N00210.AR.000862
NSTC GREAT LAKES, IL
5090.3a

SITE INSPECTION REPORT FOR MUNITIONS RESPONSE PROGRAM RANGES VOLUME II OF II NSTC GREAT LAKES IL

9/1/2010

TETRA TECH

124

Site Inspection Report (Volume II of II)

for

Munitions Response Program Ranges

MEC Investigation

Naval Station Great Lakes
Great Lakes, Illinois

NAVFAC
Naval Facilities Engineering Command
Midwest

Naval Facilities Engineering Command Midwest

Contract Number N62472-03-D-0057

Contract Task Order F274

September 2010

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLES

FIGURES

NUMBER

ACRONYMS

AA	Anti-Aircraft
ASCII	American Standard Code for Information Interchange
BASE	Bathymetry Associated with Statistical Error
CARIS	Computer Aided Resource Information System
BL&P	Blind, Loaded, and Plugged
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CLEAN	Comprehensive Long-Term Environmental Action Navy
CSM	Conceptual Site Model
CTD	Conductivity, Temperature, Depth
CTO	Contract Task Order
DI	Dark Ignition
DID	Data Item Description
°	Degree
DoD	Department of Defense
DVD	Digital Video Disc
FS	Feasibility Study
GAMS	GPS Azimuth Measurement System
GLNS	Great Lakes Navigation System
GPS	Global Positioning System
HE	High Explosive
HEI	High Explosive Incendiary
HET	High Explosive Tracers
HIPS	Hydrographic Information Processing
Hz	Hertz
IMU	Inertial Motion Unit
IHO	International Hydrographic Organization
IVS	Instrument Verification Strip
kHz	Kilohertz
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MBE	Multibeam Echosounder Sonar
MC	Munitions Constituents
MEC	Munitions and Explosives of Concern

MGA	Marine Gradiometer Array
mm	Millimeter
MPPEH	Material Potentially Presenting an Explosive Hazard
MRP	Munitions Response Program
MRS	Munitions Response Site
MRU	Motion Reference Unit
MV	Marine Vessel
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NAVFAC	Naval Facilities Engineering Command NAVSTANaval Station
Navy	United States Department of Navy
NCR	Nonconformance Report
NIRIS	Naval Installation Restoration Information System
NSGL	Naval Station Great Lakes
nT	Nanotesla
NTC	Naval Training Center
%	Percent
POS	Position and Orientation System
POSPac	Position and Orientation System Post Processing Package
ppm	Parts Per Million
QA	Quality Assurance
QC	Quality Control
RI	Remedial Investigation
RTK	Real Time Kinematic
RV	Recreational Vehicle
R/V	Research Vessel
SDZ	Safety Danger Zone
SI	Site Inspection
SSC	Service School Command
3-D	Three-Dimensional
USACE	United States Army Corps of Engineers
USBL	Ultra Short Acoustic Baseline Positioning System
UXO	Unexploded Ordnance
VCF	Vessel Configuration File
WAMS	Water Area Munitions Study
WGS 84	World Geodetic System 1984

EXECUTIVE SUMMARY

This Site Inspection (SI) Report presents the results of the geophysical investigation for one range at Naval Station Great Lakes (NSGL) in Great Lakes, Illinois. The SI was performed by Tetra Tech for Naval Facilities Engineering Command (NAVFAC) Midwest under Contract Task Order (CTO) F274 of the Comprehensive Long-Term Environmental Action Navy (CLEAN) IV Contract Number N62472-03-D-0057.

The purpose of the SI was to evaluate the potential presence of residual munitions and explosives of concern (MEC) and/or material potentially presenting and explosive hazard (MPPEH) in the marine areas associated with historical anti-aircraft (AA) training at the Naval Training Center (NTC) Lakefront at Naval Station Great Lakes (NSGL) in Great Lakes, Illinois (Figure 1-1). The primary objectives of the SI were to determine the potential presence or absence of MEC and munitions constituents (MC) on or in the sediments at the bottom of Lake Michigan, which underlie the former anti-aircraft training range at the NTC, and to determine whether additional investigation or other action [e.g., Remedial Investigation (RI)/Feasibility Study (FS), interim action, etc.] is needed. Several activities were conducted to satisfy these objectives including:

- Performance of a multi-beam echosounder (MBE) survey.
- Performance of a marine gradiometer array (MGA) survey.
- Performance of survey verification using an underwater drop camera.

NTC Lakefront is located along the shoreline of Lake Michigan. The terrestrial portion of this site is approximately 1 acre in size and is located east of the bluff on the beachfront of Lake Michigan. The area is accessible via Ziegemeir Street, which was built over the former gun mount roundels for the training center. The water portion of NTC Lakefront is a fan-shaped area (range fan) of approximately 4,765 acres that extends out from the shoreline over Lake Michigan. The range fan extends approximately 30,000 feet east from the former firing positions. The width of the fan ranges from 1,600 feet at the shoreline to 16,000 feet at the terminus. Water depth in the fan ranges from 0 feet at the shoreline to slightly less than 120 feet at the terminus. Figure 2-1 illustrates the NTC Lakefront and the surrounding area.

Between 1942 and 1945, personnel stationed at NTC used the NTC Lakefront for AA artillery training. At that time, twenty-five gun mounts located on the beachfront were used to fire at targets being towed by airplane over Lake Michigan. The ammunition used included 20-mm, 40-mm, and 1.1-inch High

Explosive (HE), High Explosive Incendiary (HEI), High Explosive Tracers (HET) and/or HET-Dark Ignition (DI) rounds. Several million rounds were fired at cable-drawn targets towed by airplanes over Lake Michigan. The dud rate is estimated at 5 to 10 percent. Therefore, several hundred thousand rounds containing explosives may be present in the Lake Michigan sediment. The munitions fired had various ranges and it was theorized that there may be "bands" of munitions or related debris stretching across the lake bottom in the range fan.

A high resolution MBE system was first used to survey identified sampling transects in the study area. The MBE system selected provided high-resolution bathymetry and was capable of detecting and identifying features above the surface of bottom sediment. The MBE data was used to identify obstacles that might interfere with the planned geophysical survey or damage the geophysical instrumentation and to identify potential areas of interest. Following the MBE survey, a custom-designed marine gradiometer array (MGA) was used to perform an underwater geophysical survey to identify metallic anomalies on or near the sediment surface, which may be MEC or related debris/scrap. A number of the anomalies were later evaluated using an underwater video camera in an effort to visually identify the items.

During the MBE survey, over 150 line miles of data were collected and three features of interest were located in addition to numerous obstacles to the MGA survey (e.g., boulders, sand bars). One was identified as the intake structure for the NSGL power plant. A second was tentatively identified as debris from a shipwreck. The third feature of interest is a unique marine foundation made up of two sets of conical supports separated by a short distance. The purpose of this structure is currently undetermined.

During the MGA survey, over 150 line-miles of data was collected corresponding to the same areas covered in the MBE survey. This data was processed and interpreted to yield a list of 3,624 anomalies. This included all anomalies having the appropriate size for munitions fired on the former AA training range at NTC Lakefront. Analysis of the anomaly data revealed that there are three areas containing concentrated metallic debris within the range fan. These areas are located approximately 500 to 2,500, 10,000 to 14,000, and 18,000 feet from the firing line for the former range (see Figure 5-2 in the report). The inner and central depositional areas cover the width of the evaluation area at about 1,300 and 7,100 feet wide, respectively. The outer depositional area is located near the right (southern) limit of evaluation and is approximately 2,900 feet wide. Metallic debris is present at the boundaries of the evaluation area and most likely continues beyond those boundaries.

The verification survey included collection of video footage while allowing the vessel to drift in the water. Video footage was successfully recorded at all planned locations. Individual frames were isolated from the video and analyzed; however, it was not possible to identify the nature of the metallic items present that generated the magnetic signature detected during the MGA survey. This was due in part to the fact that items on the sediment surface appeared to be encrusted with mussels.

The data and results of analyses suggest the following conclusions:

- The firing limits for the range (the north and south boundaries of the range fan) have not been fully defined.

- The terminus of the range fan (eastern boundary) appears to be relatively well defined. Even though the survey area ended about 915 feet short of the estimated maximum water depth range boundary based upon the depth limits set for the SI (i.e. water depth less than 120 feet), the amount of metallic debris had tapered off significantly, indicating that the terminal end of the range was in proximity to the end of the survey area.

- Deposition of MEC and/or MPPEH on the lake floor occurred in areas/bands roughly corresponding to the different average ranges of the various known munitions fired at the range.

- The underwater video camera did not prove to be an effective tool for target/anomaly verification, although it did provide data about lake bottom type and habitat.

Based on these considerations, additional evaluation will be needed to establish the nature and extent of potential MEC/MPPEH contamination of the former AA training range at NSGL. The following activities may be warranted:

1. Diving operations to evaluate the nature of selected metallic items identified during the MGA survey.

2. Additional marine survey and geophysical mapping of areas to the north, south, and east of the current survey area to bound (if possible) the metallic debris field (and potential unexploded ordnance [UXO]) associated with former range operations.

1.0 INTRODUCTION

1.1 PURPOSE OF REPORT

This is Volume II of the Site Inspection (SI) Report and presents the results of the geophysical investigation for one range at Naval Station Great Lakes (NSGL) in Great Lakes, Illinois. The SI was performed by Tetra Tech for Naval Facilities Engineering Command (NAVFAC) Midwest under Contract Task Order (CTO) F274 of the Comprehensive Long-Term Environmental Action Navy (CLEAN) IV Contract Number N62472-03-D-0057.

1.2 SCOPE OF WORK

The report has been prepared to document SI activities related to the potential presence of residual munitions and explosives of concern (MEC) in the marine areas associated with historical anti-aircraft (AA) training at the Naval Training Center (NTC) Lakefront at Naval Station Great Lakes (NSGL) in Great Lakes, Illinois (Figure 1-1).

The marine munitions response site (MRS) is being investigated to assess the presence of MEC and material potentially presenting and explosive hazard (MPPEH) under the United States Department of the Navy (Navy) Munitions Response Program (MRP). In accordance with the MRP, the Navy is following the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process for investigation and remediation of the MRS.

1.3 OBJECTIVES

The primary objectives of the SI were to determine the potential presence or absence of MEC and munitions constituents (MC) on or in the sediments at the bottom of Lake Michigan, which underlie the former AA training range at the NTC, and to determine whether additional investigation or other action [e.g., Remedial Investigation (RI)/Feasibility Study (FS), interim action, etc.] is needed. Several activities were conducted to satisfy these objectives including:

- Performance of a multi-beam echosounder (MBE) survey.
- Performance of a marine gradiometer array (MGA) survey.
- Performance of survey verification using an underwater drop camera.

This report documents the SI activities and presents the results and recommendations for the path forward for the marine MRS.

1.4 REPORT ORGANIZATION

This remainder of this report is organized in the following manner:

Section 2.0 contains a general site history and description;

Section 3.0 contains a description of the survey system configurations and the mobilization and setup procedures;

Section 4.0 describes data acquisition and processing;

Section 5.0 presents the results of the site inspection surveys;

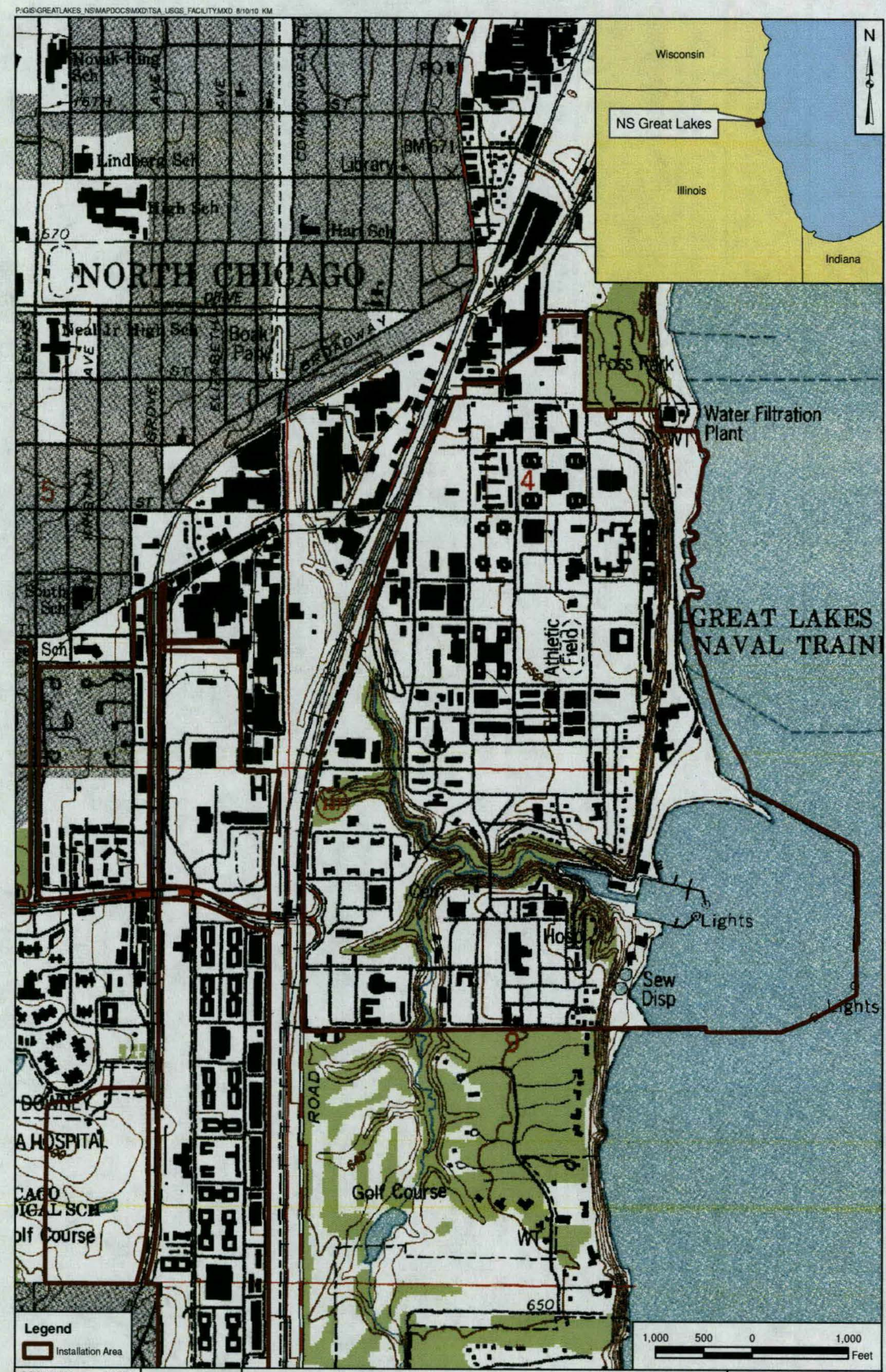
Section 6.0 contains conclusions and recommendations; and

Section 7.0 contains a reference list.

This report also contains the following for appendices:

Appendix A contains a photographic log documenting the activities conducted during the SI, equipment systems used, and other items of interest. Appendix B contains quality control (QC) data for the surveys. Appendix C contains the MBE data on digital video disc (DVD) and a full size map of the color imagery generated from the data. Appendix D contains the MGA data on DVD, along with a target/anomaly list and a full size map of the color-coded magnetic response data.

P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\TSA_USGS_FACILITY.MXD 8/10/10 KM



DRAWN BY	DATE
K. MOORE	7/26/10
CHECKED BY	DATE
J. DUCAR	8/10/10
REVISED BY	DATE
SCALE AS NOTED	

NAVFAC

FACILITY LOCATION
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NUMBER	
CTO F274	
OWNER NUMBER	
APPROVED BY	DATE
FIGURE NO.	REV
FIGURE 1-1	0

2.0 SITE DESCRIPTION AND HISTORY

2.1 SITE DESCRIPTION

NSGL sits on approximately 1,628 acres in Great Lakes, Illinois, about 20 miles north of Chicago, in Lake County, Illinois. The installation is located along the western shores of Lake Michigan, just east of U.S. Route 41 and south of the adjacent town of North Chicago. The other population center in the vicinity is the town of Waukegan, approximately 8 miles north on U.S. Route 43. NSGL is bounded by Lake Michigan to the east and Skokie Highway (U.S. Route 43) to the west. The Shore Acres Country Club is the southern border of NSGL. Figure 1-1 shows the general location of NSGL.

NSGL is the largest active duty Department of Defense (DoD) Naval training center in the US. NSGL is home to enlisted personnel training and officer accession training. The installation is one of Illinois' largest employers with over 25,000 military and civilian personnel. The Great Lakes Naval Hospital trains 4,000 Navy Corpsmen annually and is the Navy Regional Processing Site for several hundred reservists.

NSGL provides support for the Navy through the intense training and specialized itinerary for enlisted personnel preparing for the fleet. Major commands at NSGL include Naval Station (NAVSTA), a shore activity reporting command; the Recruit Training Command, at which sailors are trained; and the Service School Command (SSC), which provides initial technical training. The SSC can also be broken down into combat systems schools, engineering systems schools, and a training department.

NTC Lakefront, which is the MRS for this SI, is located along the shoreline of Lake Michigan. The terrestrial portion of this site is approximately 1 acre in size and is located east of the bluff on the beachfront of Lake Michigan. This portion of NTC Lakefront is bordered by Lake Michigan to the east, a recreational vehicle (RV) park to the north, a bluff to the west, and the Outer Harbor and Boathouse to the south. The area is accessible via Ziegemeir Street, which was built over the former gun mount roundels for the training center. Building 120 is the present lakefront magazine, according to a March 17, 2003, listing of known ammunition storage and firing locations at NSGL. Over the years, the buildings associated with the site, including the Garage and Storage, the Machine Gun Training Building, the Armory, and the Clippings and Empties Building, were demolished. A tank farm for fuel storage was constructed at the location of the former Machine Gun Training Building at NTC Lakefront to meet the needs of the power plant sometime after 1962. No construction records for the tank farm were available to provide information regarding potential munitions findings and no visible signs of the buildings exist today. The power plant, which is used by the current tank farm, is located approximately 500 feet from the tank farm at the original location of the NTC Lakefront.

Prior to using the Lakefront site, the Navy extended the shoreline area with fill material in order to install machine gun mounts. The topography of the NTC Lakefront greatly changes from the bluff to the lake. The bluff, which serves as the western boundary of the site, is steeply sloped and is the western boundary of the site. The former location of the AA training school buildings and firing points is presently paved over with concrete and asphalt and is generally flat. A sandy beach with a concrete breakwater to help control beach erosion is located to the east of the former gun mounts.

The water portion of NTC Lakefront is a fan-shaped area of approximately 4,765 acres that extends out from the shoreline over Lake Michigan. This area, known as the surface danger zone (SDZ) or range fan, is the area over which the trainees fired during historical training exercises. It is in this area where expended rounds, dud rounds, and MPPEH are anticipated to have been deposited as a result of the training activities. The range fan extends approximately 30,000 feet east from the former firing positions. The width of the fan ranges from 1,600 feet (approximately 0.3 mile) at the shoreline to 16,000 feet (approximately 3.2 miles) at the terminus. Water depth in the SDZ ranges from 0 foot at the shoreline to slightly less than 120 feet at the terminus. Figure 2-1 illustrates the NTC Lakefront and the surrounding area.

For purposes of the SI field investigation, the site was divided into two portions: the terrestrial portion, which includes the firing line and all structures and the water portion, which includes the range fan over Lake Michigan. This report addresses only the marine portion of the site.

2.2 SITE HISTORY

Between 1942 and 1945, personnel stationed at NTC used the NTC Lakefront for AA artillery training. At that time, twenty-five gun mounts located on the beachfront were used to fire at targets being towed by airplane over Lake Michigan

Approximately 1,350 sailors a day were instructed in AA training using 20- and 40-millimeter (mm) and 1.1-inch guns. Several million rounds were fired at cable-drawn targets towed by airplanes over Lake Michigan. The ammunition used included 20-mm, 40-mm, and 1.1-inch High Explosive (HE), High Explosive Incendiary (HEI), High Explosive Tracers (HET) and/or HET-Dark Ignition (DI) rounds. Based on the information obtained during the data collection process, no special consideration munitions are known or suspected to have been used at the site; therefore, the NTC Lakefront is not suspected to contain chemical warfare material filled munitions, electrically fuzed munitions, or depleted uranium associated munitions (Malcolm Pirnie 2005).

2.3 SITE CONCEPTUAL MODEL

Based upon the information available, a conceptual site model (CSM) was developed for use in the SI. This model supported the design of the field program and was later evaluated/validated using the SI data. The initial CSM is described below.

MEC may be present in Lake Michigan sediment as the result of the training operations conducted at the NTC Lakefront site. It is estimated that more than ten million rounds of ammunition were fired. The dud rate is estimated at 5 to 10 percent. Therefore, several hundred thousand rounds containing explosives may be present in the Lake Michigan sediment. Some munitions that missed the target could have automatically detonated or partially detonated as far as 3,000 yards from the firing point, meaning that MEC or MPPEH may be present at this distance from the firing point within the lake. Munitions that did not detonate at this distance may have traveled a considerable distance before impact, depending on the munitions type and typical range. Some of the munitions fired had potential ranges of up to 30,000 feet (5.68 miles). Therefore, it was theorized that there may be "bands" of munitions or related debris stretching across the lake bottom in the SDZ (range safety fan) at locations equivalent to the auto detonation distance and at other distances corresponding to impact areas associated with frequently used gun elevations or aerial target corridors. It was thought that these "bands" would more likely resemble flattened ovals, since firing would be concentrated near the center of the SDZ. Bands closer to the shore were expected to have lower density distribution with increasing density toward the middle of the SDZ. The density was expected to decrease again closer to the maximum range of the munitions items. These bands correspond to the area of secondary and primary impact based on the historical trajectory of munitions used and flight paths of the towed targets (Figure 2-1).

2.3.1 Contaminant Migration Pathways

Within the water portion of the site, MEC in the form of 20-mm and 40-mm HE rounds, 1.1-inch rounds, and associated MEC debris are expected to be located along the lake bottom within the range fan that extends over Lake Michigan. Many times these types of AA rounds used a self-destroying tracer. When the tracer detonated, it would set off the projectile burster, thereby destroying the projectile. The projectile debris would eventually settle on the lake bottom and, in the process, some MC (explosives, and metals) may have mixed into the lake water at this time. Undetonated AA rounds may corrode and decay over time, depositing explosives and metals to the lake bottom sediment. These MC may become entrained in the water column by lake mixing activities and may be transported beyond the site boundaries. These contaminants may eventually settle out onto the lake bottom or be diluted to very low levels.

2.3.2 Receptors and Exposure Pathways

Potentially complete exposure pathways exist for surface and subsurface sediment within Lake Michigan. Navy personnel, their visitors, recreationists, and commercial anglers may be exposed to MEC in sediment while diving, fishing, or swimming. Human and ecological receptors could also be exposed to MEC via dredging activities that may take place in Lake Michigan. Wave action, internal mixing, or dredging activities may result in potential MEC in subsurface sediment being transported to the surface of the lake bottom. Figure 2-2 presents a graphical CSM of the NTC Lakefront.

P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\MACHINE_GUN_RANGE_1909.MXD 11/23/09 KM

DRAWN BY K. MOORE	DATE 11/23/09		CONTRACT NUMBER F274
CHECKED BY E. LOVE	DATE 11/23/09	1909 ARCHIVAL BASE MAP PISTOL BUTTS AND MACHINE GUN RANGE NAVAL STATION GREAT LAKES	APPROVED BY ___ DATE ___
COST/SCHEDULE AREA			APPROVED BY ___ DATE ___
SCALE AS NOTED			FIGURE NO. FIGURE 2-1 / REV 0

NAVFAC

3.0 SYSTEM CONFIGURATION, MOBILIZATION AND SETUP

3.1 SURVEY VESSEL

The survey vessel for this project was the Research Vessel (R/V) Ugle Duckling, a 34-foot welded aluminum vessel with an 8.5-foot beam and a draft of 3.5 feet (see Figure 3-1). The Ugle Ducking was mobilized from Seattle, Washington to the Waukegan Marina in Waukegan, Illinois near the project site where it was sometimes moored during SI field work. At the marina, the final elements of the survey systems were installed on the vessel and all necessary measurements and calibrations were conducted. Figure 3-2 shows the final assembly of the marine gradiometer array on the dock at the Waukegan Marina.

During mobilization, all of the relative offsets of survey equipment installed on the boat were measured. These measurements were made relative to the inertial motion unit (IMU) of the Position and Orientation System (POS) 320 motion reference unit (MRU) (real time kinematic [RTK] global positioning system [GPS] with integrated inertial sensor). High-accuracy GPS was available for the duration of the survey thus providing the vertical control and positioning information for all systems aboard the vessel. These relative offset values were entered into the Computer Aided Resource Information System (CARIS) vessel configuration file (VCF) providing the information necessary to correct attitude and georeference the multibeam data.

3.2 MULTIBEAM ECHOSOUNDER AND ANCILLARY SENSORS

A high-resolution MBE system was used to survey identified sampling transects in the study area. The MBE system selected provided high-resolution bathymetry and was capable of detecting and identifying features above the surface of bottom sediment. In addition, the quality of the data made it possible to examine scour patterns potentially related to MEC or other objects residing just below the sediment surface. The MBE system had the following technical specifications and capabilities:

- An angular resolution of 0.5 degree (°) x 1.0° and a range resolution of 6-mm.
- 256 individual beams projected in an equidistant pattern (flat bottom assumed) covering a 128° swath.
- A horizontal accuracy of 9 centimeter (RTK GPS)

- The ability to detect objects ranging in size from approximately 0.25 to 1.0 meter cross-sectional area (water depth/range dependent).

The most critical characteristic for resolving and identifying features on the bottom with multibeam sonar is the system's beam width. A 400 kilohertz (kHz) system was used for this survey. This system has nearly double the beam width of the average 200 kHz system and provides much greater resolution of bottom features.

