	Retain?	Reason
Explosives	1,3,5-TRINITROBENZENE				0.25	0/6		NA		NA	0.25 to 0.25	NA	NA	NA	Uncertainty	No ESV
Explosives	1,3-DINITROBENZENE				0.25	0/6		NA		NA	0.25 to 0.25	NA	NA	NA	Uncertainty	No ESV
Explosives	2,4,6-TRINITROTOLUENE				0.25	0/6		NA		NA	0.25 to 0.25	NA	NA	NA	Uncertainty	No ESV
Explosives	2,4-DINITROTOLUENE				0.25	0/6		NA		NA	0.25 to 0.25	NA	NA	NA	Uncertainty	No ESV
Explosives	2,6-DINITROTOLUENE				0.25	0/6		NA		NA	0.25 to 0.25	NA	NA	NA	Uncertainty	No ESV
Explosives	2-AMINO-4,6-DINITROTOLUENE				0.25	0/6		NA		NA	0.25 to 0.25	NA	NA	NA	Uncertainty	No ESV
Explosives	2-NITROTOLUENE				0.25	0/6		NA		NA	0.25 to 0.25	NA	NA	NA	Uncertainty	No ESV
Explosives	3-NITROTOLUENE				0.25	0/6		NA		NA	0.25 to 0.25	NA	NA	NA	Uncertainty	No ESV
Explosives	4-AMINO-2,6-DINITROTOLUENE				0.25	0/6		NA		NA	0.25 to 0.25	NA	NA	NA	Uncertainty	No ESV
Explosives	4-NITROTOLUENE				0.25	0/6		NA		NA	0.25 to 0.25	NA	NA	NA	Uncertainty	No ESV
Explosives	HMX				0.25	0/6		NA		NA	0.25 to 0.25	NA	NA	NA	Uncertainty	No ESV
Explosives	NITROBENZENE				0.25	0/6	40	0.00%		NA	0.25 to 0.25	NA	0.0	NA	No	Not detected and average HQ is less than one.
Explosives	NITROGLYCERIN				0.65	0/6		NA		NA	0.65 to 0.65	NA	NA	NA	Uncertainty	No ESV
Explosives	PENTAERYTHRITOL TETRANITRATE				1	0/6		NA		NA	1 to 1	NA	NA	NA	Uncertainty	No ESV
Explosives	RDX				0.25	0/6		NA		NA	0.25 to 0.25	NA	NA	NA	Uncertainty	No ESV
Explosives	TETRYL				0.25	0/6		NA		NA	0.25 to 0.25	NA	NA	NA	Uncertainty	No ESV
Metals	ALUMINUM	4320		CI-SS04	2302	6/6	50	100.00%	10163.24	0.00%	--	86.4	46.0	0.4	No	Maximum is less than background
Metals	ANTIMONY				3.883	0/6	0.27	100.00%		NA	3.3 to 4.9	NA	14.4	NA	No	Not detected.
Metals	ARSENIC	3.1	J	CI-SS04	2.5	4/6	18	0.00%	3.9	0.00%	2.2 to 2.3	0.2	0.1	0.8	No	Maximum HQ is less than one and maximum is less than background.
Metals	BARIUM	6.9	J	CI-SS04	6.15	5/6	330	0.00%	23	0.00%	9 to 9	0.0	0.0	0.3	No	Maximum HQ is less than one and maximum is less than background.
Metals	BERYLLIUM				1.283	0/6	21	0.00%	0.44	100.00%	1.1 to 1.6	NA	0.1	0.0	No	Not detected and average HQ is less than one.
Metals	CADMIUM	0.24	J	CI-SS03	1.123	1/6	0.36	83.33%	1.12	50.00%	1.1 to 1.6	0.7	3.1	0.2	No	Maximum HQ is less than one. Average concentration driven by detection limits.
Metals	CALCIUM	16500		CI-SS03	3397	5/6		NA	511.32	83.33%	1130 to 1130	NA	NA	32.3	No	Mineral nutrient
Metals	CHROMIUM	12.6		CI-SS04	6.98	6/6	26	0.00%	16.96	0.00%	--	0.5	0.3	0.7	No	Maximum HQ is less than one and maximum is less than background.
Metals	COBALT				3.883	0/6	13	0.00%	2.38	100.00%	3.3 to 4.9	NA	0.3	0.0	No	Not detected and average HQ is less than one.
Metals	COPPER	7.6		CI-SS03	3.6	4/6	28	0.00%	3.76	16.67%	2.2 to 2.3	0.3	0.1	2.0	No	Maximum HQ is less than one
Metals	IRON	5850		CI-SS06	2923	6/6	200	100.00%	5958.76	0.00%	--	29.3	14.6	1.0	No	Concentrations are consistent with background.
Metals	LEAD	16.4		CI-SS04	6.717	6/6	11	16.67%	10.52	16.67%	--	1.5	0.6	1.6	No	Maximum is less than Region IV ESL, only 1 of 6 samples exceeded ESV. Average HQ is less than one.
Metals	MAGNESIUM	1890		CI-SS06	1289	5/6		NA	421.74	83.33%	1130 to 1130	NA	NA	4.5	No	Mineral nutrient
Metals	MANGANESE	24.4		CI-SS04	15.17	6/6	220	0.00%	16.72	66.67%	--	0.1	0.1	1.5	No	Maximum HQ is less than one.
Metals	MERCURY	0.026	J	CI-SS03	0.0415	1/6	0.1	0.00%	0.12	0.00%	0.036 to 0.055	0.3	0.4	0.2	No	Maximum HQ is less than one and maximum is less than background.
Metals	NICKEL	3.2		CI-SS04	2.413	4/6	38	0.00%	6.9	0.00%	2.2 to 2.3	0.1	0.1	0.5	No	Maximum HQ is less than one and maximum is less than background.
Metals	POTASSIUM	901		CI-SS04	824.2	4/6		NA	481.34	83.33%	1100 to 1130	NA	NA	1.9	No	Mineral nutrient
Metals	SELENIUM	1.3		CI-SS03	1.165	3/6	0.52	100.00%	0.56	100.00%	1.1 to 1.4	2.5	2.2	2.3	No	Selenium just barely exceeds the maximum background concentration of 1.1 mg/kg and plant lowest observable effect concentratin (LOEC) of 1 mg/kg.
Metals	SILVER				2.6	0/6	4.2	0.00%	0.82	100.00%	2.2 to 3.3	NA	0.6	0.0	No	Not detected and average HQ is less than one.
Metals	SODIUM	4280		CI-SS06	2156	6/6		NA	51.06	100.00%	--	NA	NA	83.8	No	Mineral nutrient
Metals	THALLIUM				2.6	0/6	1	100.00%	0.96	100.00%	2.2 to 3.3	NA	2.6	0.0	No	Not detected.
Metals	VANADIUM	14.1		CI-SS04	8	5/6	7.8	50.00%	19.16	0.00%	3.4 to 3.4	1.8	1.0	0.7	Yes	Concentrations are consistent with background.
Metals	ZINC	61.7		CI-SS03	18.65	5/6	46	16.67%	11.32	66.67%	4.5 to 4.5	1.3	0.4	5.5	No	Magnitude of exceedance for maximum HQ is low, average HQ is less than one, and only 1 of 6 samples exceeded ESV.