Position and water height data for the survey were provided using an RTK GPS, with satellite corrections from a local base station set up specifically for this project. Using the RTK GPS system for vessel elevation together with appropriate data quality checks eliminates the vertical uncertainties inherent with modeling vessel settlement and squat. It also automatically compensates for changes in the vessel draft due to crew and material loading.

Heading was obtained from an Applanix POS (MV [marine vessel]) 320 integrated inertial system. This high-performance system also measured vessel roll, pitch, and heave, which were used to compensate the bathymetry data for vessel motion induced by wave action and other vessel dynamics.

A sound speed profiler (the Seabird SBE-19), was used to determine sound speed versus depth through the water column. These data were input to CARIS software to model sounding refractions and determine the appropriate corrections in calculating the positions of the soundings on the lake bottom. The frequency and location of the sound speed to be used in processing the data was determined by the local conditions at each survey site. In general at least two conductivity, temperature and depth (CTD) casts were done each full survey day.

The survey system components that were used to conduct the MBE survey are listed in Table 3-1, including the software used for data acquisition and processing. The system configuration for a dual head MBE system is shown on Figure 3-3. Single sonar head system components are identical with the dual-head system with the exception that only a master sonar processor and projector/receiver array are utilized.

3.3 MARINE GRADIOMETER ARRAY

A custom-designed MGA was used to perform the underwater geophysical survey at NTC Lakefront. The MGA is towed at an altitude of approximately 2 to 2.5 meters above the lake bottom. Table 3-2 contains a description of the MGA system hardware and software components. Figure 3-4 shows the MGA deployed behind (towed by) the R/V Ugle Duckling.

3.4 SYSTEM OFFSETS

Device offsets were precisely defined for the multibeam sonar, attitude sensor, ultra-short baseline (USBL) hydrophone, and GPS antennas, so that the real-time collection and post-processing systems could accurately convert the sensor relative input data to geo-referenced XYZ locations in the defined survey coordinates.

Offsets for the SeaBat 7125 and ancillary sensors (POS MV and Trimble Ag132) were determined during the R/V Ugle Duckling mobilization at the Waukegan Marina. During this mobilization the SeaBat 7125 sonar projector and receiver arrays were attached to the hull of the vessel using the existing side mounts. Upon completion of the installation of the 7125 and support systems installation, the sensor offsets were measured by the field team.

The roll and pitch of the POS MV were recorded to provide the basis for rotating the offsets into the inertial frame of the motion sensor. Verification was performed during the GPS Azimuth Measurement System (GAMS) calibration of the POS MV system (see Section 4.5.1.2).

Installation offsets for the multibeam arrays and support sensors were entered in the data collection and processing software.

3.4.1 POS MV Offsets

The POS MV IMU was used as the point of reference for the R/V Ugle Duckling on the along-ship, across-ship, and vertical axes. The POS MV offsets are shown in Table 3-3.

3.4.2 HYPACK/HYSWEEP and CARIS HIPS Offsets

Table 3-3 shows the offsets measured in feet that were used for the HYPACK and HYSWEEP hardware setup and in the CARIS VCF. These offsets were measured relative to the POS MV IMU.

3.5 GEODESY SETTINGS

Positional data for the project were State Plane North American Datum of 1983 (NAD83) Illinois East zone. The vertical datum was North American Vertical Datum of 1988 (NAVD88). Both horizontal and vertical units were measured in feet. The HYPACK acquisition software provided the real-time datum conversion from the World Geodetic System 1984 (WGS 84) coordinates to State Plane coordinates during the survey.

3.6 DROP CAMERA FOR ANOMALY VERIFICATION

A Deep Blue Pro underwater video drop camera was used to verify selected anomalies, as possible, during the final phase of the SI. The camera was deployed on a rigid metal box frame equipped with a stabilization fin that kept the camera properly oriented as the vessel drifted over areas of interest. The Deep Blue Pro is a high-resolution color video camera equipped with two high-intensity light-emitting diode (LED) light sources. Figure 3-5 shows the camera and the frame on which it was deployed for the verification survey.

TABLE 3-1

MBE SYSTEM HARDWARE AND SOFTWARE COMPONENTS

System	Manufacturer & Model	Parameters
Multibeam Sonar System	RESON Seabat 7125	256 focused 0.5° x 1.0° beams at 400 kHz
Motion Compensation Inertial Motion Unit (IMU)	Applanix POS MV 320	0.03° accuracy – Roll, Pitch, and Heading
Multibeam Sonar Data Acquisition	HYPACK Inc.	HYPACK/HYSWEEP
Multibeam Sonar Data Processing	CARIS	HIPS
3-D Visualization and Final QC Analysis	IVS 3D	Fledermaus Professional
Global Positioning System	Leica 1230 RTK GPS/Applanix POS M/V	Kinematic mode – Horizontal: 1-2 cm ± (parts per million) ppm Vertical: 2 cm ± ppm
Auxiliary GPS	Trimble Ag132	Differential mode – Horizontal: < 1 meter RMS Vertical: Not used
Conductivity, temperature, & depth	Sea-Bird SBE-19/FSI NXIC	Conductivity, temperature, & pressure profiler for sound speed vs. depth
Sound Speed	Sea-Bird Microcat	Sound speed at the multi beam array to assist beam forming

TABLE 3-2

MGA SYSTEM HARDWARE AND SOFTWARE COMPONENTS

System	Manufacturer & Model	Parameters
MGA	Marine Magnetics/Custom Double Wide SeaQuest	Seven sensor 3-D Overhauser gradiometer
MGA Data Acquisition	SeaLINK/HyPack	Time and position tagged raw data
MGA Data Processing	Proprietary software and Geosoft Oasis Montaj	Corrected, filtered, and gridded data
USBL	IXSEA GAPS for acoustic MGA positioning	0.2% of slant range
Digital Cable Counter	Measurement Technologies LCI 90	Layback in 0.2-feet increments
Global Positioning System	Leica 1230 RTK GPS/Applanix POS M/V 320/Wavemaster	Kinematic mode – Horizontal: 1-2 centimeter ± 1ppm Vertical: 2 centimeter ± 1ppm
Auxiliary GPS	Trimble Ag132	Differential mode – Horizontal: < 1 meter RMS Vertical: Not used

TABLE 3-3

R/V UGLE DUCKLING POS MV OFFSETS

Antenna	Alongship (fwd +) (ft.)	Acrossship (stbd +) (ft.	Vertical (down +) (ft.)
Primary POS Zephyr GPS Antenna	1.18	-3.27	-9.36
Auxiliary GPS (Trimble Ag132 Antenna)	1.2	0	-9.4
Secondary POS Zephyr GPS Antenna Baseline Vector (from Primary GPS Antenna)	0	6.55	0

Note: Measured from IMU unless otherwise noted.

TABLE 3-4

R/V UGLE DUCKLING SENSOR OFFSETS

Sensor	Alongship (fwd +) (ft.)	Acrosssship (stbd +) (ft.)	Vertical (down +) (ft.)
RESON Seabat 7125	-4.74	-5.39	1.31
Motion/Position Sensor (Applanix POS MV)	0	0	0
GAPS Transducer	-4.64	5.37	3.38

FIGURE 3-1

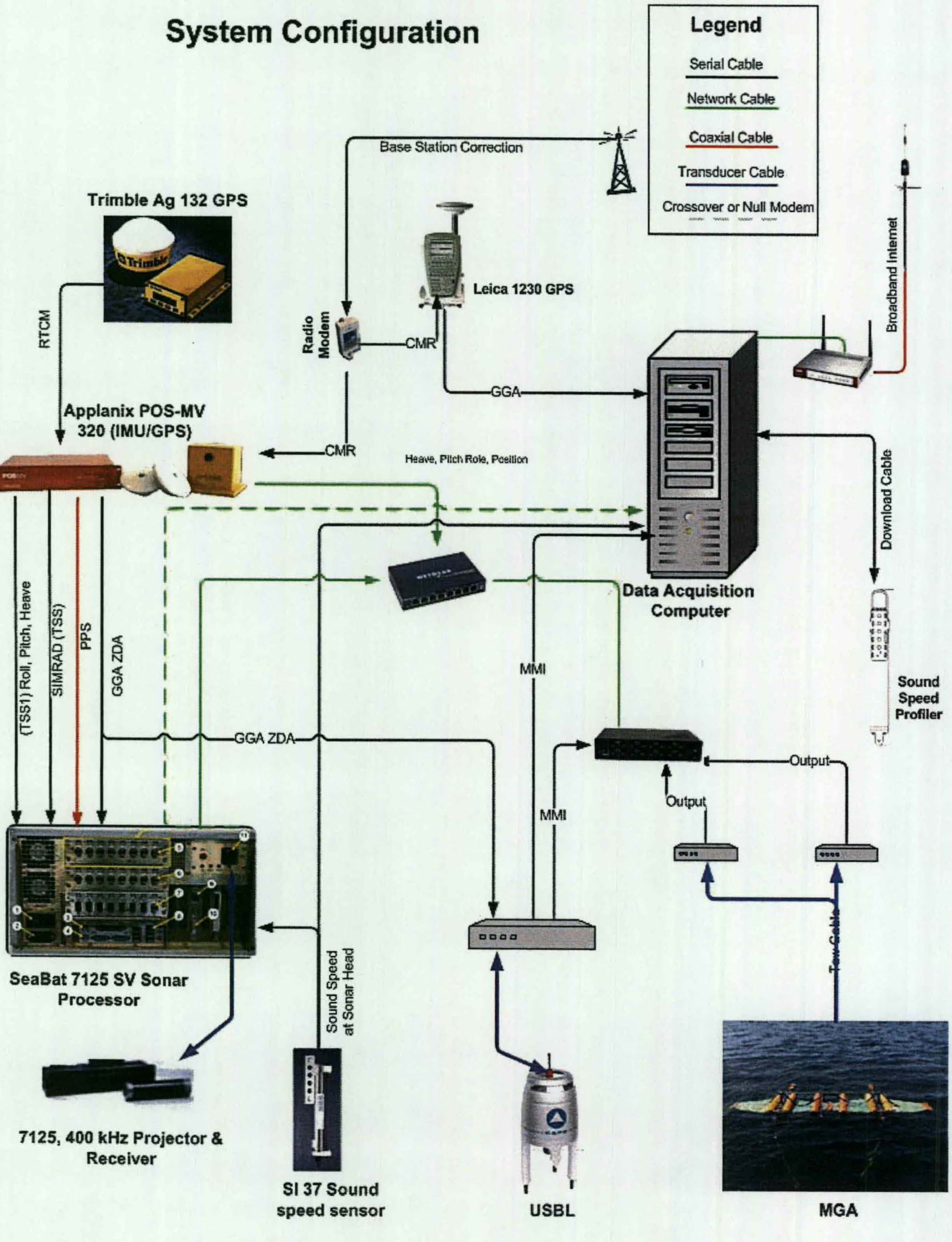
THE R/V UGLE DUCKLING

FIGURE 3-2

FINAL ASSEMBLY OF THE MGA AT THE WAUKEGAN MARINA

FIGURE 3-3

CONFIGURATION OF MARINE SURVEY SYSTEMS



Update: June 23, 2010

FIGURE 3-4

MGA DEPLOYED BEHIND THE SURVEY VESSEL

FIGURE 3-5

UNDERWATER CAMERA AND DEPLOYMENT FRAME

4.0 DATA ACQUISITION, PROCESSING, INTERPRETATION, AND USE

The boundaries for the survey were established using historical maps and data for the former AA training range at NTC Lakefront. Maps were available showing the historical SDZ that reportedly included the area between the right and left limits of fire from the firing line to the maximum range of the munitions used during training. The SDZ established for the site covers approximately 6.9 square nautical miles.

The marine surveys were conducted along a series of transects extending radially from the firing line for the historical AA training range to the terminus of the range fan, and spaced evenly to provide uniform coverage of the range fan between the right and left limits of fire. In addition, numerous cross line transects were established perpendicular to the firing line.

The use of two sets of transects, roughly perpendicular to each other, provided for cross-line ground truthing of the survey data (i.e., provided common/shared data points where the accuracy of location, sonar, and geophysical data could be compared for consistency).

Approximately 150 survey line nautical miles were surveyed in water depths ranging from 10 to 110 feet. The extreme eastern portion of the range fan (at the terminus) was not subject to survey since water depths exceeded the limit in the project scope. However, the area beyond the 110-foot depth was quite minimal. Figure 4-1 shows the SDZ and the survey transect locations. The same transects were utilized for both MBE and MGA surveys.

4.1 MBE SURVEY

4.1.1 <u>Data Acquisition</u>

MBE survey operations for the NSGL were conducted between April 16 and 23, 2010. Prior to the survey, all pre-survey calibration and QC operations detailed in Section 4.5 were completed to ensure collection of consistent, high-quality data. The survey was conducted in general accordance with the most recent U.S. Army Corps of Engineers (USACE) Hydrographic Surveying Engineering Manual (EM 1110-2-1003 and appendices; USACE 2002) for an acoustic multi-beam survey, as modified by the project-specific technical specifications provided in the approved Uniform Federal Policy Sampling and Analysis Plan (UFP-SAP) Volume II (Tetra Tech 2010).

The MBE survey was performed by navigating along the identified survey transects, allowing the MBE sonar to map a swath of bathymetry while ancillary systems tracked the 3 dimensional (3-D) movement of the vessel in real time. HYPACK hydrographic software utilizing the HYSWEEP multibeam module was the primary acquisition software for the survey. This software recorded data from the various devices and displayed it in real-time for QC by the system operator. The software also provided real-time vessel navigation information to the helmsman. The line plan and vessel tracks were displayed with the multibeam swath coverage during survey operations. This gave the hydrographers immediate indications of data quality and coverage. HYPACK monitors data quality such as time syncing between device and GPS data. The software produces audible and visual alarms if data quality is outside of preset limits. Hydrographers continuously monitored HYPACK and the acquired data during acquisition to ensure data were within project specifications. The sonar was adjusted as necessary to maximize the signal to noise ratio and optimize across-track coverage by adjusting the range, power, and gain during the survey operations. Vessel speeds were also adjusted as necessary to maintain an adequate sounding density and to meet International Hydrographic Organization (IHO) Order 1A standards.

More detailed procedures for the MBE survey, including performance criteria, are available in the approved UFP-SAP Volume II (Tetra Tech 2010)

4.1.2 Data Processing

Post-processing of the multibeam data was conducted utilizing CARIS Hydrographic Information Processing (HIPS) multibeam analysis and presentation software. Further surface analyses were performed with Fledermaus Pro software. Patch test data were analyzed and any alignment corrections necessary were applied. Sound velocity profiles were generated from CTD measurements taken in the field and were used to correct slant range measurements and compensate for ray path bending.

Data processing consisted of navigation, attitude, swath, and subset editing. Navigation edits included reviewing the data for time jumps and removing abrupt vessel turns. Attitude data were reviewed for gaps and consistency. As a result of the high quality of the post processed POS Post Processing Package data, no navigation or attitude edits were necessary for this survey. Depth filtering was used to eliminate large outliers in the water column.

Processing with the swath edit mode was used to remove the remaining outlying data points clearly identified as being noise (fliers). Fliers are often the result of bottom multiples (i.e., second returns), noise due to aeration or objects in the water column, or other environmental acoustic interference. These data points were flagged as rejected and were not used in the final data set. Sounding data were not eliminated and could be re-accepted during the subset editing process. Rejected data may also have been re-accepted, if needed, to fill data gaps if they meet accuracy standards based on comparisons to adjacent data. The number of depth cell "hits" that confirm a target above grade is three. Confirmed "targets" were retained within the database and included in all representative plots.

The HIPS subset editor and bathymetry associated with statistical error (BASE) surface creation software were the final phases of editing. Subset editing enables the hydrographer to evaluate each swath against data from overlapping survey lines while identifying potential tidal, GPS and motion artifacts. The verification of feature alignment from adjacent swaths was used to confirm sensor offsets. BASE surfaces were created to identify systematic errors or artifacts within the data set. The BASE surfaces were analyzed with multiple resolutions, sun angles, sun azimuths, and vertical exaggerations to confirm data quality. The BASE surface routine produced images representing depth, shoal-biased depth, deep-biased depth, mean depth, standard deviation, sounding density, and depth uncertainty. During acquisition in the field, editing steps were expedited to create BASE surfaces to confirm adequate multibeam coverage for each survey area and to access data quality. Comparative analysis was performed using cross-plan line depth comparisons. The multibeam survey did not cover 100 percent of the area and was primarily used to find obstructions hazardous to the MGA. Therefore, the line to line comparisons discussed above are only relevant to the data collected during the patch test and for cross-lines data in relation to the primary north-south multibeam lines.

Final exported data from the BASE surfaces included American Standard Code for Information Interchange (ASCII) XYZ text files and an Arc ASCII Grid. A final analysis was performed on the depth surfaces with the HIPS QC Report and/or Fledermaus Pro software. Final processing of the bathymetry required verified tides and was completed after field operations.

Interpretation, analysis and use of the MBE data are discussed in more detail in Section 4.3.1.

4.2 GEOPHYSICAL SURVEY

4.2.1 Data Acquisition

Geophysical survey operations for the NSGL were conducted between May 3 and 15, 2010. Prior to the survey, all pre-survey calibration and QC operations detailed in Section 4.5 were completed to ensure collection of consistent, high-quality data.

The geophysical survey was performed in much the same manner as the MBE survey by navigating along the identified survey transects and allowing the MGA to collect data while ancillary systems tracked the boat and MGA in real time. The major difference between the two survey processes is that the MGA is not mounted to the vessel, but rather is towed astern. In addition to monitoring the position of the vessel, the geophysicist must also utilize a USBL acoustic positioning system to track the MGA and verify that the array is flying along the identified survey transect. The operator also monitors attitude and altitude sensor data from the towfish to ensure it is in the proper orientation and at the proper altitude to acquire high-quality magnetic field data. The GAPS USBL tracks the position of the MGA towfish using a pole mounted acoustic array. The position of the MGA is provided to the HYPACK software where the navigation and sensor data are integrated, recorded, and displayed in real time.

The Marine Magnetic SeaLink software was used to configure and monitor the MGA. At the start of each survey, sensors were time synchronized and configured to sample at 2 Hertz (Hz). After deploying the towfish, manual tuning was applied to the sensors to reflect the earth's ambient magnetic field strength at the survey location. For NSGL, a value to 54,000 nanotesla (nT) was applied. Sealink provided a real-time graphical display of the magnetic field strength data as well as multi-axis gradients between the MGAs sensors. The raw MGA data was also recorded in SeaLink as a backup to the data stored by HYPACK.

More detailed procedures for the MGA survey, including performance criteria are available in the approved UFP-SAP Volume II (Tetra Tech 2010)

4.2.2 Data Processing

The MGA generates multiple data streams of time series total field measurements, one for each of the seven magnetometers in the array. These data can be further processed to extract a set of difference values, or gradients, between measurements from selected pairs of sensors. Each array can be processed to derive vertical, horizontal, and lateral gradients, which can be combined to form a 3-D analytic signal. Components of the MGA data must be looked at individually as well as in total (total field) in order to identify "targets" of interest. The gradient and analytic signal data provide improved resolution and positioning over that provided by the total field data alone, will often allow the reliable detection of smaller targets, and will allow identification of multiple magnetic sources.

The MGA data was first processed with MagProc software, which merged the total field data with time coincident attitude, altitude, heading, and position data to determine the XYZ position corresponding to each sensor measurement in the selected survey coordinate system. The program also computes and georeferences the gradient and analytic signal data for each of the two arrays. MagProc outputs two file types, one with the total field and position data for each sensor, and one that includes the calculated gradient and analytic values and corresponding array positions.

Initially, the MagProc files were processed using the "find magnetic dipples" function of Oasis Montaj on the total field data. Then the Gridpeak.gx function of Oasis Montaj software to identify anomalies (targets) meeting the specified project selection criteria (i.e., size representative of munitions of interest) in the analytic signal data.

The full data interpretation process is discussed in more detail in Section 4.3.2.

4.3 SURVEY DATA INTERPRETATION AND USE

4.3.1 MBE Data

Following processing, MBE data were used to identify and evaluate bathymetry, features of interest, and obstacles that might interfere with safe collection of geophysical data. Since the MGA "flies" relatively close to the sediment surface, it is essential to identify and avoid boulders, cultural debris, or other obstacles that might damage the equipment array or threaten the safety of the field crew aboard the survey vessel. The flight altitude of the MGA was adjusted in specific areas to prevent collisions with obstacles while still obtaining good quality data with which to locate and evaluate features of interest.

In addition, the MBE data revealed the presence of several cultural features in the survey area. This allowed the field personnel to select a "clear path" for the MGA. While the Navy was aware of an existing water intake for the NSGL power plant, they were not able to provide an exact location. The intakes appear clearly in the MBE data, highlighting an added benefit from the survey.

4.3.2 Geophysical Data

As previously stated, the geophysical data was initially interpreted using an automated target picking algorithm in the Oasis Montaj™ software. This is a preliminary interpretation, since this algorithm selects targets based only on amplitude and does not consider qualitative criteria such as signal shape. The potential target locations selected using Oasis Montaj were transcribed onto a color-coded image used for manual interpretation by an experienced geophysicist. Since the automated target picks are completely quantitative, they provided a QC check that prevented the geophysicist interpreter from being overly subjective during the manual interpretation. The results of the instrument verification strip (IVS) testing, the known characteristics of the survey area, and past experience regarding how underwater munitions appear within the geophysical data also contributed to the interpretation. Once targets were selected, they were placed on a final target list (Appendix D-11).

4.4 SURVEY VERIFICATION

An underwater video investigation of the bottom was performed using an underwater video drop camera mounted in a protective cage equipped with external liquid crystal display (LCD) light sources. This frame was equipped with a rudder that kept the camera consistently oriented while the vessel drifted over the bottom. The cage was occasionally lowered onto the sediment surface to provide closer examination of features/items of interest. The camera was flown at a constant altitude using the A-frame and winch onboard the survey vessel. Once the camera was in place, video was recorded for real-time viewing and future analysis.

4.5 QUALITY ASSURANCE/QUALITY CONTROL

To ensure that the data collected met the survey requirements, several quality assurance (QA)/QC measures were implemented, including system confidence checks prior to the start of survey operations. QA/QC measures included water level checks, lead lines, and/or bar checks. The velocity of sound through the water column was derived from conductivity, temperature, and depth measurements (CTD casts). Frequency of the sound velocity casts was conducted twice per day at a minimum, but was increased as necessary to maintain survey accuracy requirements. Spatial variability was taken into account as well as temporal variability when determining cast locations. These locations were recorded, and each cast was compared to the previous in order to identify any significant changes in the water column. During data collection, turns were limited and vessel speed was adjusted to ensure adequate seafloor ensonification and mapping. Specific QC tasks and activities for each survey element are discussed in the following sections.

4.5.1 MBE Survey

4.5.1.1 GPS Position Checks

Prior to the start of each survey day, an operator would set p the base station on the control point used for the RTK GPS. A rover GPS, identical to the one installed on the vessel, would then be taken to one or more different control points and the XYZ position reported by the rover would be compared to the published position of the control point.

4.5.1.2 GPS Azimuth Measurement Subsystem Calibration

Prior to initiating field surveys at NSGL and whenever necessary as automatically determined by the Applanix software (POSView), an alignment calibration of the Applanix POS MV motion and heading sensor was performed. This procedure, which Applanix refers to as a GAMS calibration, utilizes software integrated into the motion sensors. The GAMS calibration procedure is initiated while the survey vessel maneuvers in a figure-eight pattern. This calibration procedure allows the POSView software to calculate offsets between the motion sensor's two GPS antennas and to align the measured heading with the vessel, resulting in achievement of the POS MV specified heading accuracies that range from 0.02 to 0.06 degree.

4.5.1.3 Water Surface Checks

The water level check compares the water level reported by the HYPACK acquisition software to the value measured at the same time by a field technician using a Leica RTK GPS rover identical to the model installed on the survey boat. This test verified proper installation offsets on the vessel and that the GPS was configured properly and receiving accurate real time corrections. The average difference for the duration of the MBE survey was 0.09 foot. Appendix B contains a detailed table of daily QC measurements.

4.5.1.4 Sonar Bar Check

The accuracy of the sonar's ability to measure a known distance was verified each day by performing a bar check. An aluminum plate affixed to a surveyor rope was lowered below the sonar to a distance measured and marked on the surveyor rope relative to the water level. A measurement was then taken with the sonar using the HYSWEEP bar check utility. Readings were corrected for draft, pitch, and roll and differences in the values were recorded. The average difference for the duration of the project was 0.1 foot (Appendix B provides a detailed table of daily QC measurements).

4.5.1.5 Multibeam Patch Test

A standard patch test, also known as an installation calibration test, was carried out prior to the MBE survey to calculate the residual angular offsets between the multibeam echosounder and the Applanix POS MV motion compensator IMU. The installation calibration process was used to derive the precise roll, pitch, and yaw angular offsets between the multibeam sonar and the local reference frame defined by IMU. The patch test was also used to determine latency in the positioning equipment. The sonar and acquisition computers are time synchronized by the Applanix POS MV GPS; as a result, there should be no latency detected between sensors.

The patch test was conducted over an area where multiple distinct bathymetry features were present and significant changes in depth occurred over short distances along track. The area selected for the patch test was located near the entrance to the Waukegan Harbor. Pitch, roll, and yaw were measured using areas with the following characteristics:

- Roll - reciprocal lines surveyed over a flat bottom.
- Pitch - reciprocal lines surveyed over a sloping bottom, or a distinct linear feature.
- Yaw – parallel offset lines surveyed in the same direction over a sloping bottom, or a distinct linear feature.