Notes
Avg - average
ESV - ecological screening value
HQ - hazard quotient
mg/L - milligrams per liter

Table F-2
Sediment Screening
Former Cat Island Bomb Target BT-2 and Surface Danger Zone
MCAS Cherry Point, North Carolina

Parameter Class	Chemical	Maximum Concentration (mg/kg)		Location of Maximum Concentration	Average Concentration (mg/kg)	Detection Ratio	Ecological Screening Value (ESV) (mg/kg)	Frequency of Exceedance of ESV	Detection Limit Range for Non Detects (mg/kg)	Hazard Quotient (Max/ESV)	Hazard Quotient (Avg/ESV)	Retain?	Reason
Explosives	1,3,5-TRINITROBENZENE				0.125	0/12		NA	0.25 to 0.25	NA	NA	No	Not detected
Explosives	1,3-DINITROBENZENE				0.125	0/12		NA	0.25 to 0.25	NA	NA	No	Not detected
Explosives	2,4,6-TRINITROTOLUENE				0.125	0/12		NA	0.25 to 0.25	NA	NA	No	Not detected
Explosives	2,4-DINITROTOLUENE				0.125	0/12		NA	0.25 to 0.25	NA	NA	No	Not detected
Explosives	2,6-DINITROTOLUENE				0.125	0/12		NA	0.25 to 0.25	NA	NA	No	Not detected
Explosives	2-AMINO-4,6-DINITROTOLUENE				0.125	0/12		NA	0.25 to 0.25	NA	NA	No	Not detected
Explosives	2-NITROTOLUENE				0.125	0/12		NA	0.25 to 0.25	NA	NA	No	Not detected
Explosives	3-NITROTOLUENE				0.125	0/12		NA	0.25 to 0.25	NA	NA	No	Not detected
Explosives	4-AMINO-2,6-DINITROTOLUENE				0.125	0/12		NA	0.25 to 0.25	NA	NA	No	Not detected
Explosives	4-NITROTOLUENE				0.125	0/12		NA	0.25 to 0.25	NA	NA	No	Not detected
Explosives	HMX				0.125	0/12		NA	0.25 to 0.25	NA	NA	No	Not detected
Explosives	NITROBENZENE				0.125	0/12		NA	0.25 to 0.25	NA	NA	No	Not detected
Explosives	NITROGLYCERIN				1.25	0/12		NA	2.5 to 2.5	NA	NA	No	Not detected
Explosives	PENTAERYTHRITOL TETRANITRATE				1.25	0/12		NA	2.5 to 2.5	NA	NA	No	Not detected
Explosives	RDX				0.125	0/12		NA	0.25 to 0.25	NA	NA	No	Not detected
Explosives	TETRYL				0.125	0/12		NA	0.25 to 0.25	NA	NA	No	Not detected
Metals	ALUMINUM	3650	J	CI-SD11	1233	12/12		NA	--	NA	NA	Uncertainty	
Metals	ANTIMONY				1.821	0/12	2	100.00%	3.4 to 4	NA	0.91	No	Not detected
Metals	ARSENIC	3.2		CI-SD11	1.431	7/12	7.24	0.00%	2.3 to 2.5	0.44	0.20	No	HQ is less than 1
Metals	BARIUM	5.7	J	CI-SD11	2.608	11/12		NA	9.4 to 9.4	NA	NA	Uncertainty	
Metals	BERYLLIUM				0.6042	0/12		NA	1.1 to 1.3	NA	NA	No	Not detected
Metals	CADMIUM				0.6042	0/12	0.676	100.00%	1.1 to 1.3	NA	0.89	No	Not detected
Metals	CALCIUM	10800		CI-SD11	1522	12/12		NA	--	NA	NA	Uncertainty	
Metals	CHROMIUM	12.2		CI-SD11	5.108	12/12	52.3	0.00%	--	0.23	0.10	No	HQ is less than 1