The following table summarizes the installation offsets determined for the survey vessel

4.5.1.6 Cross-Line Comparisons

The cross-line comparison is both a measure of the system function and a data quality check. This test was performed by collecting data along lines intersecting and roughly orthogonal to the primary data collection lines. Analysis of the intersecting line data provides verification of data repeatability, and the validity of both the refraction corrections and installation linear and angular offsets. Data points co-incident to both data sets were then compared to ensure that the data was consistent. Since a large number of transects were mapped for this project and seven cross lines were established (the seven radial transects shown on Figure 4-1), a large number of data points were available for this QC comparison.

4.5.2 Magnetometer Survey

4.5.2.1 Background Test

This test evaluated system and external noise sources while the system was outside the range of any major magnetic anomalies. The test was performed by flying the array in a background area free of metal (often in mid-water column during a dive approaching a survey line). The system was allowed to collect data, which was reviewed and recorded. The geophysicist used this data to evaluate whether or not the MGA was functioning properly (i.e., that there were no large sources of noise). Statistical analysis of the data showed that for the Great Lakes Navigation System (GLNS) survey, the system operated with a low background noise level. The statistics shown on Figure 4-2 represent approximately 3 minutes of quiet data. During this time period no magnetic anomalies were observed. After applying a median filter to level and correct the data for variations in the background levels of the earth's magnetic field, all measurements were within a 2 nT range with a standard deviation of 0.33 nT.

The red line on the graph shows the uncorrected readings. The pink line shows the filtered values and the blue box (column) is the time period selected for statistical evaluation. A large magnetic target can be seen mid-line as a sharp peak.

4.5.2.2 Instrument Verification Strip

Prior to beginning the MGA survey work, the field staff installed an IVS. This verification strip provided a consistent target array used to verify the equipment function both prior to the implementation of geophysical mapping and on a daily basis during mapping. In addition to providing the basis for equipment verification, the IVS provided data on the standard response signals for the various types of munitions (either alone or in clusters) present in the test array.

The IVS for this project consisted of a plastic mat measuring approximately 4 feet by 150 feet. Actual inert munitions representative of those expected to be present in the former range area were attached to the mat either alone or in small clusters to provide an assessment of system functionality under various conditions. The mat was then deployed in an area that had been previously surveyed with the MGA and was held in place on the sediment surface using a four-point anchoring system. After deployment, the location of the IVS was determined through MBE mapping. The location of the IVS is shown on Figure 4-3. Figure 4-4 shows the construction of the IVS mat in progress (note: one of the items attached to the mat material can be seen in the photograph). Figure 4-5 shows the layout of the IVS mat including the size, number, and relative location of the items along the mat. Figure 4-6 shows examples of the seed items on the mat, including both individual and clustered items.

A suitable area free of metallic items was not able to be located for the proper placement of the IVS. The available area within the Outer Harbor that had suitable water depths and enough buffer area for boat navigation was limited. Therefore, the IVS data was not useful for discrimination of individual IVS seed items from the surrounding cultural debris. However, the test was run daily to confirm positional accuracy, equipment functionality, repeatability of results, and the feasibility of detecting metallic objects in the harbor.

Figure 9994-7a-f presents the IVS data summary. Figure 9994-7a shows the MGA total field (TF) m Map of the IVS area prior to deploying the seed items attached to the IVS mat, while Figure 9994-7c presents the analytic signal map of the IVS area prior to deploymentying the. A small area will only few anomalies exists in the center of this map view. The IVS was deployed here, but was surrounded by numerousmany pre-existing anomalies, which made it making it difficult to locate items at each end of the IVS. A total field compilation map off all MGA IVS surveys (Figure 9994-7b) shows many, if not all, of the dipole anomalies representing IVS targets. An analytic signal compilation map off all MGA IVS surveys (Figure 9994-7d) also shows some of the larger IVS items as linear line of anomalies that were not present in the pre- IVS survey. Additional examples of the daily IVS surveys are shown in Figures 9994-7e&f.

The magnetic anomalies seen in the IVS data collected onfrom the May 10th and 12th are nearly identical. At least five magnetic dipole anomalies oriented perpendicular to the IVS are clearly identifiable. On both maps dipole polarization alternates consistently between each item. On May 12th, the MGA was positioned using a cable counter and layback algorithm, where as on May 10th the MGA was positioned with the USBL. Despite using two separate positioning systems the magnetic anomalies from the IVS items are located consistently. During the data collection with the MGA tow fish, positioning was accomplished with a combination of USBL and cable counter. The magnetic anomalies seen in Figures 9994-7a-f are on average 20 feet across in the along track direction. Seed items on the IVS were only spaced at 10-foot increments, resulting in the magnetic anomalies of smaller items being masked by larger ones.

4.5.2.3 Drop Camera

Video footage was initially viewed in real time, and then replayed and reviewed in the office. The footage was re-played on a computer monitor with the screen image size ranging from approximately 9 inches by 12 inches to approximately 10 inches by 14 inches (full screen mode) by the project geophysicist, project scientists, and by Tetra Tech UXO personnel. No MEC items were identified in the drop camera video. However, Given given the cloudiness of the water, heavily populated mussel habitat, and sandy bottom this was not surprisingexpected. The gently rolling waves of the lake caused the camera to move up and down in the water column, obscuring the camera's view by disturbing the soft silty-sand bottom and by moving in and out of focus. Furthermore, the survey conditions (wind and current direction, boat maneuverability, etc.) prevented the surveyors from directly guiding the camera onto selected targets.

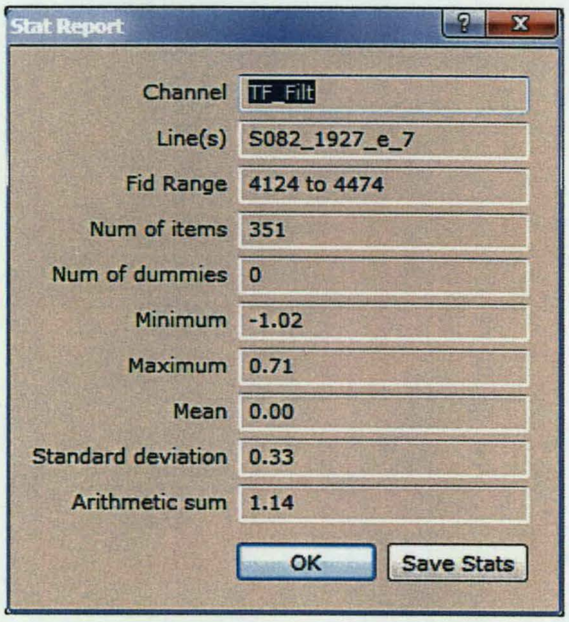
TABLE 4-1

PATCH TEST CALIBRATION RESULTS

Parameter	Offset Value
Roll	0.0 °
Pitch	2.0 °
Yaw	0.2 °
Latency	0.0 seconds

FIGURE 4-2

BACKGROUND TEST DATA FROM OASIS SOFTWARE



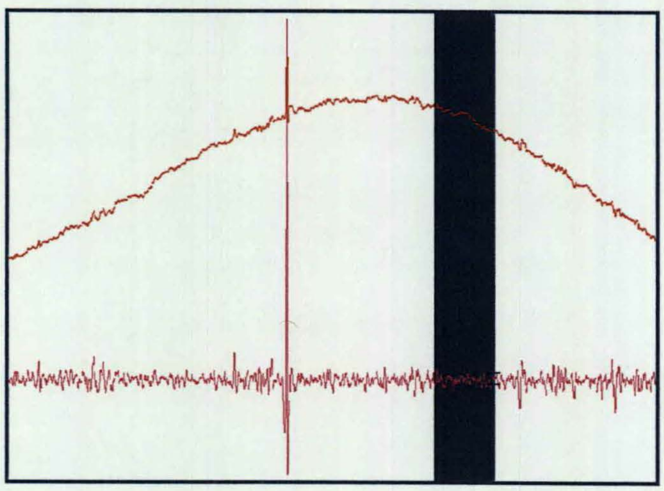


FIGURE 4-3

IVS MAT LAYOUT

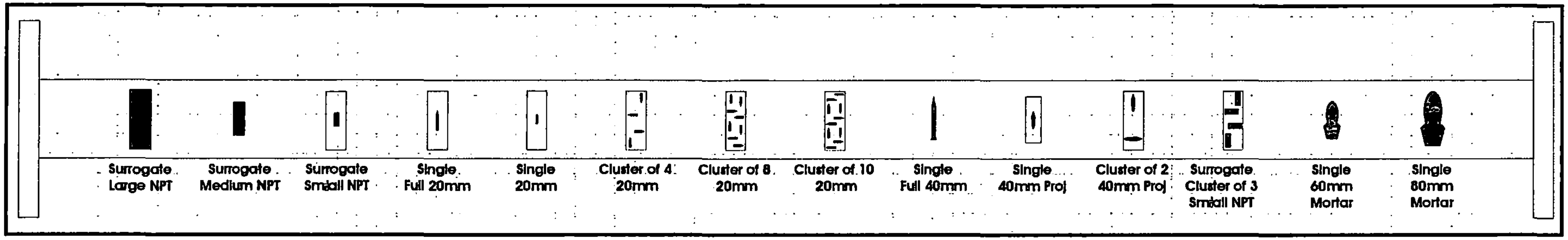


FIGURE 4-4

CONSTRUCTION OF IVS SEED MAT

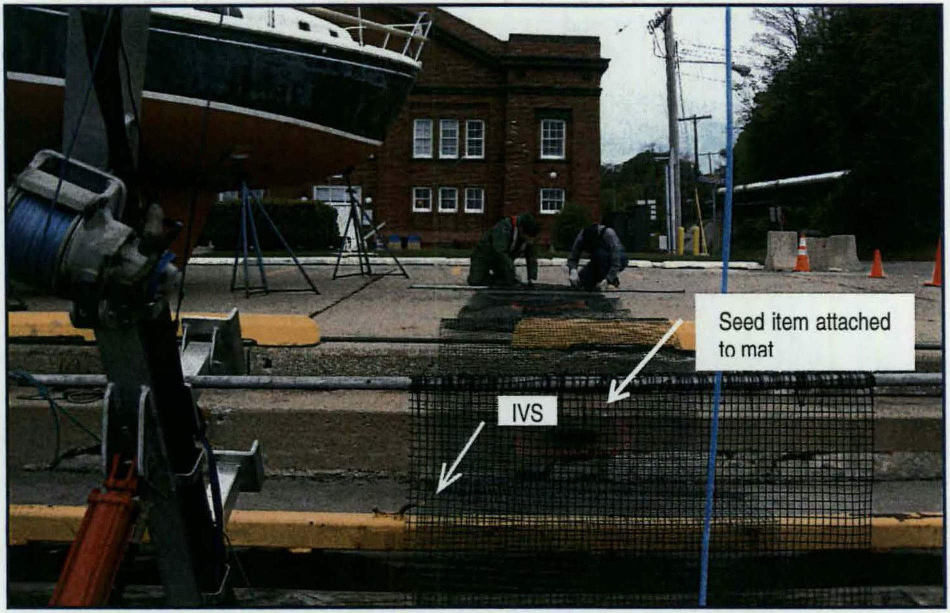


FIGURE 4-5

IVS MAT LAYOUT

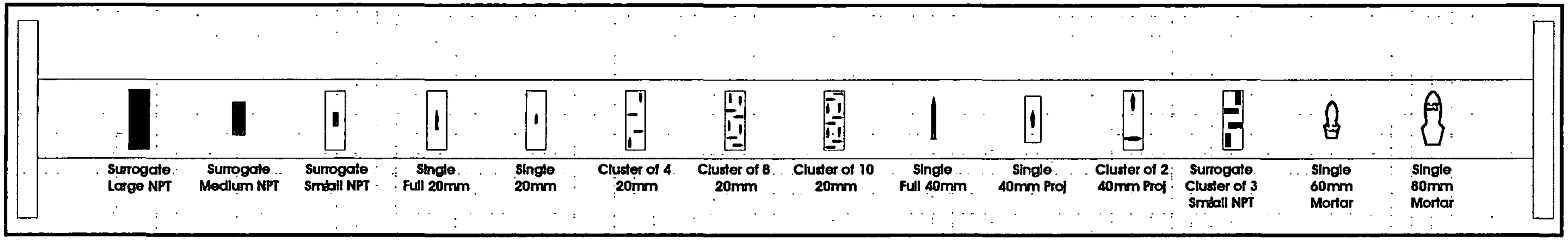
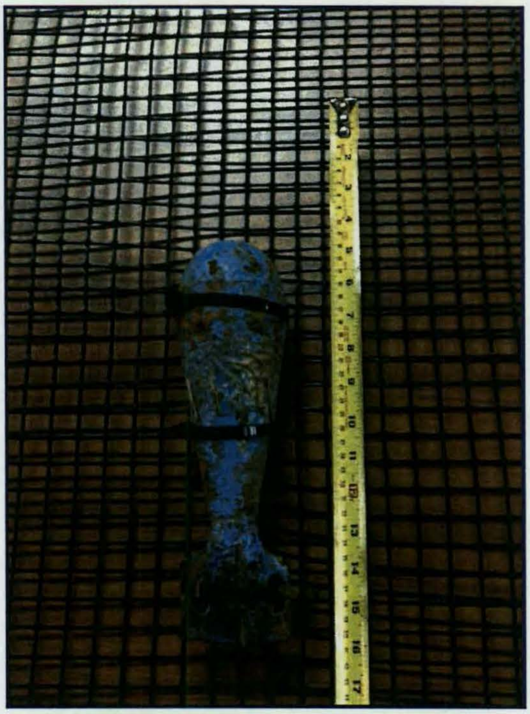


FIGURE 4-6

SINGLE AND CLUSTERED ITEMS ON THE IVS MAT



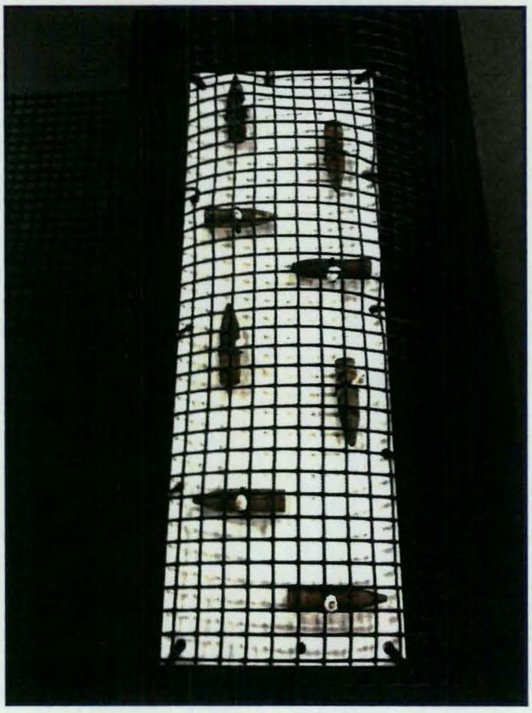


FIGURE 4-7A

MGA TF MAP OF IVS AREA PRIOR TO DEPLOYING THE SEED ITEMS

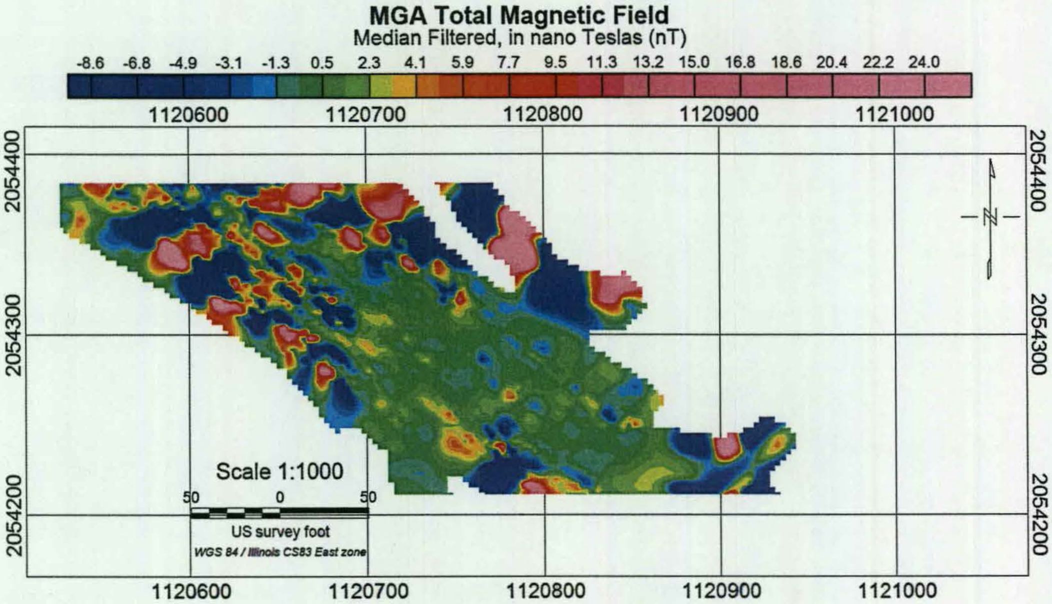


FIGURE 4-7B

A TOTAL FIELD COMPILATION MAP OFF ALL MGA IVS SURVEYS SHOWING MANY DIPOLE ANOMALIES REPRESENTING IVS TARGETS.

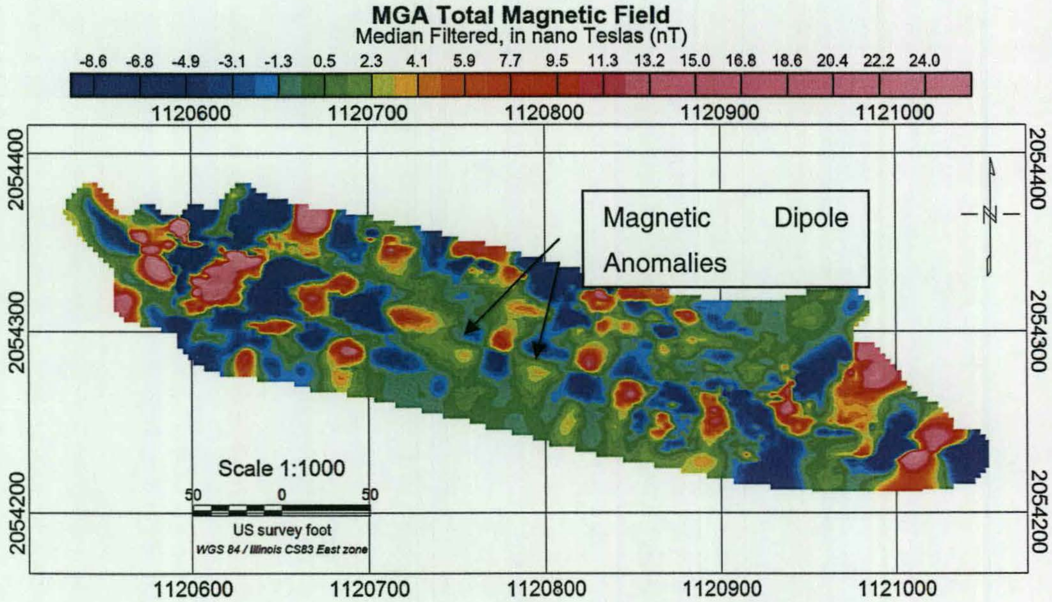


FIGURE 4-7C

MGA ANALYTIC SIGNAL MAP OF IVS AREA PRIOR TO DEPLOYING THE IVS MAT WITH ATTACHED SEED ITEMS.

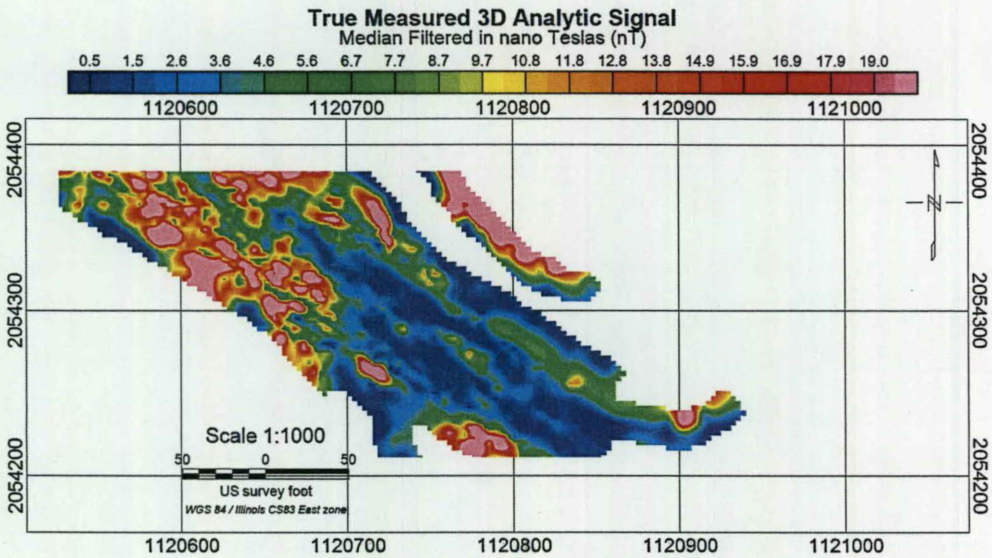


FIGURE 4-7D

AN ANALYTIC SIGNAL COMPILATION MAP OFF ALL MGA IVS SURVEYS A LINEAR LINE OF ANOMALIES THAT WERE NOT PRESENT IN THE PRE IVS SURVEY.

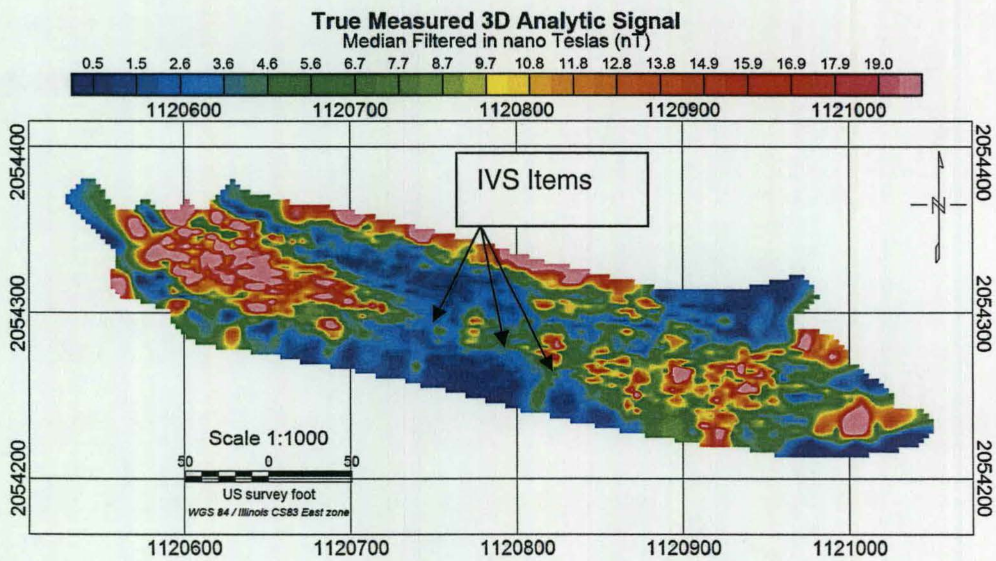


FIGURE 4-7E

TOTAL FIELD DATA FROM MAY 12TH IVS SURVEY. CIRCLES REPRESENT LARGER IVS ITEMS.

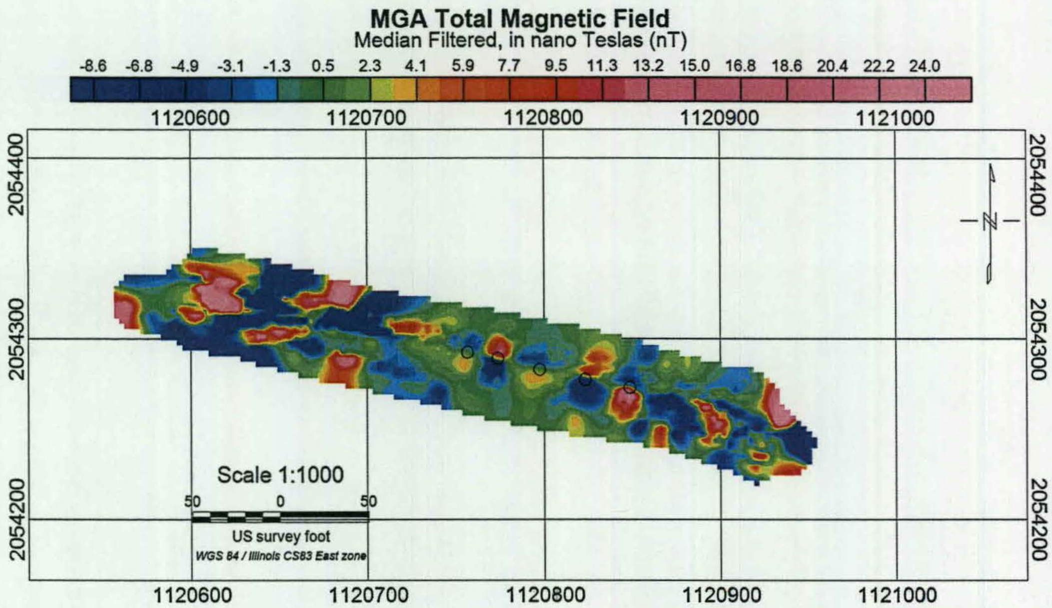
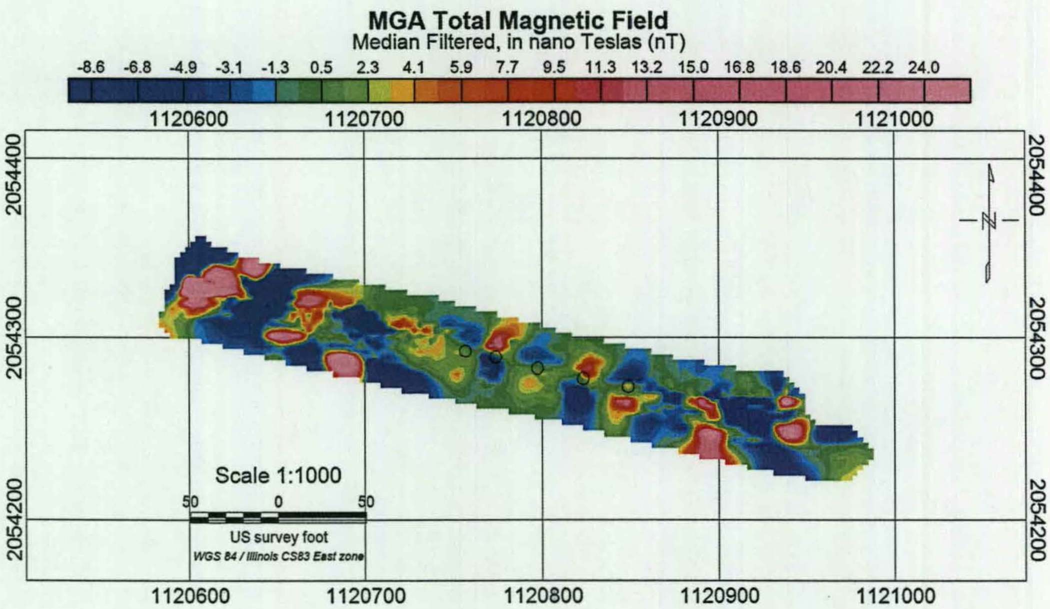


FIGURE 4-8F

TOTAL FIELD DATA FROM MAY 10TH IVS SURVEY. CIRCLES REPRESENT LARGER IVS ITEMS.



5.0 RESULTS

5.1 MULTIBEAM ECHOSOUNDER SURVEY

MBE data was successfully obtained along all planned transect lines, with the exception of near-shore areas where water depths were less than approximately 10 feet. This resulted in the collection of (150 line-miles) of data. The MBE data met all specifications called out in the approved UFP-SAP and provided clear and detailed imagery of the bottom conditions in the survey area. The processed MBE data is presented on DVD in Appendix C. Figure 5-1 contains a full- size figure of the MBE imagery.

Using the MBE data, three specific features of interest were identified, along with numerous obstacles (boulders, etc.). In addition, the MBE data revealed the presence of various geological features such as sand ridges, sand waves, and gravel/boulder zones (Figure 5-1 and Appendix C). The three large cultural features of interest identified in the MBE data are listed and described in Table 5-1. Images of the features are presented on Figures 5-1 and Appendix C. All three of these features produced very large magnetic anomalies. Both the marine foundation and the water intake structure were accompanied by linear magnetic anomalies running toward shore. These anomalies potentially represent pipelines or cables.

5.2 GEOPHYSICAL SURVEY

Geophysical data was successfully collected along all transects surveyed during MBE survey operations. This resulted in the collection of 150 line-miles of data. The geophysical data met all specifications called out in the approved UFP-SAP. The processed MGA data is presented on DVD in Appendix D. This appendix also contains a full size figure of the color- coded, magnetic signature MGA imagery.

InitallyInitiallyT the geophysical data was processed and interpreted to yield a list of 3,624 anomalies. The anomaly list was generated using Geosoft's Oasis Montaj software "Find Peak Dipoles" function. All dipoles with a minimum of a 2 nT peak (positive or negative pole peak) with less than a 20- foot dipole separation were picked. This included all anomalies having the appropriate size for munitions fired on the former AA training range at NTC Lakefront. After this initial target picking of the total field data, the Gridpeak.gx function of Oasis Montaj software was used to identify anomalies (targets) meeting the specified project selection criteria (i.e., size representative of munitions of interest) in the analytic signal data. The anomalies that met the criteria are listed and shown on the MGA imagery figure in Appendix D. The analytic signal noise threshold was determined to be 1 nT or less by analyzing areas with few anomalies that were representative of background. Figure 5-2 shows examples of the noise threshold statistics, with a mean of 0.22 - 0.5 nT, and a standard deviation of 0.13 - 0.27 nT. Targets were then selected if they had a peak value over 2 nT. The IVS results at the site did not allow for the calculation of anomaly size based on item, but based on previous IVS data collected by Tt a prioritization was conducted based on anomaly peak only. During the previous IVS testing, at another site, analytic signal peak values were recorded for the following range of items: single 20 mm and 40 mm projectiles, full single 20 mm and 40 mm, as well as clusters of 20 mm and 40 mm projectiles ranged from 2 nT to 15 nT. This is the basis of our prioritization. The anomalies were then prioritized based on peak values.

Target anomalies with a larger peak than 15 nT are not considered to likely be due to AA rounds or clusters of AA rounds. The target table in Appendix D-711 shows the prioritized list of 10,205 targets. Target anomalies that were larger than 15 nT have been given a low priority of "0" while those from 2-15 nT were given a priority of "1". There are 859 priority 0 and 9,346 priority 1 targets present. Since the targets were picked along both MGA analytic signal profiles (one from the starboard side, and one for the port) there are many targets that are potentially duplicates (especially the larger target anomalies, as they will be seen by both sides of the MGA).

Analysis of the color imagery and interpretation results indicated that, as anticipated-based on historical information regarding munitions fired at the range, there are distinct bands of metallic debris present at several locations in the range fan. Specifically, there are three areas containing concentrated metallic debris. These areas are located approximately 500 to 2,500, 10,000 to 14,000, and 18,000 feet from the firing line for the former range (see Figure 5-2 3 and Appendix D). The inner and central depositional areas cover the width of the evaluation areas, which are at about 1,300 and 7,100 feet wide, respectively. The outer depositional area is located near the right (southern) limit of evaluation and is approximately 2,900 feet wide. Metallic debris is present at the boundaries of the evaluation area and most likely continues beyond those boundaries.

While the areas of concentrated metallic debris can be seen in the general concentration of anomalies in the total field data (FiguresAppendix D-1), there is also an overall signature that can be seen in the analytic signal data (Figure 5-4, Figures 5-?3a?, 5-?3?bAppendix, D-7a and D-7b & D8). The analytic signal response is elevated just east of the start of the primary impact zone out to approximately 16,000 feet from shore. This corresponds well with the area that should contain the most MEC fall out from properly functioning AA fire. The analytic signal appears to be picking up numerous very small targets (~1-3 nT) that are likely caused by the concentration of AA shell fragments present there.

5.3 VERIFICATION SURVEY

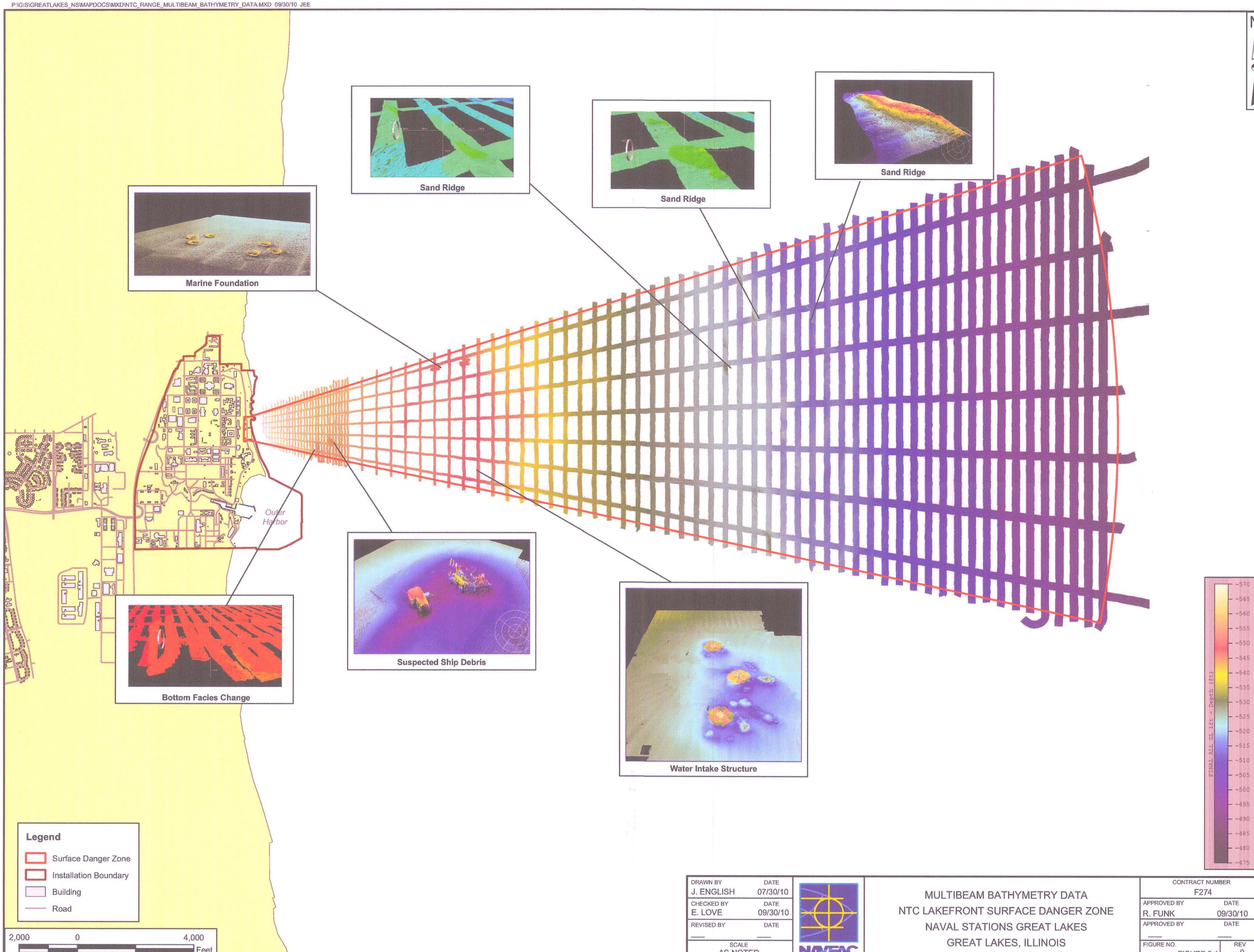
The verification survey included collection of video footage (as discussed in Section 4.4) while allowing the vessel to drift in the water. Several attempts were made to drift over target locations in various portions of the SDZ. Video footage was successfully recorded at all planned locations. Individual frames were isolated from the video and analyzed; however, it was not possible to identify the nature of the metallic items present that generated the magnetic signature detected during the MGA survey. This was due in part to the fact that items on the sediment surface appeared to be encrusted with mussels. Figure 5-35 shows a still photograph isolated from the video footage recorded at one location in the SDZ. Shell debris is present; however, the source of the magnetic signature at this site cannot be determined from the photograph. All available video footage collected during the verification survey is presented in Appendix A (DVD).

TABLE 5-1

FEATURES IDENTIFIED USING MBE DATA

Feature	Distance Offshore	Location in SDZ	Description
Intake Structure	~7,700 ft.	Inner 1/3 of range near the right (southern) limit of fire	Three intake ports running from the structure to the shoreline in the vicinity of the NSGL power plant. Navy personnel indicated that such a structure was present, but were unable to provide an exact location.
Marine Foundation	~6,800 ft.	Inner 1/3 of range near the left (northern) limit of fire	Underwater foundation structure consisting of two sets of three cone-like structures (25 ft diameter, 6 ft height) separated by approx. 30 feet. The relative location of the two sets of supports suggests the former structure had an east-west orientation (roughly parallel to the firing line for the former range)
Suspected Ship Debris	~3,300 ft.	Inner 1/8 of range near the left (northern) limit of fire	Cluster of large metallic debris items, shapes suggest ship debris.

P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\NTC_RANGE_MULTIBEAM_BATHYMETRY_DATA.MXD 09/30/10 JEE



DRAWN BY	DATE
J. ENGLISH	07/30/10
CHECKED BY	DATE
E. LOVE	09/30/10
REVISED BY	DATE
SCALE AS NOTED	

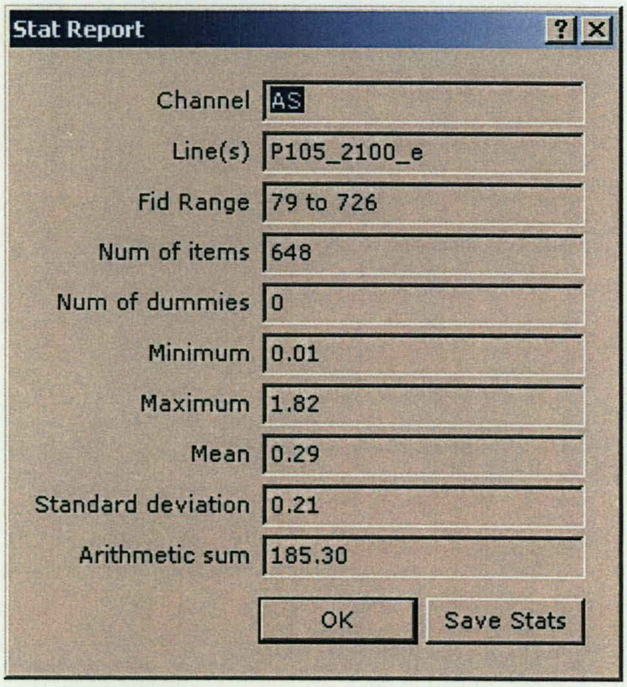
NAVFAC

MULTIBEAM BATHYMETRY DATA
NTC LAKEFRONT SURFACE DANGER ZONE
NAVAL STATIONS GREAT LAKES
GREAT LAKES, ILLINOIS

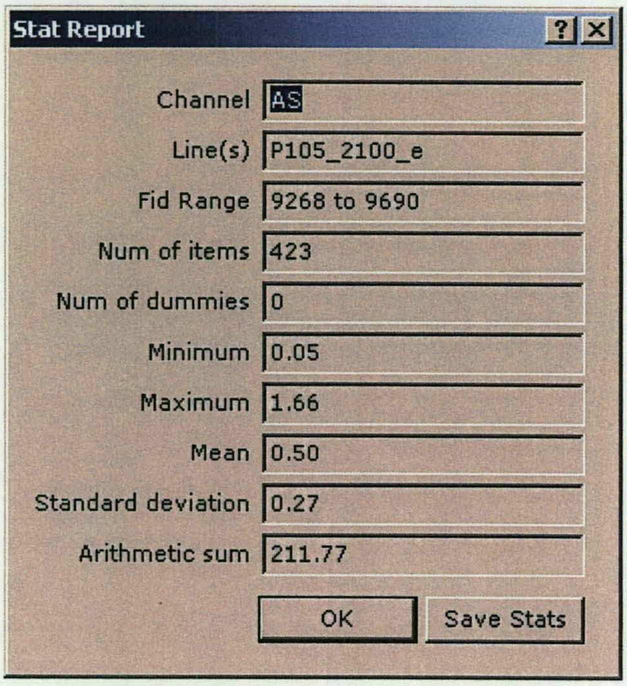
CONTRACT NUMBER	
F274	
APPROVED BY	DATE
R. FUNK	09/30/10
APPROVED BY	DATE
FIGURE NO. FIGURE 5-1	REV 0

Figure 5-2

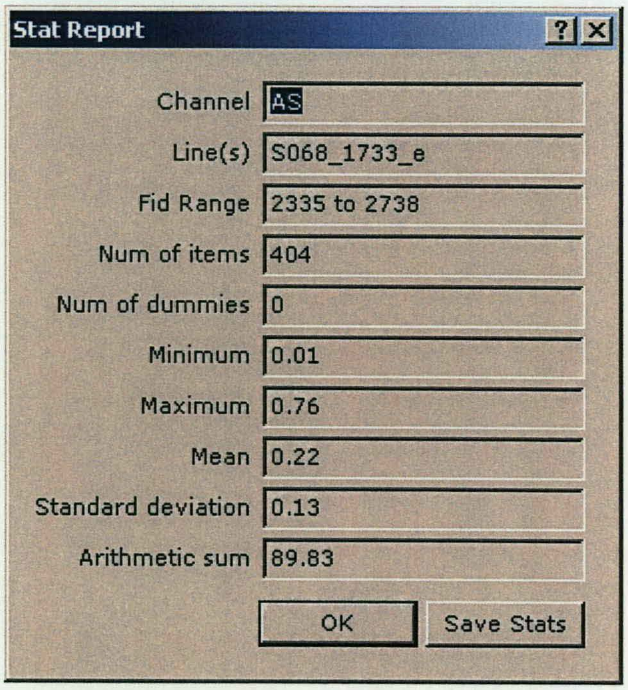
MGA Analytic Signal Noise Threshold Statistics



Statistics from out in the eastern edge of the AA fan

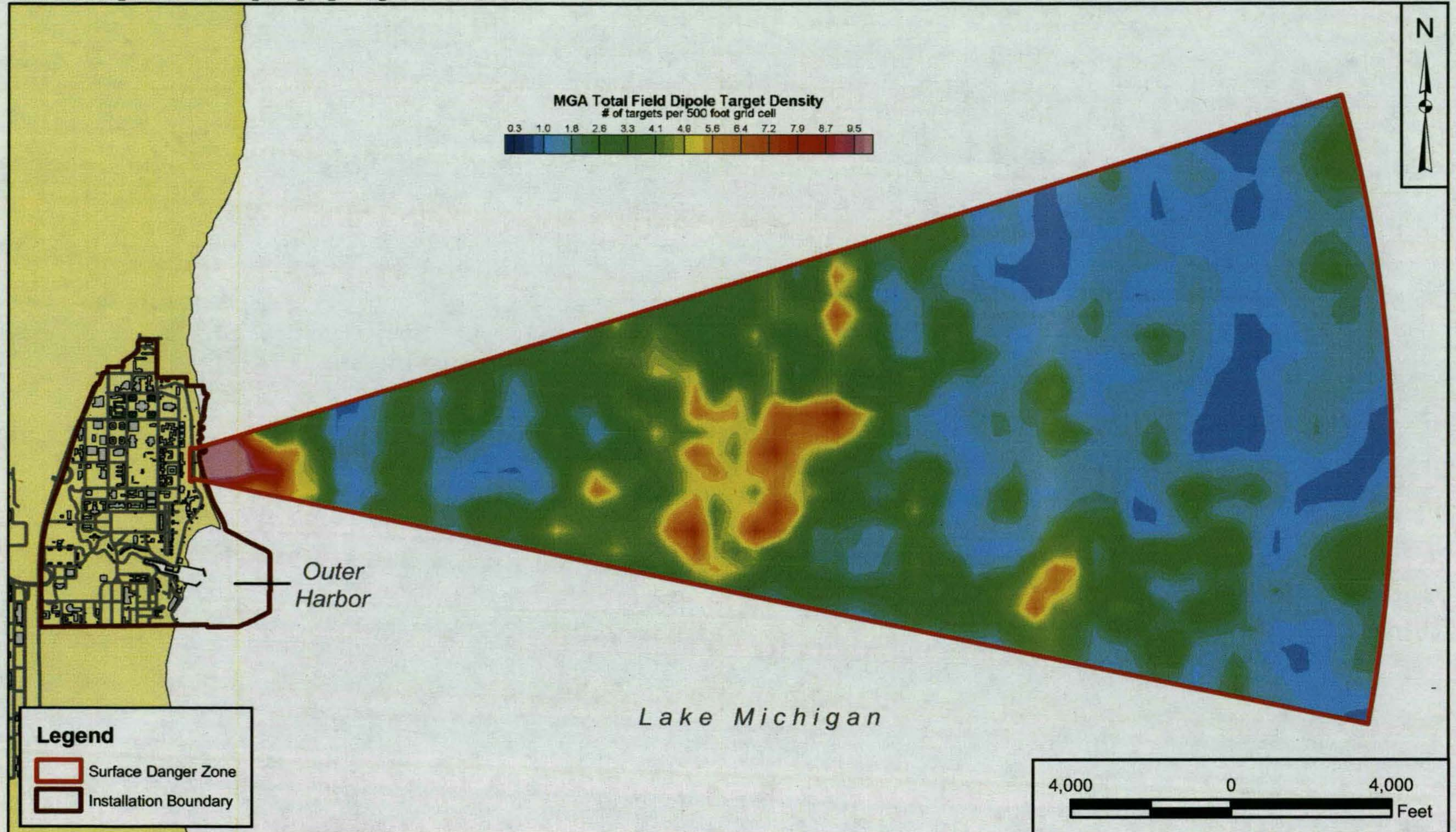


Statistics from within the secondary impact zone



Statistics in another portion of the primary impact zone

P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\NTC_RANGE_MGA_TARGET_DENSITY.MXD 07/30/10 JEE



DRAWN BY	DATE		CONTRACT NUMBER	
J. ENGLISH	07/23/10	MGA TARGET DENSITY	F274	
CHECKED BY	DATE	NTC LAKEFRONT SURFACE DANGER ZONE	APPROVED BY	DATE
E. LOVE	07/30/10	NAVAL STATION GREAT LAKES	R. FUNK	08/05/10
COST/SCHEDULE AREA		GREAT LAKES, ILLINOIS	APPROVED BY	DATE
SCALE	AS NOTED	NAVFAC	FIGURE NO. FIGURE 5-3	REV 0

FIGURE 5-4

LINE 104 PROFILE DATA SHOWING CONCENTRATIONS OF VERY SMALL ANOMALIES IN THE PRIMARY IMPACT ZONE

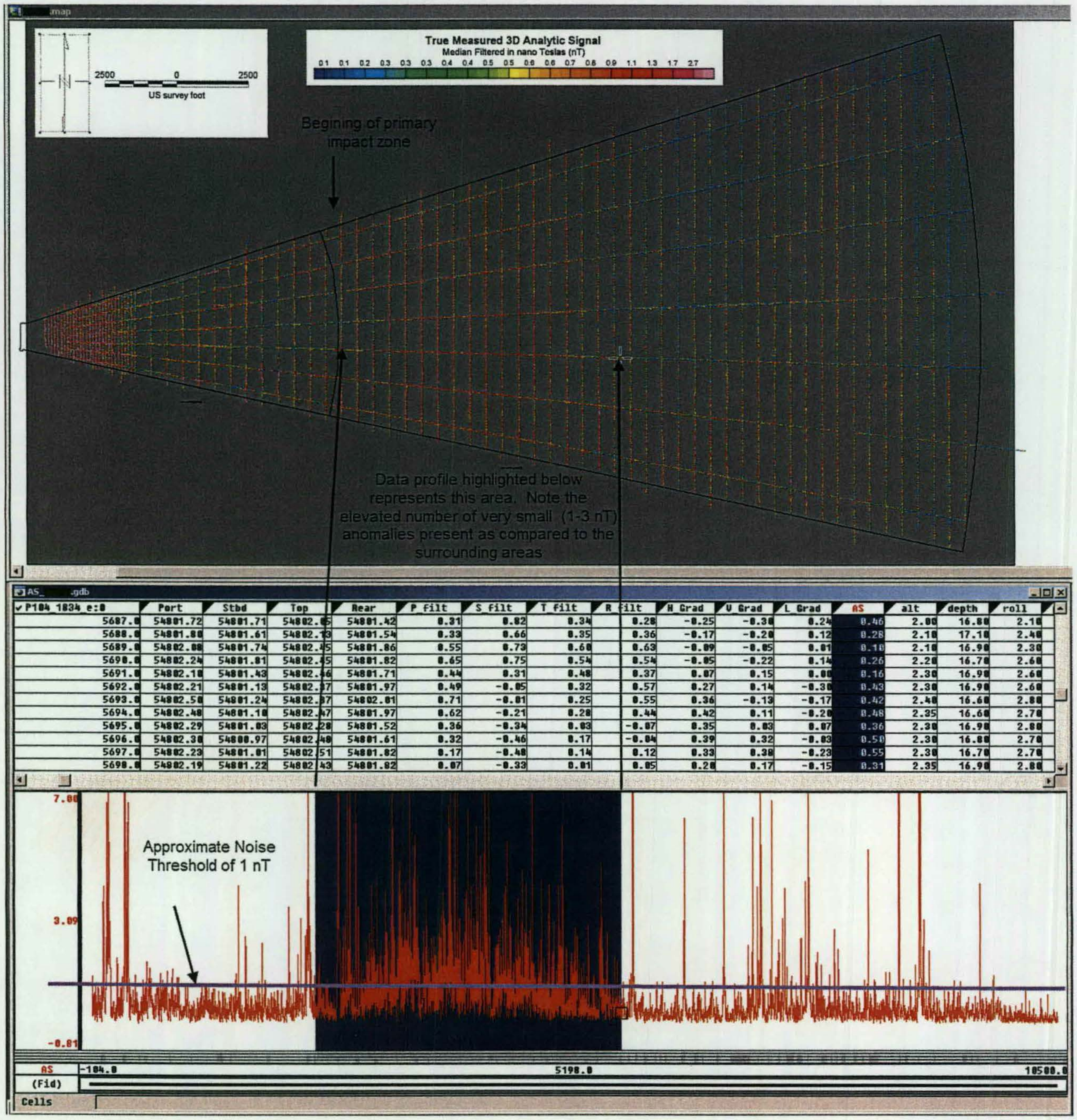
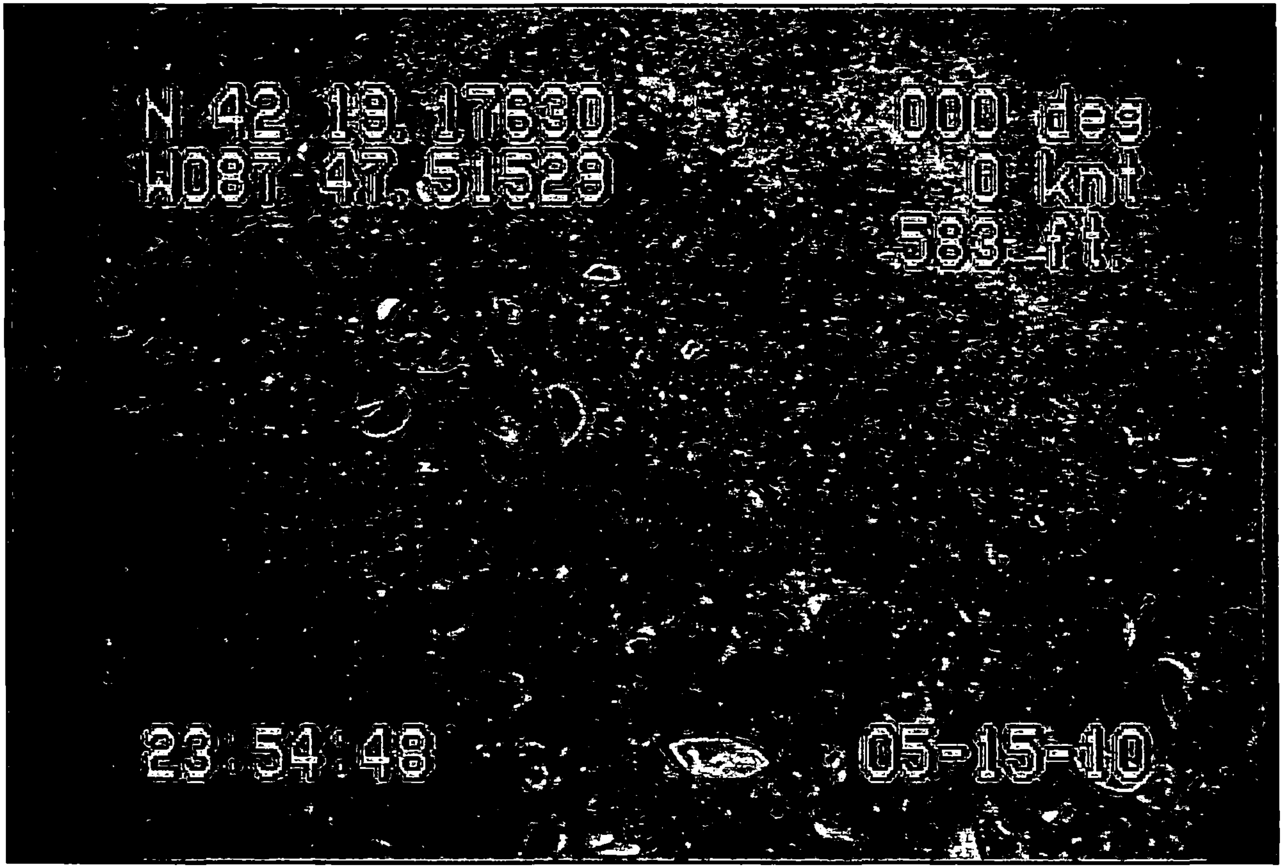


FIGURE 5-5

STILL SHOT FROM UNDERWATER VIDEO FOOTAGE



6.0 CONCLUSIONS AND RECOMMENDATIONS

The data and results of analyses presented in the previous sections suggest the following conclusions:

- The firing limits for the range (the north and south boundaries of the SDZ) have not been fully defined. The bands of metallic debris detected extend beyond the current estimated north and south boundaries of the historical AA training range.
- The terminus of the SDZ (eastern boundary) appears to be relatively well defined. The survey was completed to the design limits of the area (estimated maximum range of munitions). Even though the survey area ended about 915 feet short of the estimated maximum water depth range boundary based upon the depth limits set for the SI (i.e. water depth slightly less than 120 feet), the amount of metallic debris had tapered off significantly, indicating that the terminal end of the range was in proximity to the end of the survey area.
- Magnetic anomalies, which may represent MEC and/or MPPEH were detected on the lake floor occurred in bands roughly corresponding to the different average ranges of the various known munitions fired at the range.
- The underwater video camera did not prove to be an effective tool for target/anomaly verification, although it did provide data about lake bottom type and habitat.