Metals	COBALT				1.821	0/12		NA	3.4 to 4	NA	NA	No	Not detected
Metals	COPPER	1.9	J	CI-SD11	1.271	1/12	18.7	0.00%	2.3 to 2.6	0.10	0.07	No	HQ is less than 1
Metals	IRON	5180	J	CI-SD11	1690	12/12		NA	--	NA	NA	Uncertainty	
Metals	LEAD	4.2		CI-SD11	2.073	12/12	30.2	0.00%	--	0.14	0.07	No	HQ is less than 1
Metals	MAGNESIUM	2040		CI-SD11	858.4	12/12		NA	--	NA	NA	Uncertainty	
Metals	MANGANESE	27.2		CI-SD11	8.592	12/12		NA	--	NA	NA	Uncertainty	
Metals	MERCURY				0.02079	0/12	0.13	0.00%	0.038 to 0.046	NA	0.16	No	Not detected
Metals	NICKEL	2.9		CI-SD11	1.26	9/12	15.9	0.00%	2.3 to 2.5	0.18	0.08	No	HQ is less than 1
Metals	SELENIUM				0.6042	0/12		NA	1.1 to 1.3	NA	NA	No	Not detected
Metals	SILVER				1.221	0/12	0.733	100.00%	2.3 to 2.6	NA	1.67	No	Not detected
Metals	SODIUM				1391	0/12		NA	1320 to 4150	NA	NA	No	Not detected
Metals	THALLIUM				1.221	0/12		NA	2.3 to 2.6	NA	NA	No	Not detected
Metals	VANADIUM	10.9		CI-SD11	4.467	12/12		NA	--	NA	NA	Uncertainty	
Metals	ZINC	13		CI-SD11	3.888	2/12	124	0.00%	4.6 to 5.5	0.10	0.03	No	HQ is less than 1

Notes
Avg - average
ESV - ecological screening value
HQ - hazard quotient
mg/L - milligrams per liter

Table F-3
Surface Water Screening
Former Cat Island Bomb Target BT-2 and Surface Danger Zone
MCAS Cherry Point, North Carolina

Parameter Class	Chemical	Maximum Concentration (mg/L)		Location of Maximum Concentration	Average Concentration (mg/L)	Detection Ratio	Ecological Screening Value - Marine (ESV) (mg/L)	Frequency of Exceedance of ESV	Detection Limit Range for Non Detects (mg/L)	Hazard Quotient (Max/ESV)	Hazard Quotient (Avg/ESV)	Retain?	Reason
Explosives	1,3,5-TRINITROBENZENE	0.000078	J	CI-SW02	0.000173	1/6		NA	0.00018 to 0.0002	NA	NA	Uncertainty	
Explosives	1,3-DINITROBENZENE				0.0001917	0/6		NA	0.00018 to 0.0002	NA	NA	No	Not detected
Explosives	2,4,6-TRINITROTOLUENE				0.0001917	0/6		NA	0.00018 to 0.0002	NA	NA	No	Not detected
Explosives	2,4-DINITROTOLUENE				0.0001917	0/6		NA	0.00018 to 0.0002	NA	NA	No	Not detected
Explosives	2,6-DINITROTOLUENE	0.00012	J	CI-SW05	0.0001605	2/6		NA	0.00018 to 0.0002	NA	NA	Uncertainty	
Explosives	2-AMINO-4,6-DINITROTOLUENE				0.0001917	0/6		NA	0.00018 to 0.0002	NA	NA	No	Not detected
Explosives	2-NITROTOLUENE	0.000073	J	CI-SW02	0.0001722	1/6		NA	0.00018 to 0.0002	NA	NA	Uncertainty	
Explosives	3-NITROTOLUENE				0.0001917	0/6		NA	0.00018 to 0.0002	NA	NA	No	Not detected
Explosives	4-AMINO-2,6-DINITROTOLUENE				0.0001917	0/6		NA	0.00018 to 0.0002	NA	NA	No	Not detected