Based on these considerations, additional evaluation will be needed to establish the nature and extent of potential MEC/MPPEH contamination of the former AA training range at NSGL. The following activities may be warranted:

1. Diving operations to evaluate the nature of selected metallic items identified during the MGA survey.
2. Additional marine survey and geophysical mapping of areas to the north, south, and east of the current survey area to bound (if possible) the metallic debris field (and potential unexploded ordnance [UXO]) associated with former range operations.

REFERENCES

1. IHO (International Hydrographic Organization). 1998. International Hydrographic Organization Special Publication No. 44, 4th Edition.

2. Malcolm Pirnie, 2005. Final Water Area Munitions Study Naval Training Center lakefront Naval Station Great lakes, Illinois. April.

3. Tetra Tech, 2010. Sampling and Analysis Plan Volume II, NTC Lakefront Site, Naval Station Great Lakes, Great lakes, Illinois. January.

4. U.S. Army Corps of Engineers (USACE), 2002. Data Item Description (DID) OE-025.01, 2002. Personnel Work Standards for Ordnance and Explosives (OE) Projects, USACE Ordnance and Explosives Center for Expertise, Huntsville, Alabama (CEHNC-OE-CX). 2002.

5. USACE. 2002. Hydrographic Surveying Engineering Manual (EM 1110-2-1003 and appendices). http://140.194.76.129/publications/eng-manuals/em1110-2-1003/toc.htm

6. USACE, 2003. Ordnance and Explosives Digital Geophysical Mapping Guidance – Operational Procedures and Quality Control Manual (DGM QC Guidance). U.S. Army Engineering and Support Center, Huntsville, Alabama. December 2003.

APPENDIX A

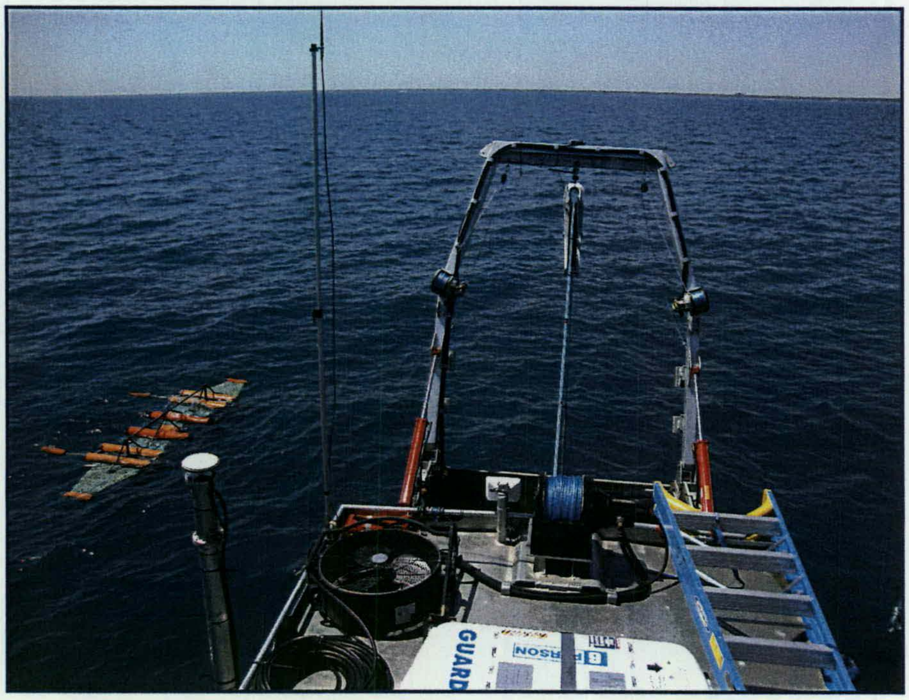
PHOTOGRAPHIC LOG

Note: Additional underwater video is provided on the attached DVD.

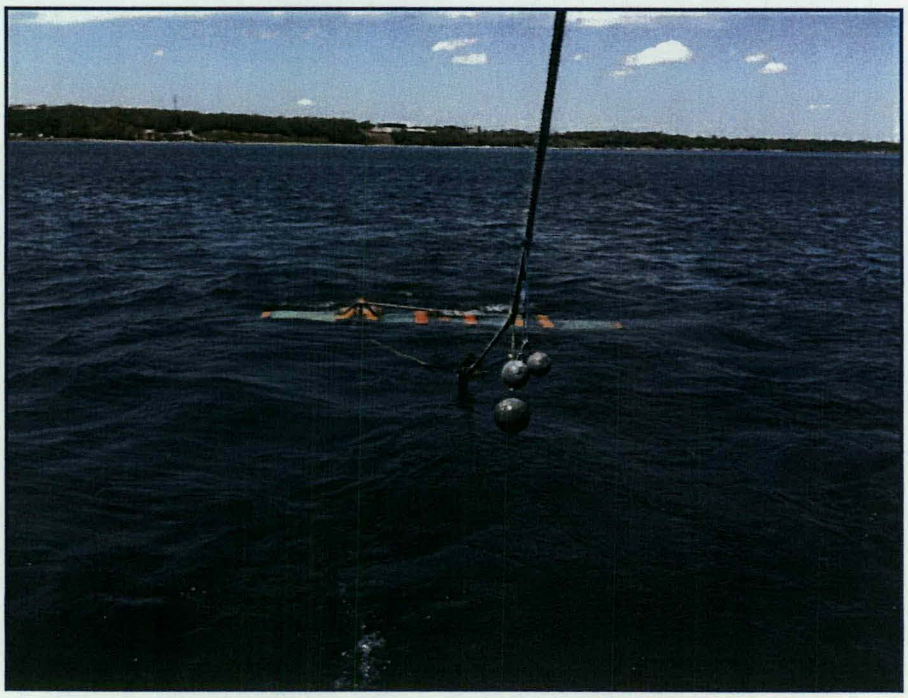
Photograph 1. R/V Ugle Duckling at Waukegan Marina.

Photograph 2. MGA mounted on "A" Frame on R/V Ugle Duckling.

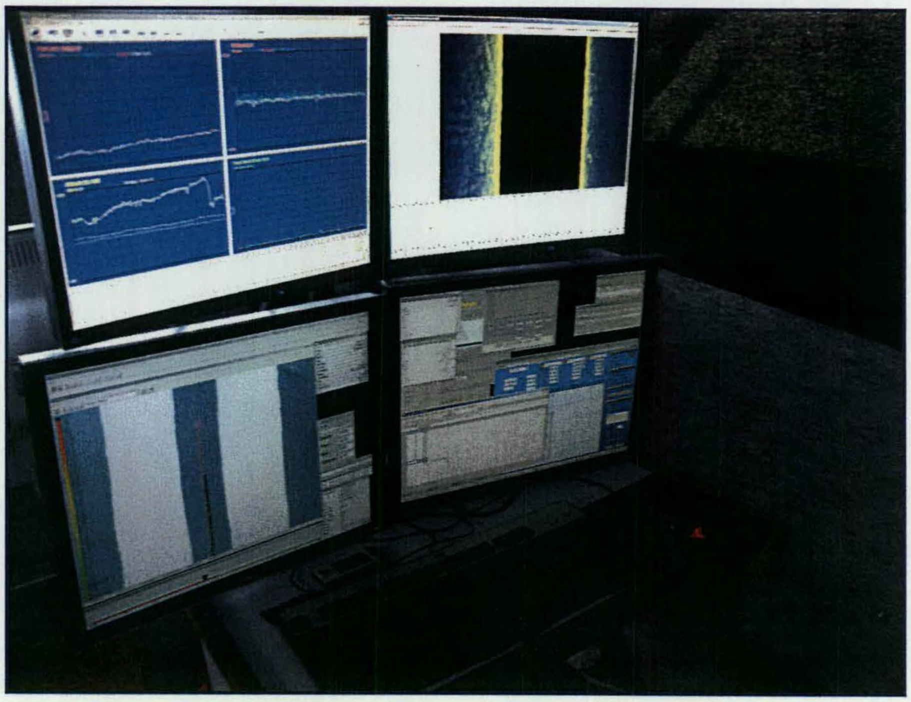
Photograph 3. MGA Static Astern of the R/V Ugle Duckling.



Photograph 4. MGA Being Towed During Data Collection.

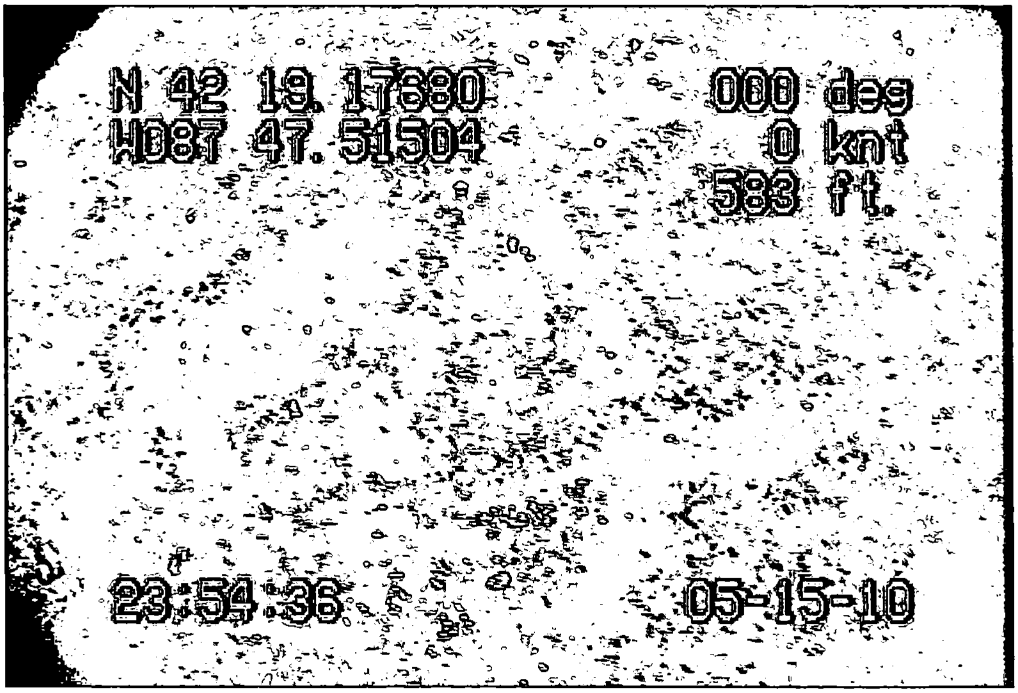


Photograph 5. Real-Time Computer Displays During MBE.

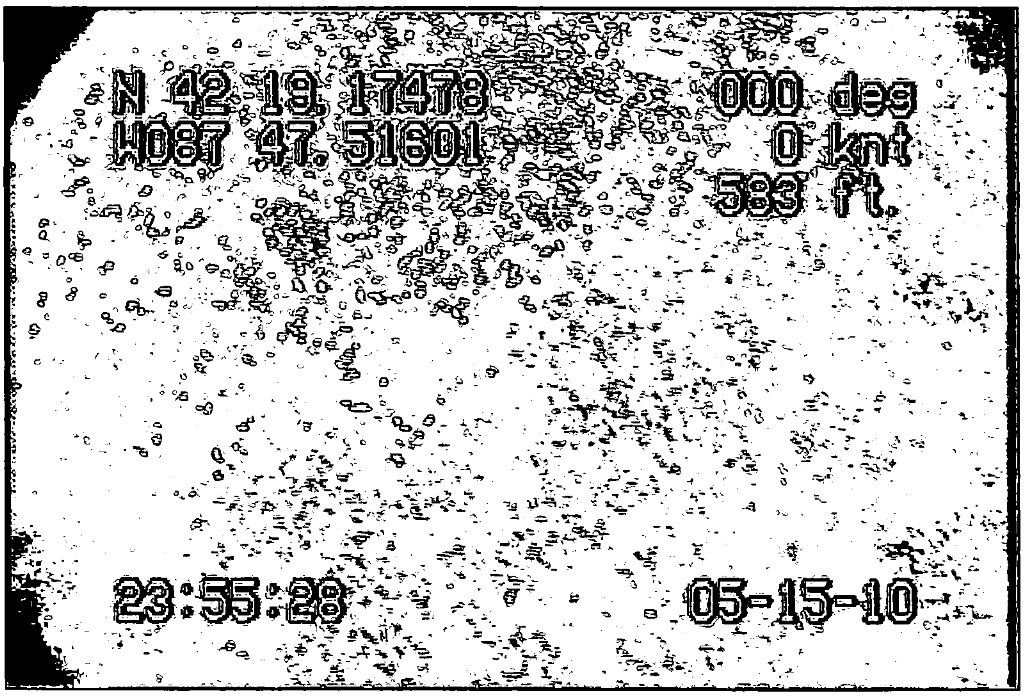


Photograph 6. IVS Mat After Retrieval.

Photograph 7. Drop Video Camera Image.



Photograph 8. Drop Video Camera Image.



APPENDIX B

DATA USABILITY ASSESSMENT

Appendix B
MRP Field Investigation
Naval Station Great Lakes
North Chicago, Illinois

Usability Checklist Table			
Phase of Work	**Item to be checked/verified**	**Verified (Yes or No)**	**Comments or Deviations**
Pre-Survey	Qualification of Survey Team evaluated	Yes	
	Personnel reviewed and signed-off on relevant SAP section(s)	Yes	
Survey	QC evaluation of survey equipment (tests and checklists satisfactorily completed)	Yes	
	Conformance to SAP requirements and procedures for all survey work and rework (including documentation requirements), and all deficiencies documented	Yes	
	Coverage of Areas to be Investigated fulfilled and located within accuracy levels required for the SI	Yes	
	Interpretation and Summary of Geophysical Data satisfies SAP requirements and conformance with Data Processing Flowchart (Worksheet 17 of UFP-SAP)	Yes	

APPENDIX B

QC FIELD DATA

DATA USABILITY ASSESSMENT -
QUALIFICATION AND CERTIFICATION OF SURVEY TEAM
MARINE CORPS AIR STATION
BEAUFORT, SOUTH CAROLINA

This table lists each member of the detector-aided surface sweep team and subsurface geophysics team and the required certifications and training in order to demonstrate competency.

Name	Title/Role	Responsibilities	Education and/or Experience Qualifications (Minimal)	Meets Requirements
Robert Feldpausch	In-water Survey Manager	Oversees project, financial, schedule, and technical management of the In-water Survey Program. • Ensures timely resolution of project-related technical, quality, and safety questions associated with in-water geophysics. • Coordinates and oversees in-water geophysical work performed by Tetra Tech field and office technical staff, including data collection and interpretation. • Coordinates preparation and review of geophysical deliverables.	BS, Environmental Studies and Policy, Michigan State University, 1998 A.S., Geographic Resources and Environmental Technology, Lansing Community College, 1996 Eleven years experience in conducting and managing hydrographic, geophysical and other in-water studies and projects. Specializes in performing and managing single and multibeam echosounder hydrographic surveys in accordance with the U.S. Army Corps of Engineers (USACE) Hydrographic Surveying Manual Standards. Additional experience includes management of marine unexploded ordinance (UXO)/MEC, sediment MC investigations and offshore survey projects and Hydrographic Tech training provided by the USACE and Shallow Water Multibeam training provided by NOAA and University of New Hampshire.	Yes

MBE Bar Check Results

Project Max	0.25
Project Avg.	0.098

Date	Bar Depth	Meas. Depth	Sonar	Sonar Draft	Pitch	Pitch Corr.	Roll	Roll Corr.	Corr. Depth	Diff.	ABS(Diff.)
4/16/2010	9	8.33	2.2	0.89	0.25	0.02	-1.16	-0.11	9.13	-0.13	0.13
4/16/2010	9	8.33	2.2	0.89	0.25	0.02	-1.15	-0.11	9.13	-0.13	0.13
4/16/2010	8	7.36	2.2	0.89	0.34	0.03	-0.70	-0.07	8.21	-0.21	0.21
4/16/2010	8	7.37	2.2	0.89	0.33	0.03	-0.71	-0.07	8.22	-0.22	0.22
4/16/2010	8	7.33	2.2	0.89	0.33	0.03	-0.71	-0.07	8.18	-0.18	0.18
4/17/2010	8.1	7.38	2.2	0.89	0.36	0.03	-1.02	-0.10	8.20	-0.10	0.10
4/17/2010	8.1	7.38	2.2	0.89	0.37	0.03	-1.00	-0.09	8.21	-0.11	0.11
4/17/2010	8.1	7.38	2.2	0.89	0.38	0.03	-0.99	-0.09	8.21	-0.11	0.11
4/17/2010	8	7.26	2.2	0.89	0.33	0.03	-1.05	-0.10	8.08	-0.08	0.08
4/17/2010	8	7.35	2.2	0.89	0.33	0.03	-1.05	-0.10	8.17	-0.17	0.17
4/17/2010	8	7.32	2.2	0.89	0.33	0.03	-1.06	-0.10	8.14	-0.14	0.14
4/18/2010	8	7.41	2.2	0.89	0.37	0.03	-1.34	-0.13	8.20	-0.20	0.20
4/18/2010	8	7.38	2.2	0.89	0.37	0.03	-1.34	-0.13	8.17	-0.17	0.17
4/18/2010	8	7.46	2.2	0.89	0.37	0.03	-1.34	-0.13	8.25	-0.25	0.25
4/18/2010	9	8.33	2.1	0.79	0.36	0.03	-1.35	-0.13	9.02	-0.02	0.02
4/19/2010	8	7.35	2.1	0.79	0.36	0.03	-1.10	-0.10	8.07	-0.07	0.07
4/19/2010	8	7.38	2.1	0.79	0.36	0.03	-1.09	-0.10	8.10	-0.10	0.10
4/19/2010	8	7.35	2.1	0.79	0.36	0.03	-1.10	-0.10	8.07	-0.07	0.07
4/20/2010	8	7.38	2	0.69	0.24	0.02	-0.68	-0.06	8.03	-0.03	0.03
4/20/2010	8	7.38	2	0.69	0.24	0.02	-0.70	-0.07	8.02	-0.02	0.02
4/20/2010	8	7.4	2	0.69	0.25	0.02	-0.70	-0.07	8.04	-0.04	0.04
4/21/2010	8	7.4	2	0.69	0.3	0.02	-1.23	-0.12	8.00	0.00	0.00
4/21/2010	8	7.42	2	0.69	0.31	0.03	-1.23	-0.12	8.02	-0.02	0.02
4/21/2010	8	7.43	2	0.69	0.31	0.03	-1.23	-0.12	8.03	-0.03	0.03
4/22/2010	8.7	8.04	2	0.69	0.27	0.02	-1.27	-0.12	8.63	0.07	0.07
4/22/2010	8.7	8.04	2	0.69	0.27	0.02	-1.27	-0.12	8.63	0.07	0.07
4/22/2010	8.7	8.07	2	0.69	0.27	0.02	-1.27	-0.12	8.66	0.04	0.04
4/23/2010	9	8.43	2	0.69	0.36	0.03	-2.30	-0.22	8.93	0.07	0.07
4/23/2010	9	8.43	2	0.69	0.35	0.03	-2.29	-0.22	8.93	0.07	0.07
4/23/2010	9	8.53	2	0.69	0.35	0.03	-2.28	-0.21	9.03	-0.03	0.03

MBE Water Level Check

Project Max	0.37
Project Avg	0.09

Date	Time	Rover Ht.	Hysweep Tide	Pitch	Pitch Corr.	Roll	Roll Corr.	Ant Ht.	Lieca Draft	Leica Tide Draft	Corr. Tide	Diff	ABS(Diff)
4/16/2010		465.81	465.1	0.2	0.02	-0.70	-0.07	9.50	0.89	8.61	465.94	-0.13	0.128
4/17/2010		577.66	576.95	0.35	0.03	-1.63	-0.15	9.50	0.80	8.7	577.63	0.03	0.033
4/18/2010	13:23	578.09	577.45	0.25	-0.50	-0.35	-0.03	9.50	0.80	8.7	577.72	0.37	0.373
4/19/2010	12:24	578.10	577.35	0.47	0.04	-1.20	-0.11	9.50	0.80	8.7	578.08	0.02	0.020
4/20/2010	12:46	578.09	577.5	0.1	0.01	0.10	0.01	9.50	0.70	8.8	578.22	-0.13	0.129
4/21/2010	11:56	578.32	577.7	0.2	0.02	0.10	0.01	9.50	0.70	8.8	578.43	-0.10	0.102
4/22/2010	9:54	578.37	577.75	0.3	0.02	-1.20	-0.11	9.50	0.70	8.8	578.36	0.01	0.006
4/22/2010	16:50	578.37	577.75	0.2	0.02	-0.90	-0.08	9.50	0.70	8.8	578.38	-0.02	0.017
4/23/2010	15:31	691.01	690.45	0.3	0.02	-1.60	-0.15	9.50	0.70	8.8	691.02	-0.01	0.012
4/23/2010	18:59	577.92	577.345	0.45	0.04	-1.10	-0.10	9.50	0.70	8.8	577.98	-0.06	0.056