Explosives	4-NITROTOLUENE	0.0002	J	CI-SW02	0.0001933	1/6		NA	0.00018 to 0.0002	NA	NA	Uncertainty	
Explosives	HMX				0.000195	0/6		NA	0.00018 to 0.00022	NA	NA	No	Not detected
Explosives	NITROBENZENE				0.0001917	0/6	0.0668	0.00%	0.00018 to 0.0002	0.0	0.0	No	Not detected
Explosives	NITROGLYCERIN				0.00142	0/6		NA	0.00051 to 0.002	NA	NA	No	Not detected
Explosives	PENTAERYTHRITOL TETRANITRATE				0.001512	0/6		NA	0.00078 to 0.002	NA	NA	No	Not detected
Explosives	RDX	0.0023		CI-SW04	0.0005227	2/6		NA	0.00018 to 0.0002	NA	NA	Uncertainty	
Explosives	TETRYL				0.0001917	0/6		NA	0.00018 to 0.0002	NA	NA	No	Not detected
Metals	ALUMINUM	1.04		CI-SW05	0.5475	5/6		NA	0.2 to 0.2	NA	NA	No	Concentrations in soil are consistent with background
Metals	ANTIMONY				0.015	0/6		NA	0.015 to 0.015	NA	NA	No	Not detected
Metals	ARSENIC	0.0055	J	CI-SW05	0.01592	1/6	0.036	16.67%	0.01 to 0.05	0.2	0.4	No	Maximum HQ is less than one
Metals	BARIUM	0.0195	J	CI-SW05	0.01553	6/6		NA	--	NA	NA	Uncertainty	
Metals	BERYLLIUM				0.005	0/6		NA	0.005 to 0.005	NA	NA	No	Not detected
Metals	CADMIUM	0.0106	J	CI-SW04	0.00375	6/6	0.0088	16.67%	--	1.2	0.4	No	Magnitude of exceedance is low
Metals	CALCIUM	409		CI-SW03	387.8	6/6		NA	--	NA	NA	No	Mineral nutrient
Metals	CHROMIUM				0.02333	0/6	0.05	0.00%	0.01 to 0.05	NA	0.5	No	Not detected, average HQ is less than one
Metals	COBALT				0.015	0/6		NA	0.015 to 0.015	NA	NA	No	Not detected
Metals	COPPER				0.01	0/6	0.0031	100.00%	0.01 to 0.01	NA	3.4	No	Not detected
Metals	IRON	1.5	J	CI-SW05	0.5139	6/6		NA	--	NA	NA	Uncertainty	
Metals	LEAD				0.013	0/6	0.0081	83.33%	0.003 to 0.015	NA	1.5	No	Not detected
Metals	MAGNESIUM	1190		CI-SW04	1138	6/6		NA	--	NA	NA	No	Mineral nutrient
Metals	MANGANESE	0.0236		CI-SW05	0.04558	3/6		NA	0.075 to 0.075	NA	NA	Uncertainty	
Metals	MERCURY				0.0002	0/6	0.00094	100.00%	0.0002 to 0.0002	NA	0.2	No	Not detected, average HQ is less than one
Metals	NICKEL	0.0055	J	CI-SW02	0.006717	4/6	0.0082	33.33%	0.01 to 0.01	0.7	0.8	No	Maximum HQ is less than one
Metals	POTASSIUM	463		CI-SW04	441.5	2/2		NA	--	NA	NA	No	Mineral nutrient
Metals	SELENIUM	0.0175	J	CI-SW04	0.00765	6/6	0.071	0.00%	--	0.2	0.1	No	Maximum HQ is less than one
Metals	SILVER	0.0017	J	CI-SW06	0.00955	5/6	0.00023	100.00%	0.05 to 0.05	7.4	41.5	No	ESV is conservative. Maximum detect was barely above the squirt value for silver (Buchman, 2008). Average driven by detection limits.