APPENDIX C

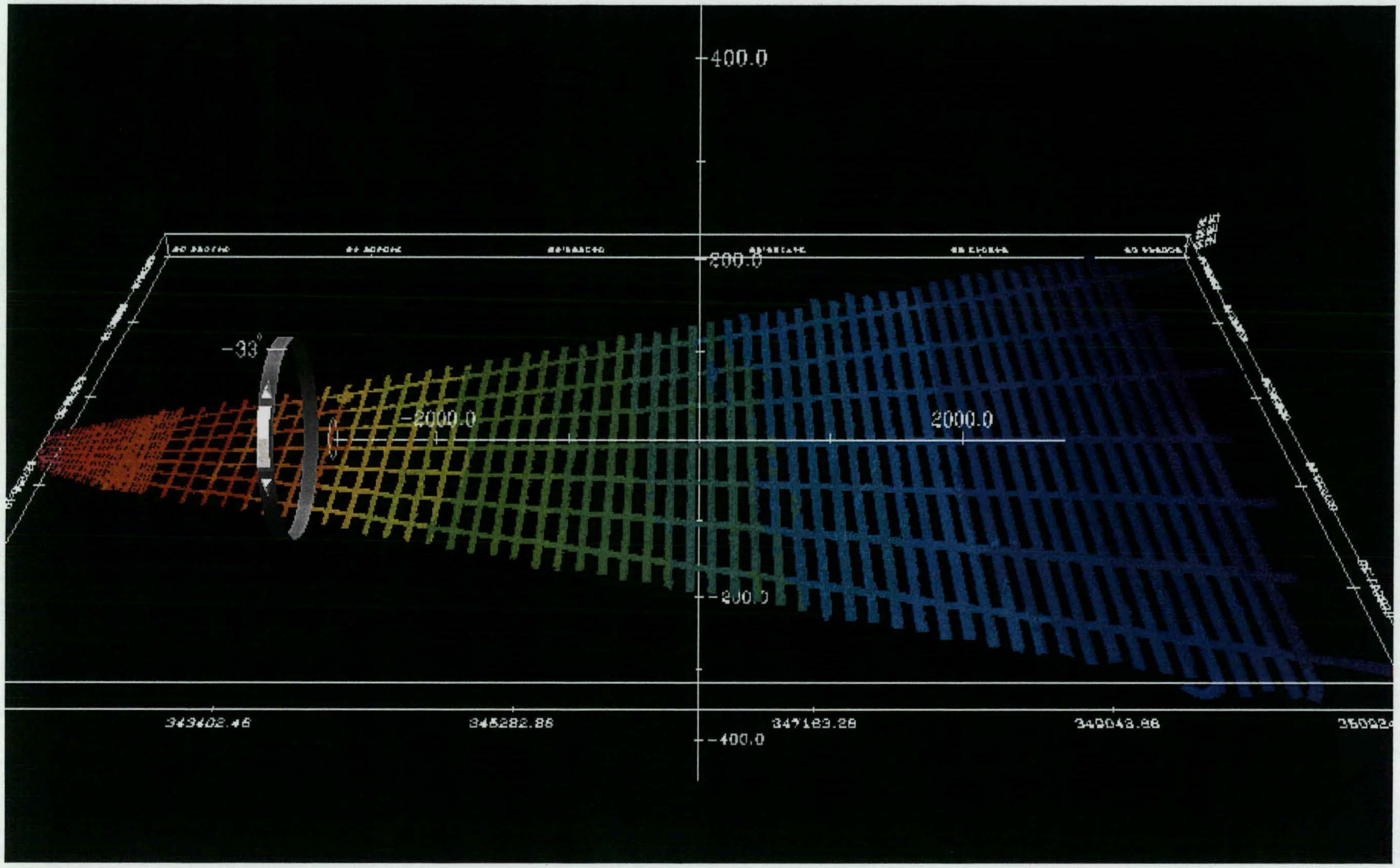
DATA AND MAPS FOR MULTIBEAM ECHOSOUNDER SONAR (MBE) SURVEY

(Data to be provided on DVD)

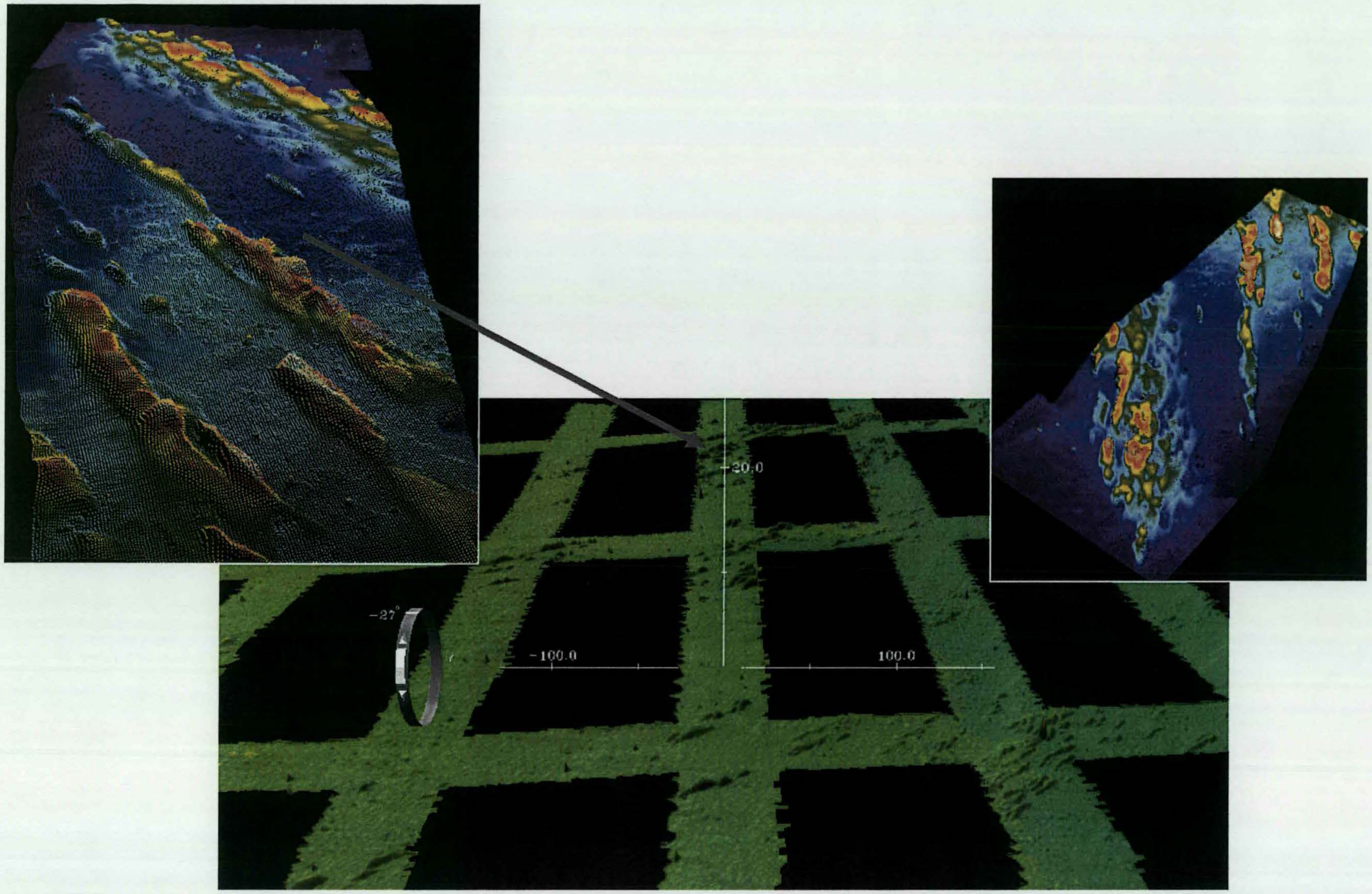
Appendix C-1

Multibeam (MBE) Bathymetry Data Features

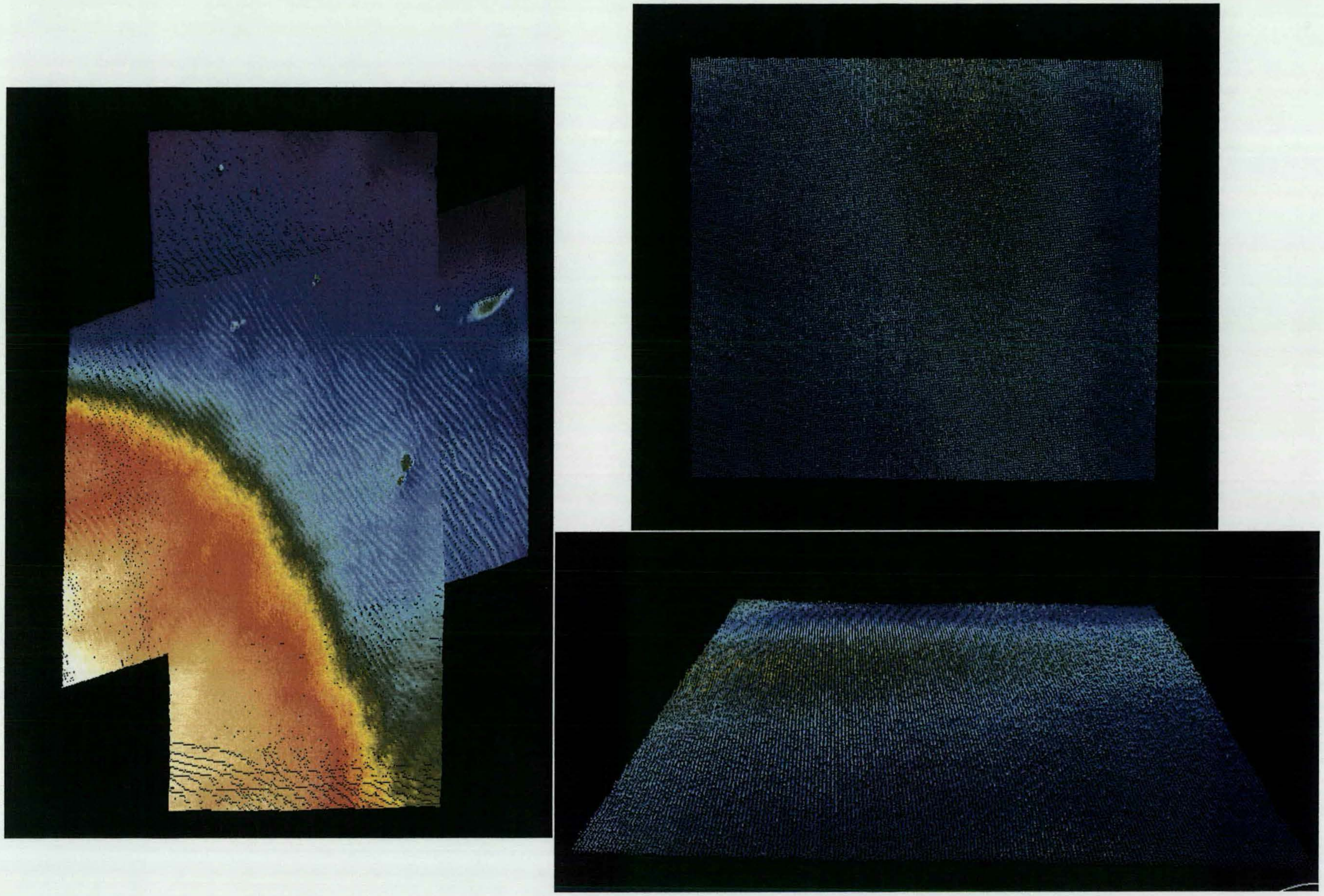
C1-1 - 3-D scene of multibeam data coverage. The pink indicates shallow water depth and magenta deep water depth.



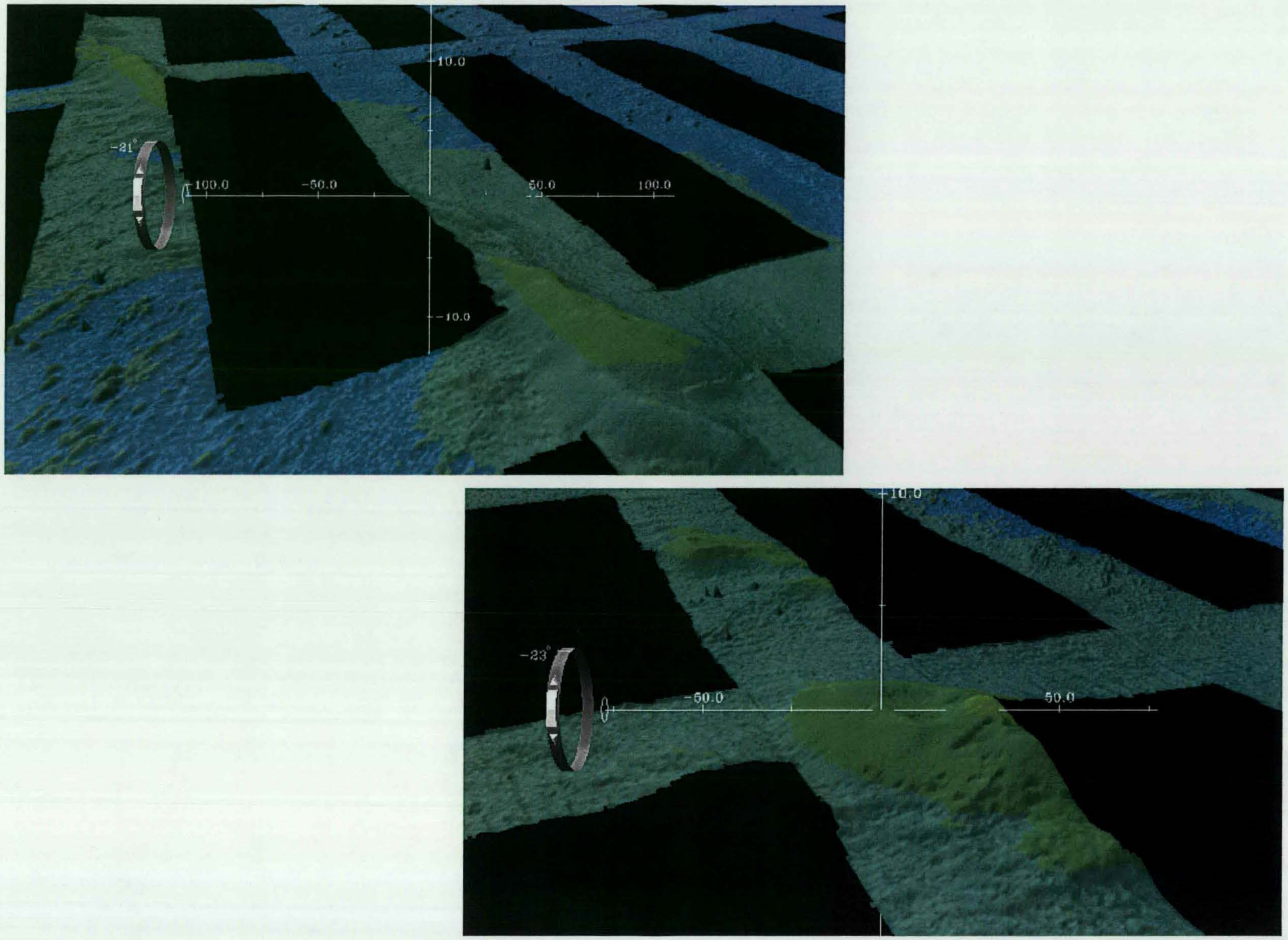
C1-2 – MBE bottom features.



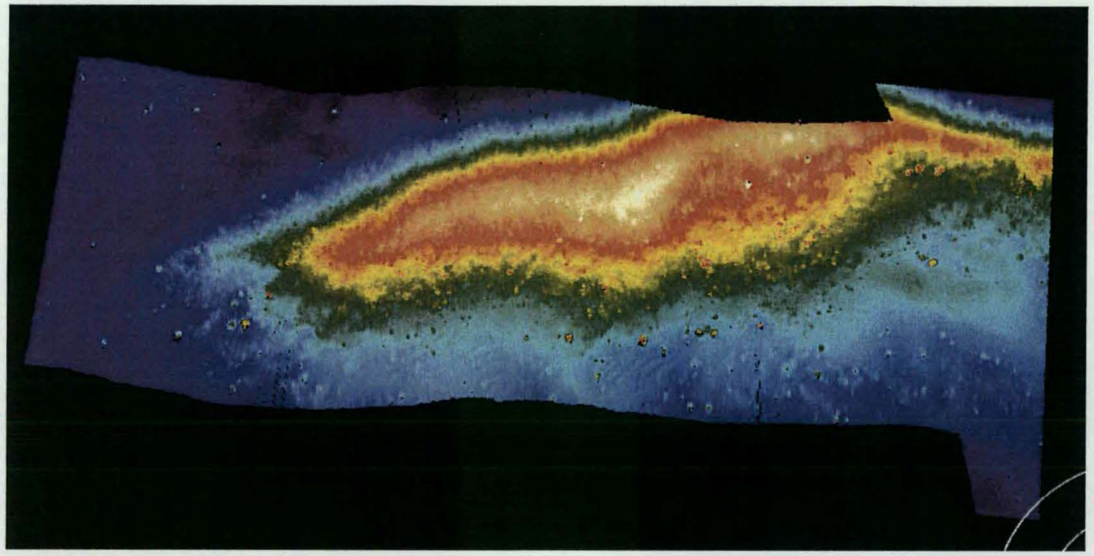
C1-3 – Examples of mega ripples identified in the MBE bathymetry data.

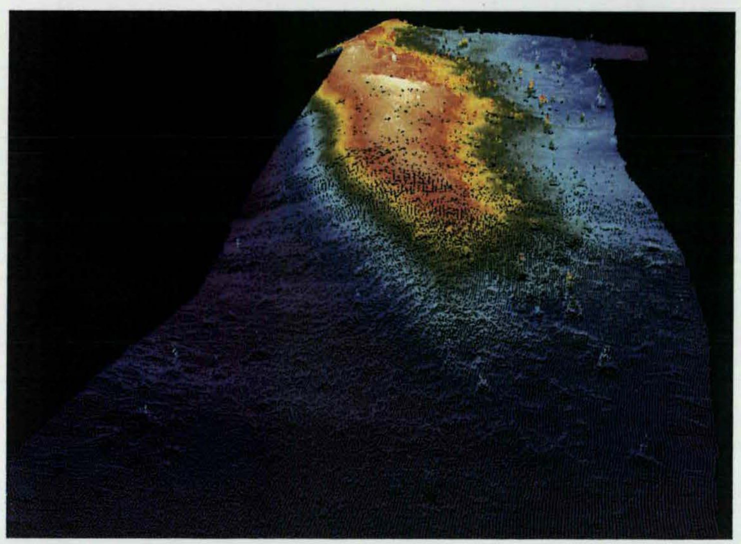


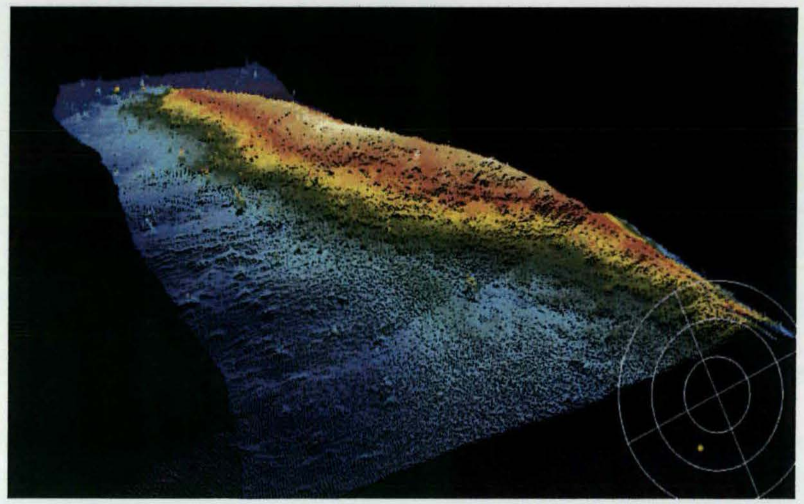
C1-4 – Sand Ridges identified in the MBE bathymetry data.



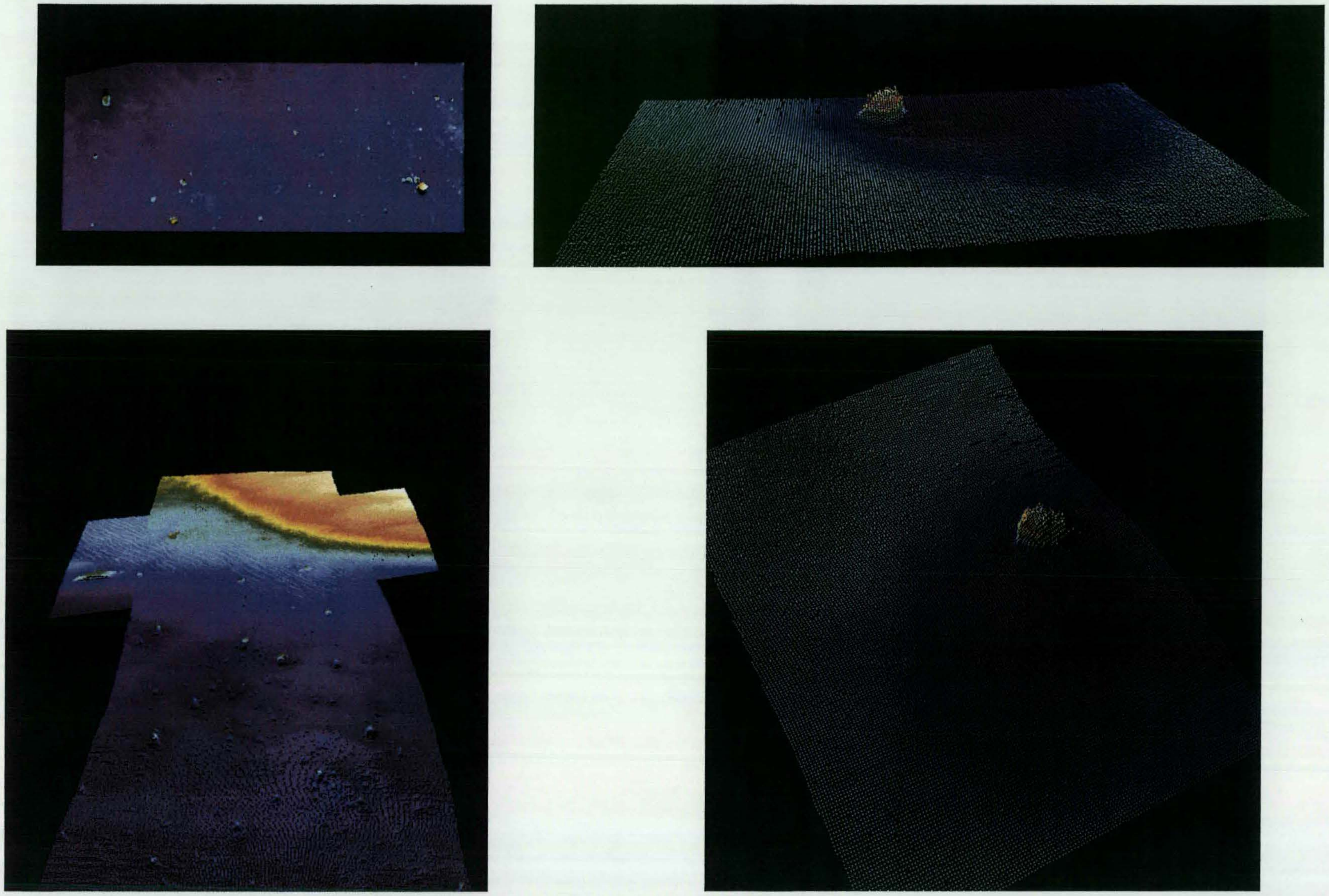
C1-5 – Sand Ridges identified in the MBE bathymetry data.



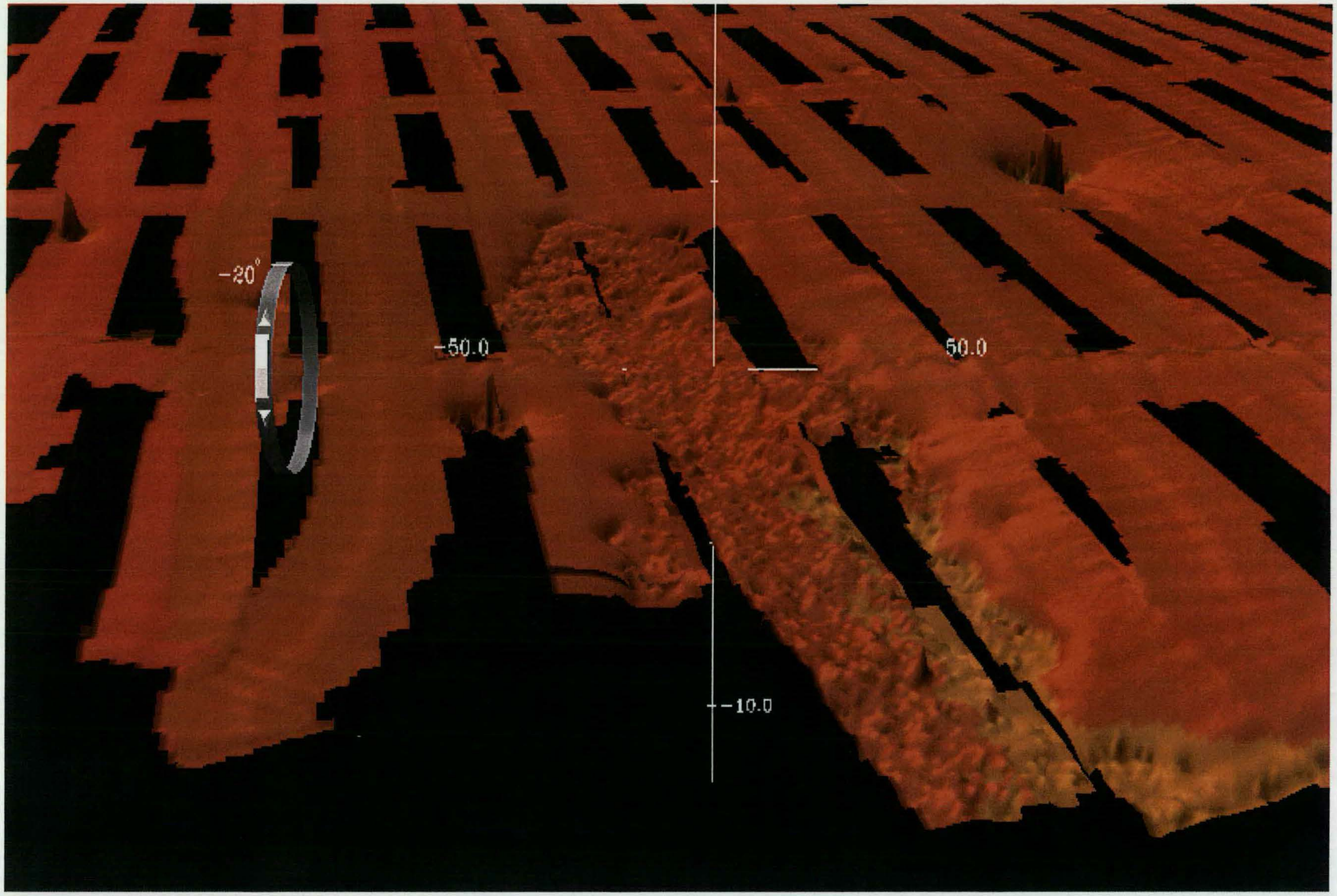




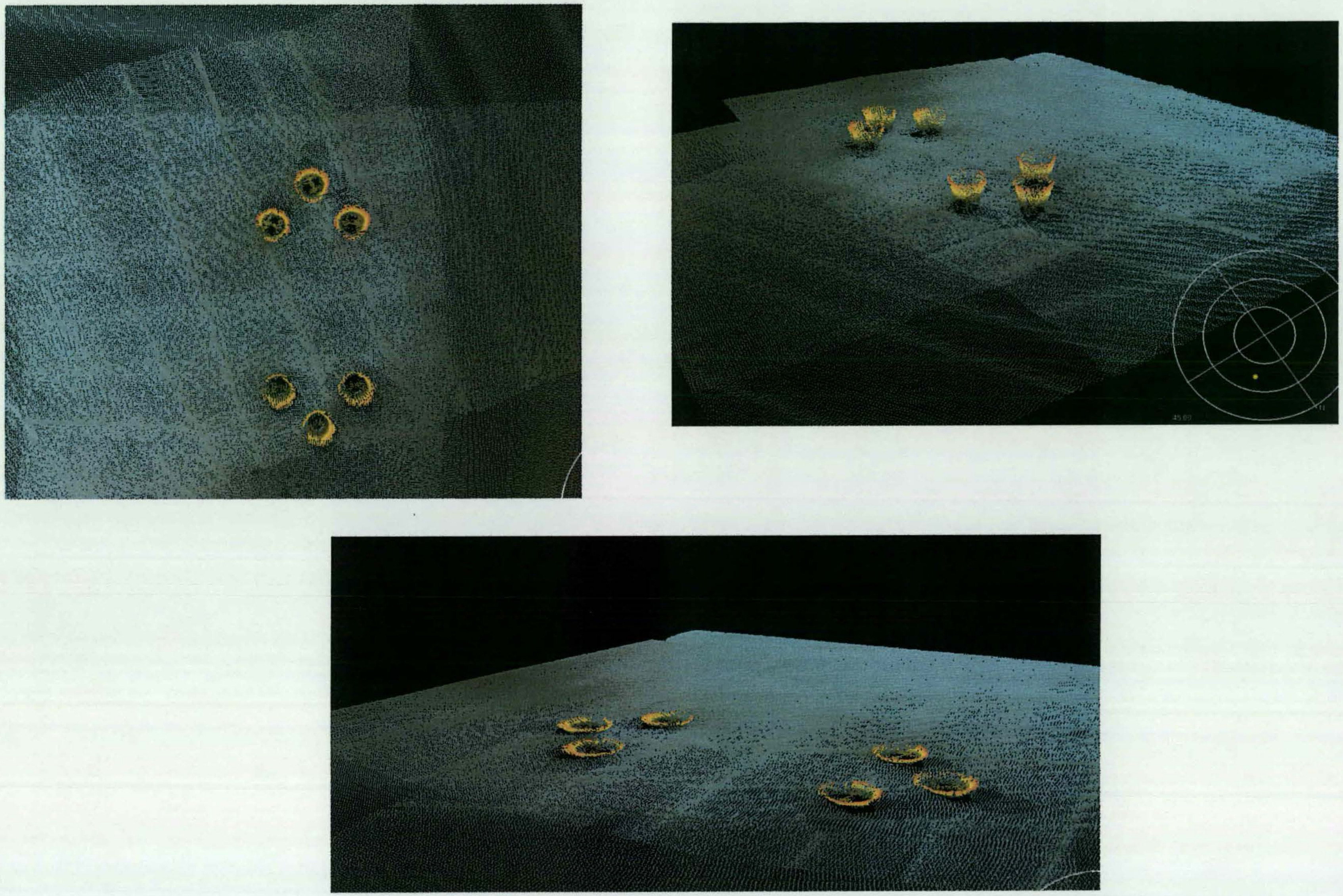
C1-6 – Boulders identified in the MBE bathymetry data.



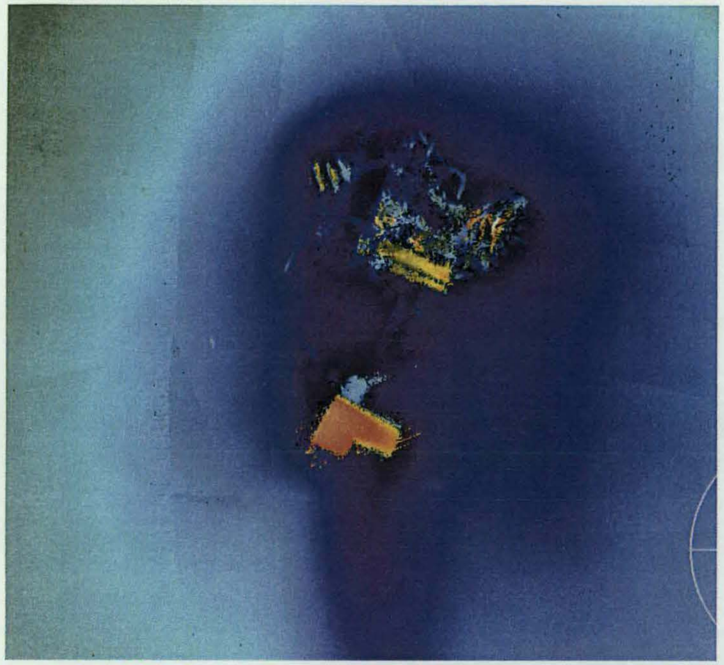
C1-7 - Bottom type fasces change from smooth to rough identified in the MBE data.

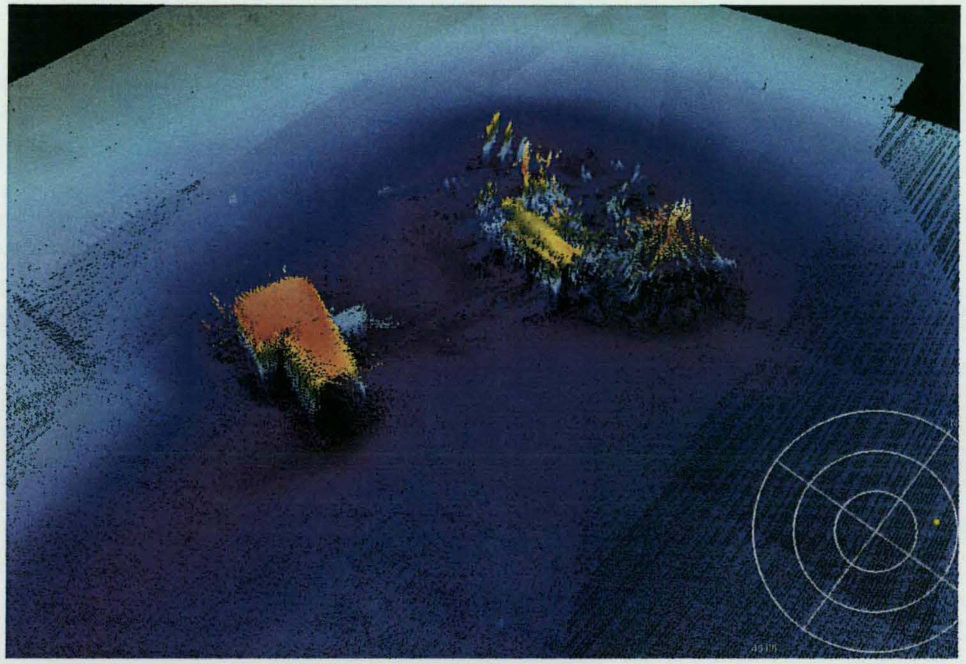


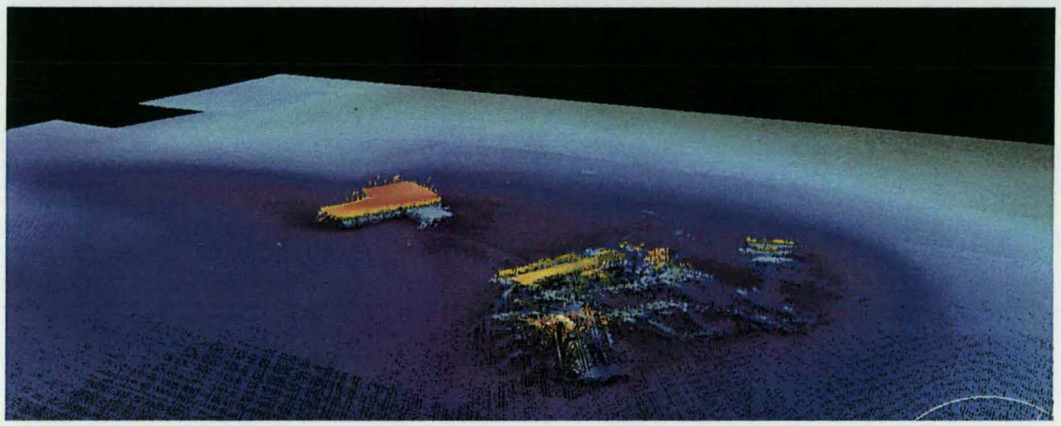
C1-8 – Marine foundations identified in MBE bathymetry data. Features are about 4 feet proud of the lake bottom.



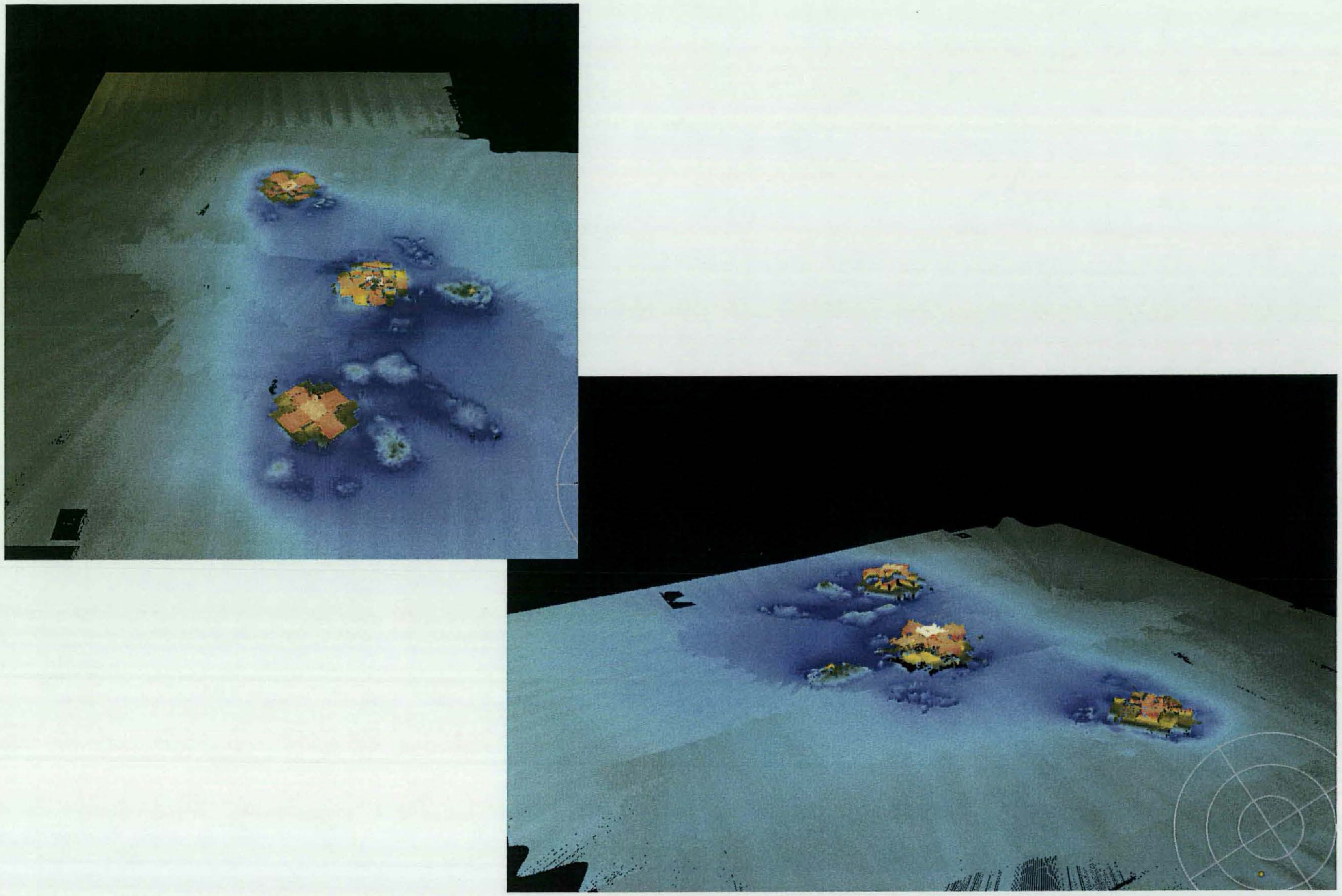
C1- 9 - Possible vessel debris field identified in the near shore







C1-10 – Apparent water intake structures. A linear magnetic anomaly was identified between the shore and the structures.

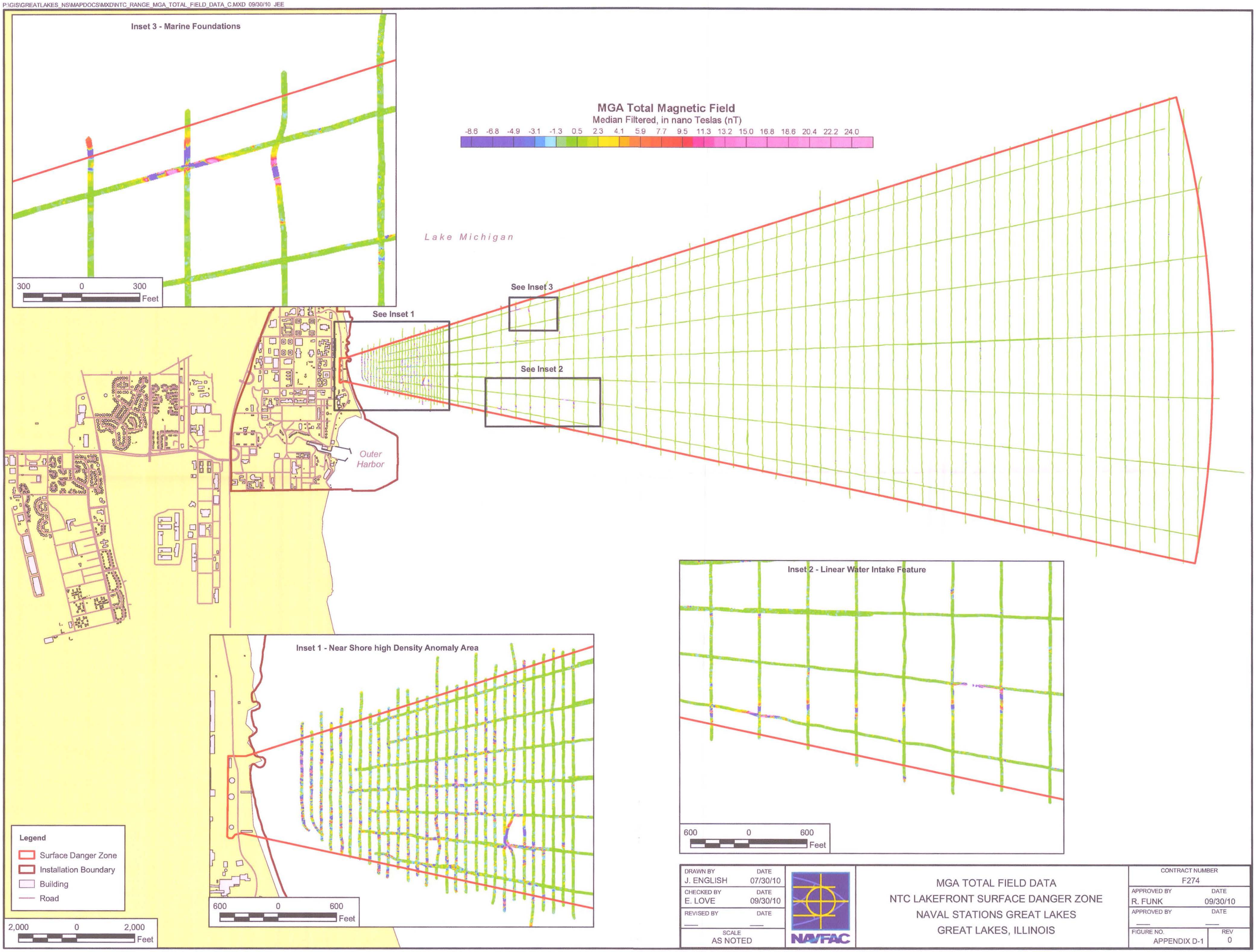


APPENDIX D

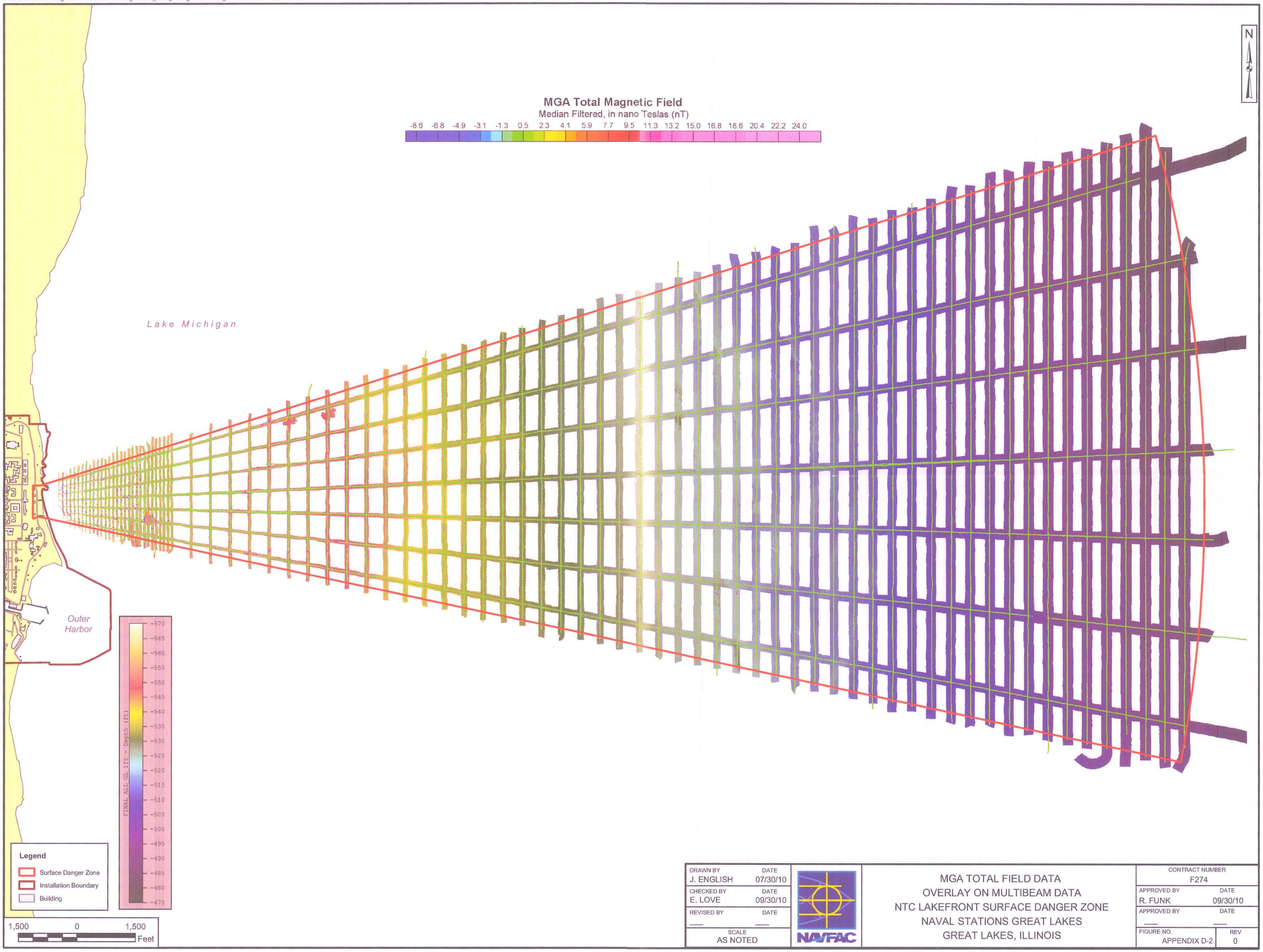
DATA AND MAPS FOR MARINE GRADIOMETER ARRAY (MGA) SURVEY

(Data to be provided on DVD)

P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\NTC_RANGE_MGA_TOTAL_FIELD_DATA_C.MXD 09/30/10 JEE