Metals	SODIUM	10400		CI-SW04	9577	6/6		NA	--	NA	NA	No	Mineral nutrient
Metals	THALLIUM				0.01	0/6		NA	0.01 to 0.01	NA	NA	No	Not detected
Metals	VANADIUM	0.0057	J	CI-SW03	0.008667	4/6		NA	0.015 to 0.015	NA	NA	Uncertainty	
Metals	ZINC				0.07333	0/6	0.081	66.67%	0.02 to 0.1	NA	0.9	No	Not detected, average HQ is less than one
Metals	ALUMINUM, DISSOLVED	0.511	J	CI-SW04	0.2877	2/6		NA	0.2 to 0.2	NA	NA	No	Concentrations in soil are consistent with background
Metals	ANTIMONY, DISSOLVED				0.015	0/6		NA	0.015 to 0.015	NA	NA	No	Not detected
Metals	ARSENIC, DISSOLVED	0.0098	J	CI-SW05	0.009967	1/6	0.036	0.00%	0.01 to 0.01	0.3	0.3	No	Maximum HQ is less than one
Metals	BARIUM, DISSOLVED	0.0155	J	CI-SW05	0.01417	6/6		NA	--	NA	NA	Uncertainty	
Metals	BERYLLIUM, DISSOLVED				0.005	0/6		NA	0.005 to 0.005	NA	NA	No	Not detected
Metals	CADMIUM, DISSOLVED	0.0026	J	CI-SW05	0.0024	6/6	0.0088	0.00%	--	0.3	0.3	No	Maximum HQ is less than one
Metals	CALCIUM, DISSOLVED	402		CI-SW06	386.2	6/6		NA	--	NA	NA	No	Mineral nutrient
Metals	CHROMIUM, DISSOLVED				0.02333	0/6	0.05	0.00%	0.01 to 0.05	NA	0.5	No	Not detected, average HQ is less than one
Metals	COBALT, DISSOLVED				0.015	0/6		NA	0.015 to 0.015	NA	NA	No	Not detected
Metals	COPPER, DISSOLVED				0.01	0/6	0.0031	100.00%	0.01 to 0.01	NA	3.4	No	Not detected
Metals	IRON, DISSOLVED				0.3667	0/6		0.00%	0.1 to 0.5	NA	NA	No	Not detected
Metals	LEAD, DISSOLVED	0.0135	J	CI-SW05	0.01475	1/6	0.0081	100.00%	0.015 to 0.015	1.6	1.7	No	Low magnitude of exceedance and only one detection
Metals	MAGNESIUM, DISSOLVED	1310		CI-SW01, CI-	1258	6/6		NA	--	NA	NA	No	Mineral nutrient
Metals	MANGANESE, DISSOLVED	0.0158		CI-SW05	0.05375	2/6		NA	0.075 to 0.075	NA	NA	Uncertainty	
Metals	MERCURY, DISSOLVED				0.0002	0/6	0.00094	100.00%	0.0002 to 0.0002	NA	0.2	No	Not detected
Metals	NICKEL, DISSOLVED				0.01	0/6	0.0081	100.00%	0.01 to 0.01	NA	1.2	No	Not detected
Metals	POTASSIUM, DISSOLVED	470		CI-SW04	444.5	2/2		NA	--	NA	NA	No	Mineral nutrient
Metals	SELENIUM, DISSOLVED	0.0064	J	CI-SW01	0.0053	4/6	0.071	0.00%	0.005 to 0.005	0.1	0.1	No	Maximum HQ is less than one
Metals	SILVER, DISSOLVED	0.0015	J	CI-SW05	0.001333	6/6	0.00023	100.00%	--	6.5	5.8	No	ESV is conservative. Maximum detect was barely above the squirt value for silver (Buchman, 2008).
Metals	SODIUM, DISSOLVED	10800		CI-SW04	10030	6/6		NA	--	NA	NA	No	Mineral nutrient
Metals	THALLIUM, DISSOLVED				0.01	0/6		NA	0.01 to 0.01	NA	NA	No	Not detected
Metals	VANADIUM, DISSOLVED				0.015	0/6		NA	0.015 to 0.015	NA	NA	No	Not detected
Metals	ZINC, DISSOLVED	0.0296	J	CI-SW03	0.0616	1/6	0.081	50.00%	0.02 to 0.1	0.3	0.7	No	Maximum HQ is less than one

Notes
Avg - average
ESV - ecological screening value