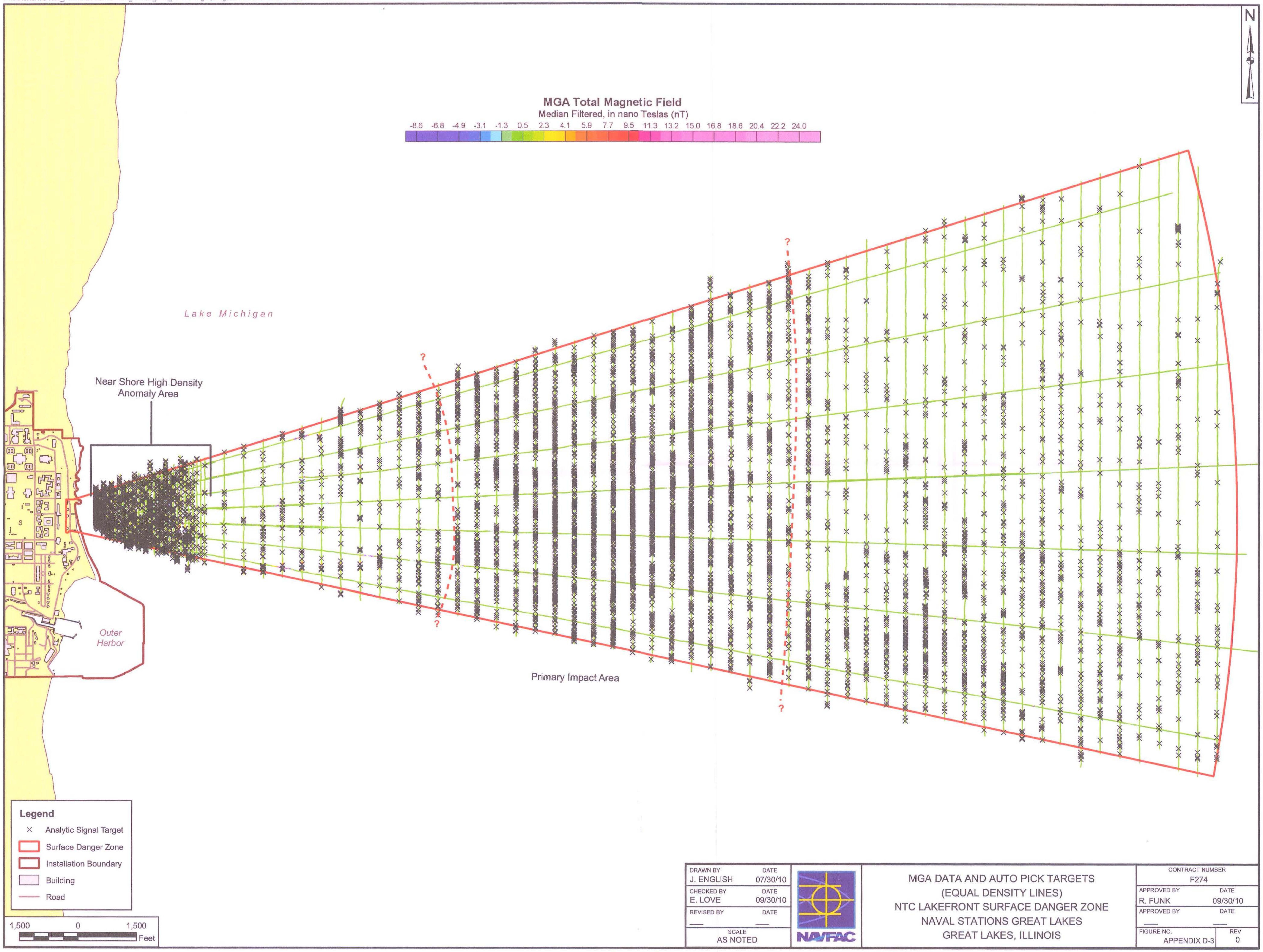


P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\NTC_RANGE_MGA_WITH_MULTIBEAM_OVERLAY.MXD 09/30/10 JEE



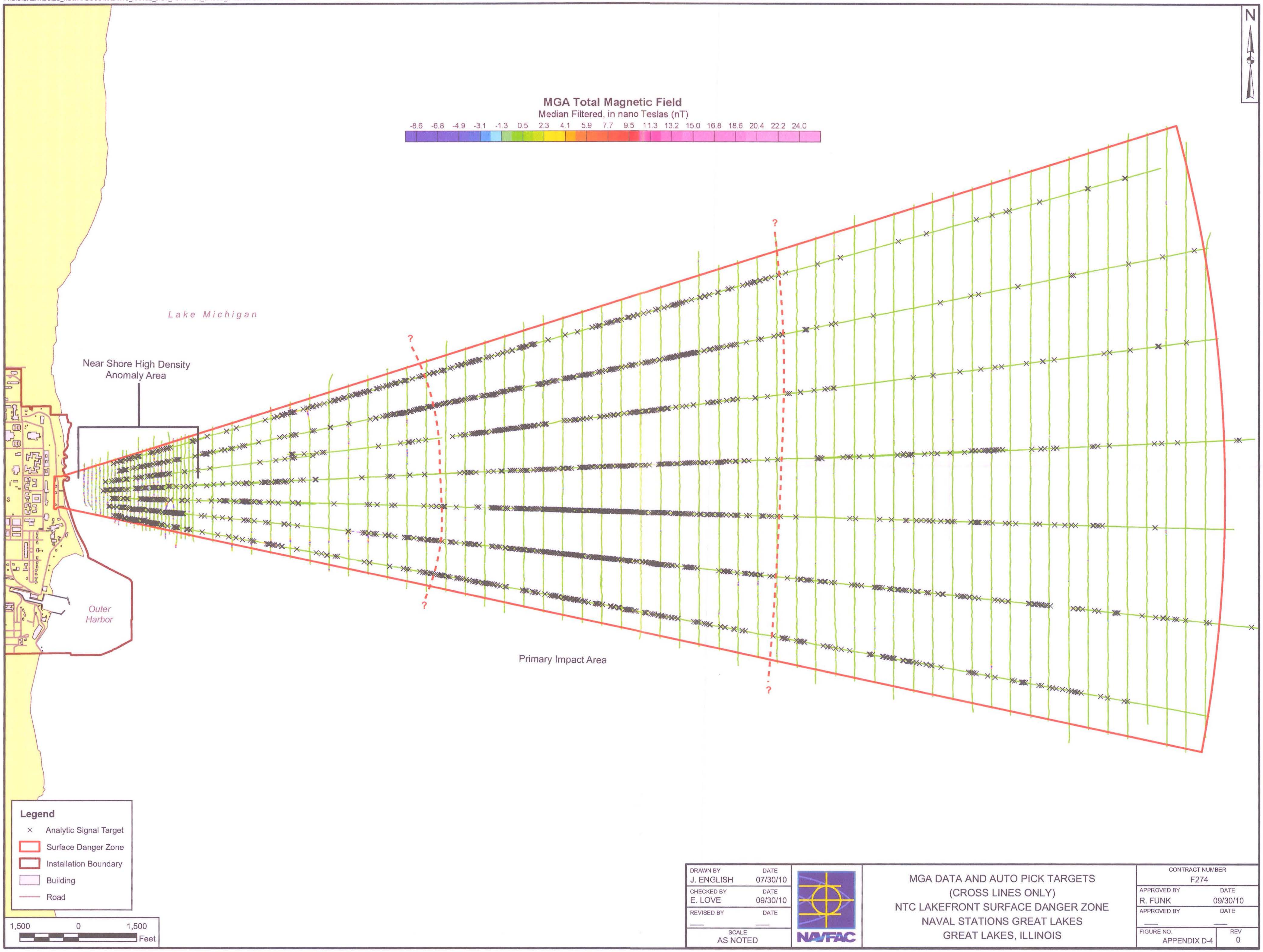
DRAWN BY J. ENGLISH — DATE 07/30/10 CHECKED BY E. LOVE — DATE 09/30/10 REVISED BY — DATE SCALE AS NOTED	NAVFAC	MGA TOTAL FIELD DATA OVERLAY ON MULTIBEAM DATA NTC LAKEFRONT SURFACE DANGER ZONE NAVAL STATIONS GREAT LAKES GREAT LAKES, ILLINOIS	CONTRACT NUMBER F274 APPROVED BY R. FUNK — DATE 09/30/10 APPROVED BY — DATE FIGURE NO. APPENDIX D-2 — REV 0

P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\NTC_RANGE_MGA_AUTOPICK_EQUAL_DENSITY.MXD 09/30/10 JEE



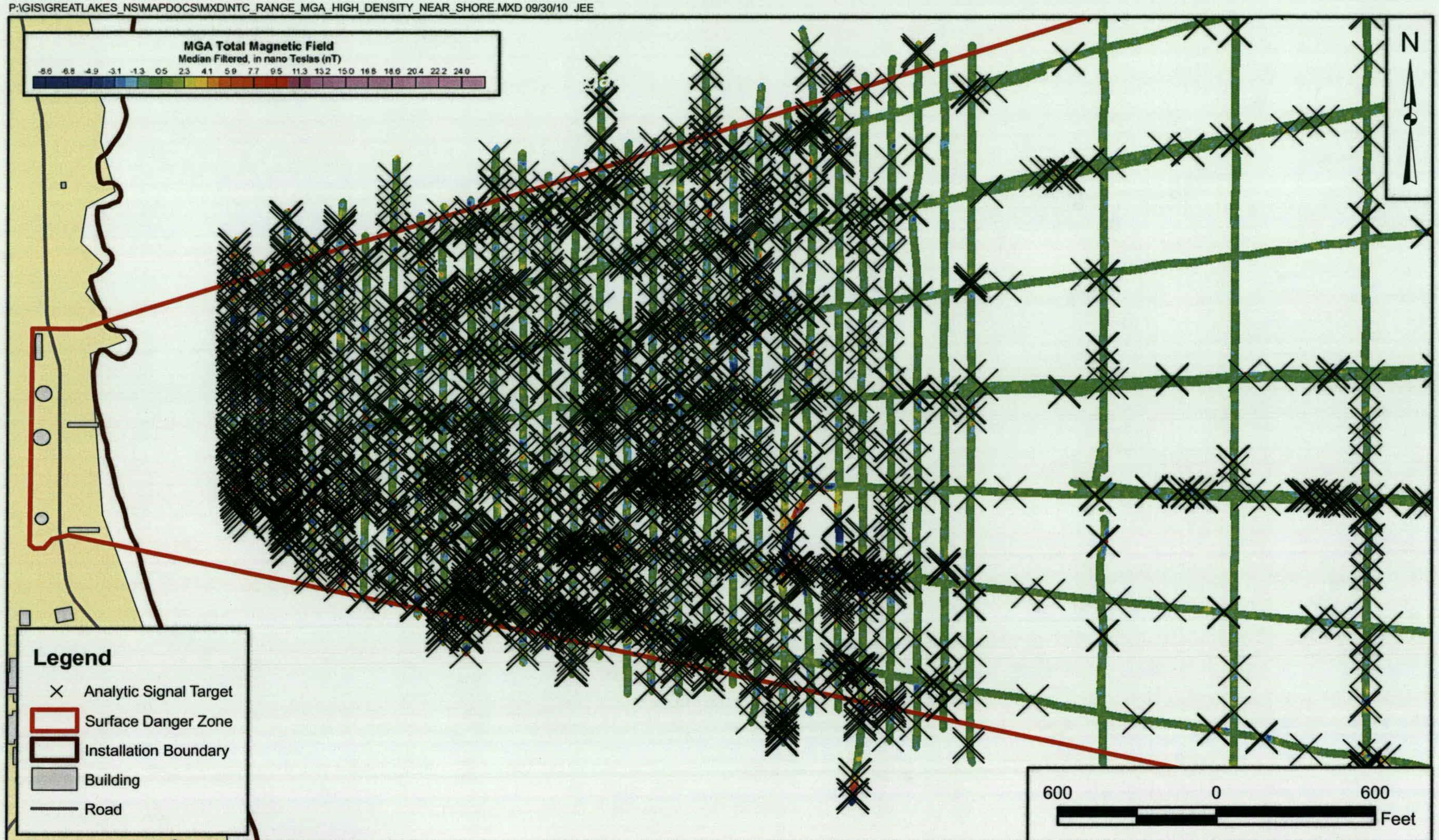
DRAWN BY: J. ENGLISH — DATE: 07/30/10	NAVFAC	MGA DATA AND AUTO PICK TARGETS (EQUAL DENSITY LINES) NTC LAKEFRONT SURFACE DANGER ZONE NAVAL STATIONS GREAT LAKES GREAT LAKES, ILLINOIS	CONTRACT NUMBER: F274
CHECKED BY: E. LOVE — DATE: 09/30/10			APPROVED BY: R. FUNK — DATE: 09/30/10
REVISED BY: ___ — DATE: ___			APPROVED BY: ___ — DATE: ___
SCALE: AS NOTED			FIGURE NO.: APPENDIX D-3 — REV: 0

P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\NTC_RANGE_MGA_AUTOPICK_CROSS_LINES.MXD 09/30/10 JEE



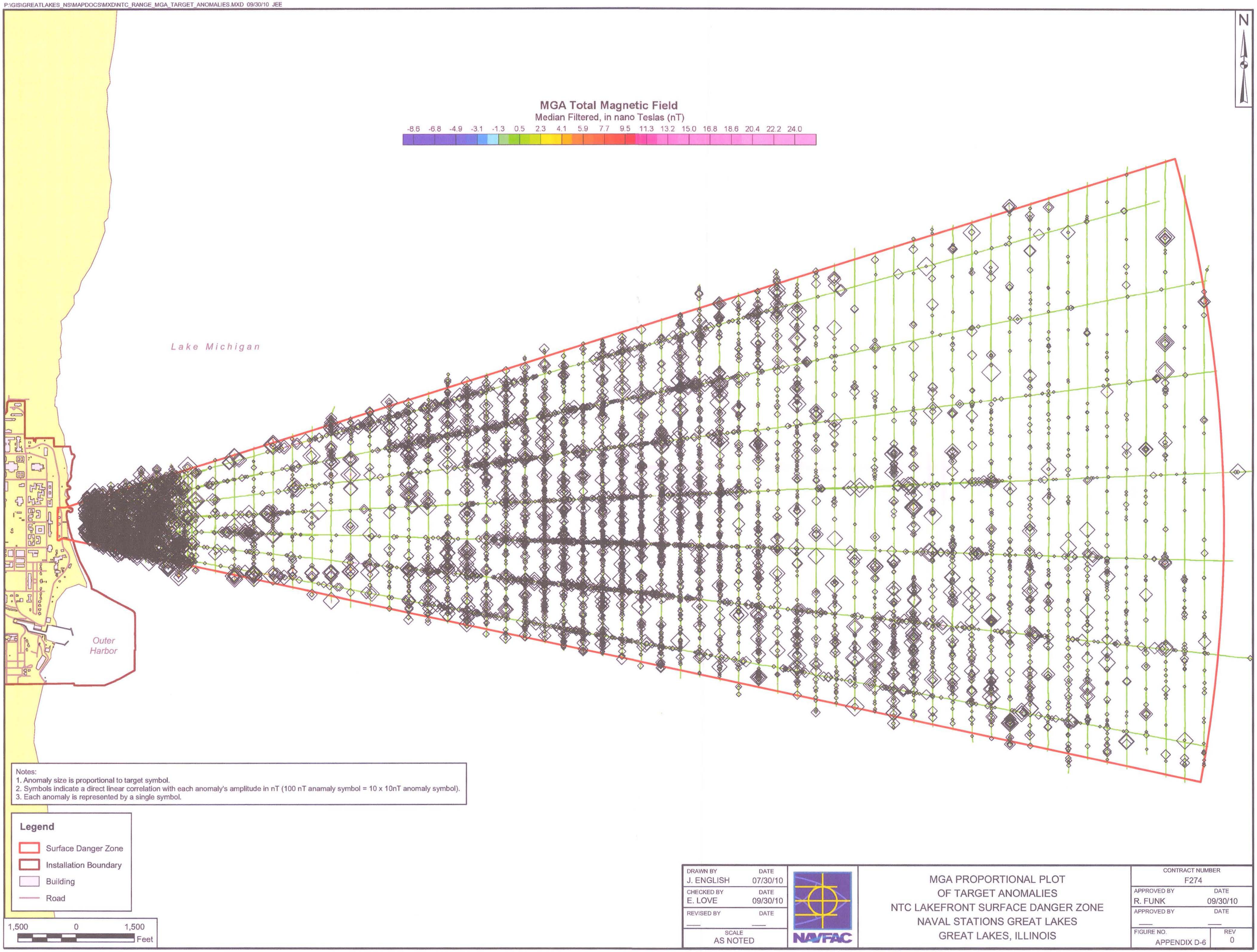
DRAWN BY J. ENGLISH / DATE 07/30/10	NAVFAC	MGA DATA AND AUTO PICK TARGETS (CROSS LINES ONLY) NTC LAKEFRONT SURFACE DANGER ZONE NAVAL STATIONS GREAT LAKES GREAT LAKES, ILLINOIS	CONTRACT NUMBER F274
CHECKED BY E. LOVE / DATE 09/30/10			APPROVED BY R. FUNK / DATE 09/30/10
REVISED BY — / DATE —			APPROVED BY — / DATE —
SCALE AS NOTED			FIGURE NO. APPENDIX D-4 / REV 0

P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\NTC_RANGE_MGA_HIGH_DENSITY_NEAR_SHORE.MXD 09/30/10 JEE

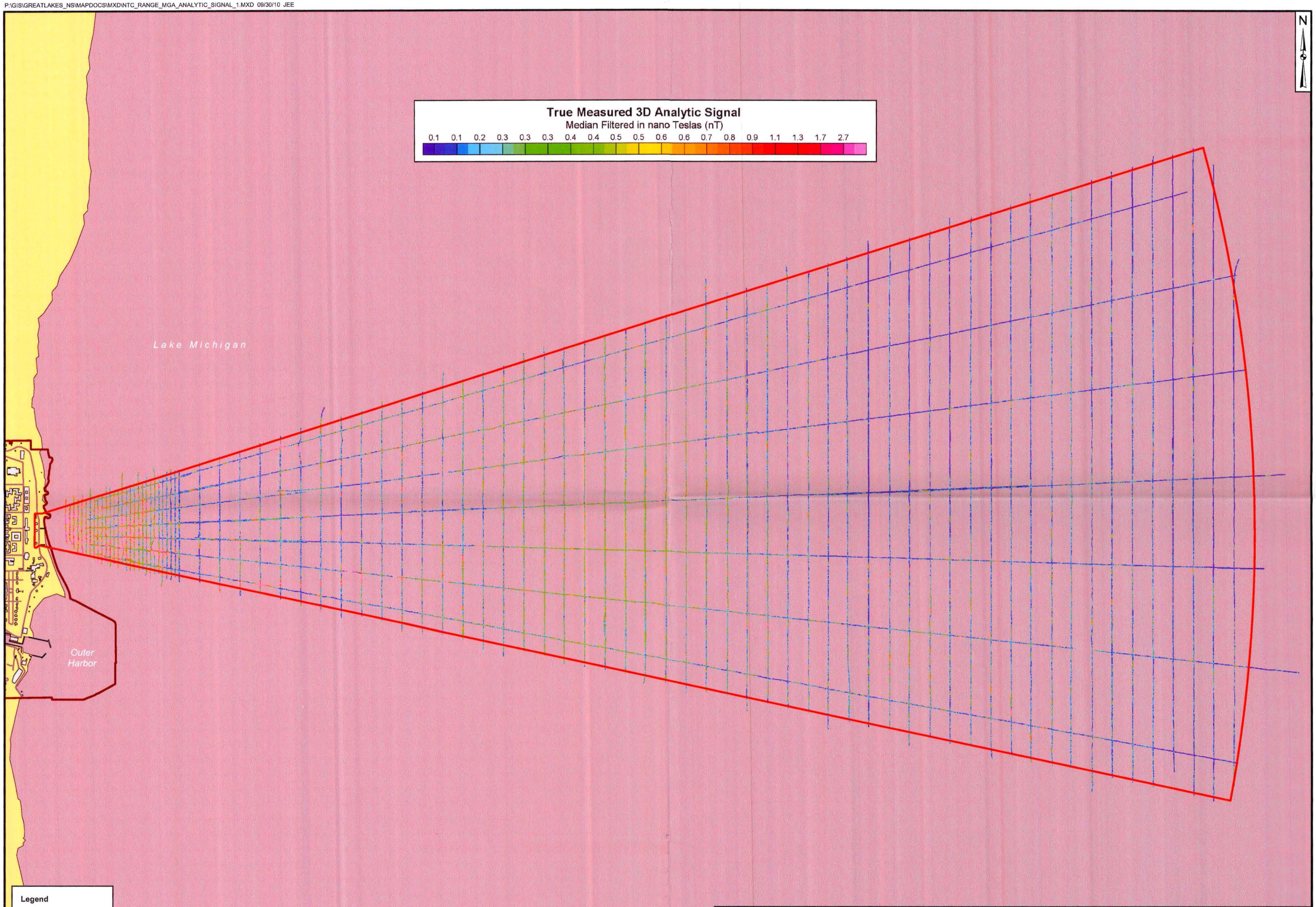


DRAWN BY J. ENGLISH	DATE 07/30/10	NAVFAC	MGA WITH AUTO DIPOLE TARGET PICKS NEAR SHORE HIGH DENSITY LINE SPACING NTC LAKEFRONT SURFACE DANGER ZONE NAVAL STATION GREAT LAKES GREAT LAKES, ILLINOIS	CONTRACT NUMBER F274
CHECKED BY E. LOVE	DATE 09/30/10			APPROVED BY R. FUNK — DATE 09/30/10
COST/SCHEDULE AREA				APPROVED BY — DATE
SCALE AS NOTED				FIGURE NO. APPENDIX D-5 — REV 0

P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\NTC_RANGE_MGA_TARGET_ANOMALIES.MXD 09/30/10 JEE



P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\NTC_RANGE_MGA_ANALYTIC_SIGNAL_1.MXD 09/30/10 JEE



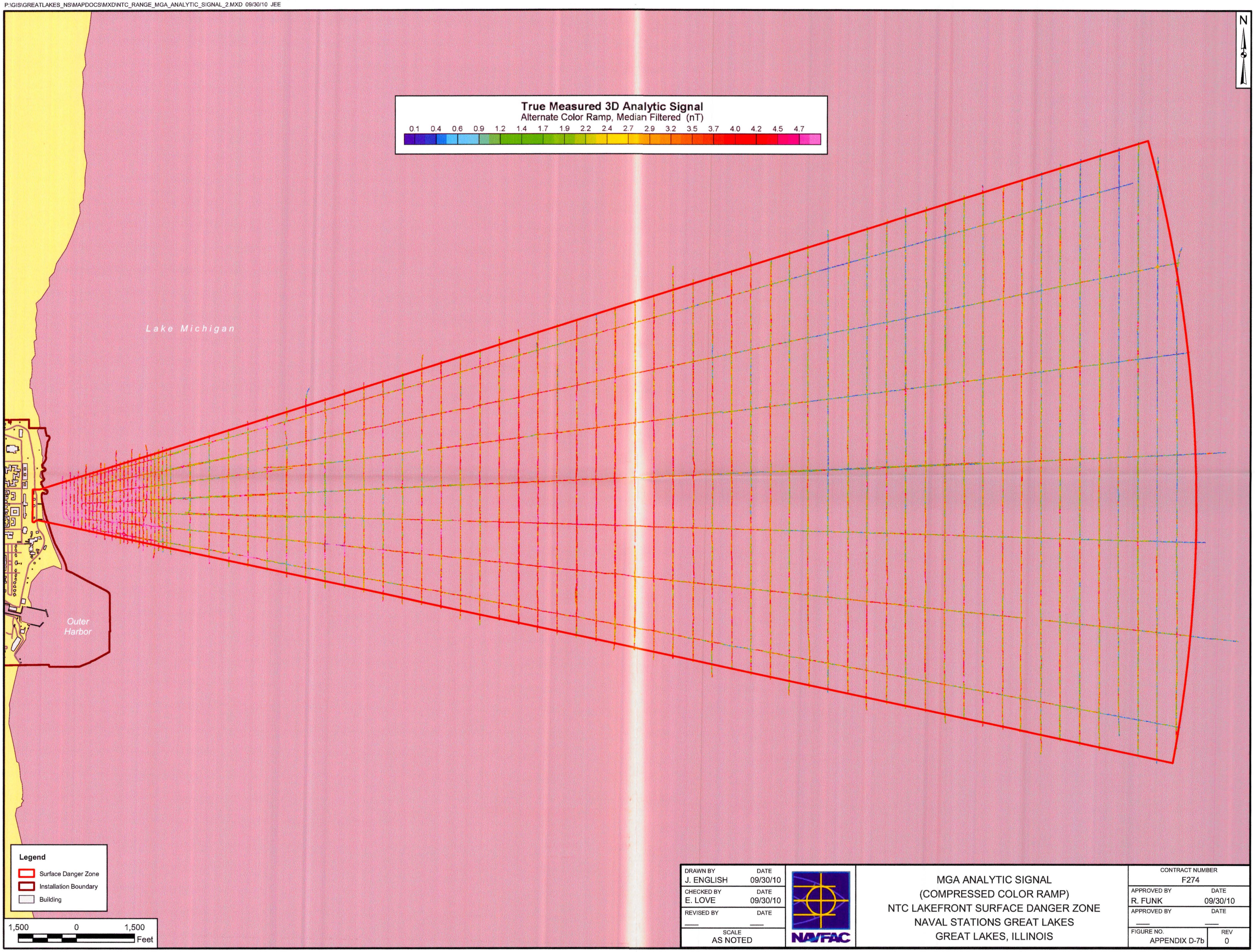
DRAWN BY J. ENGLISH	DATE 09/30/10	
CHECKED BY E. LOVE	DATE 09/30/10	
REVISED BY ___	DATE ___	
SCALE AS NOTED		

NAVFAC

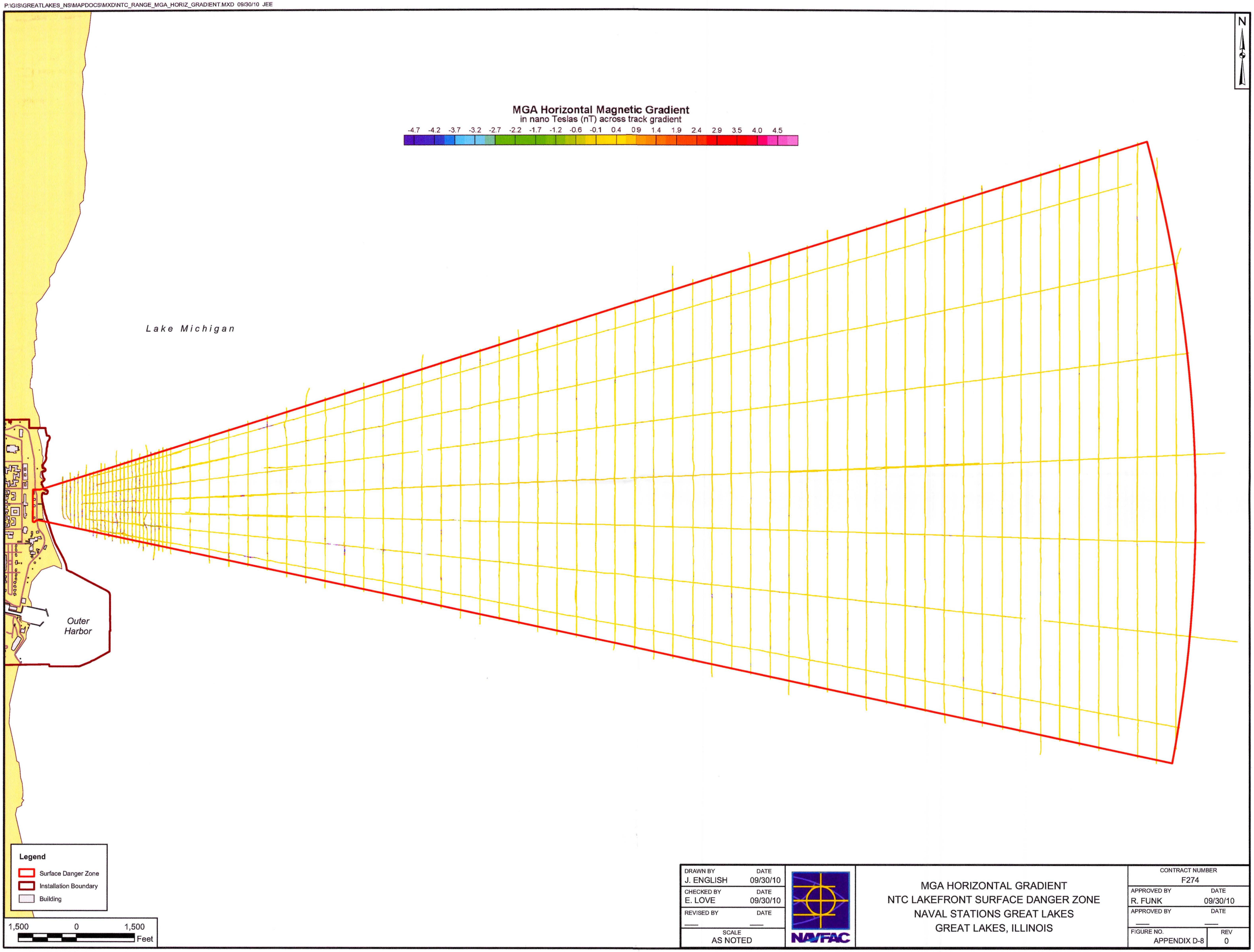
MGA ANALYTIC SIGNAL
(COMPRESSED COLOR RAMP)
NTC LAKEFRONT SURFACE DANGER ZONE
NAVAL STATIONS GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NUMBER F274	
APPROVED BY R. FUNK	DATE 09/30/10
APPROVED BY ___	DATE ___
FIGURE NO. APPENDIX D-7a	REV 0

P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\NTC_RANGE_MGA_ANALYTIC_SIGNAL_2.MXD 09/30/10 JEE



P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\NTC_RANGE_MGA_HORIZ_GRADIENT.MXD 09/30/10 JEE



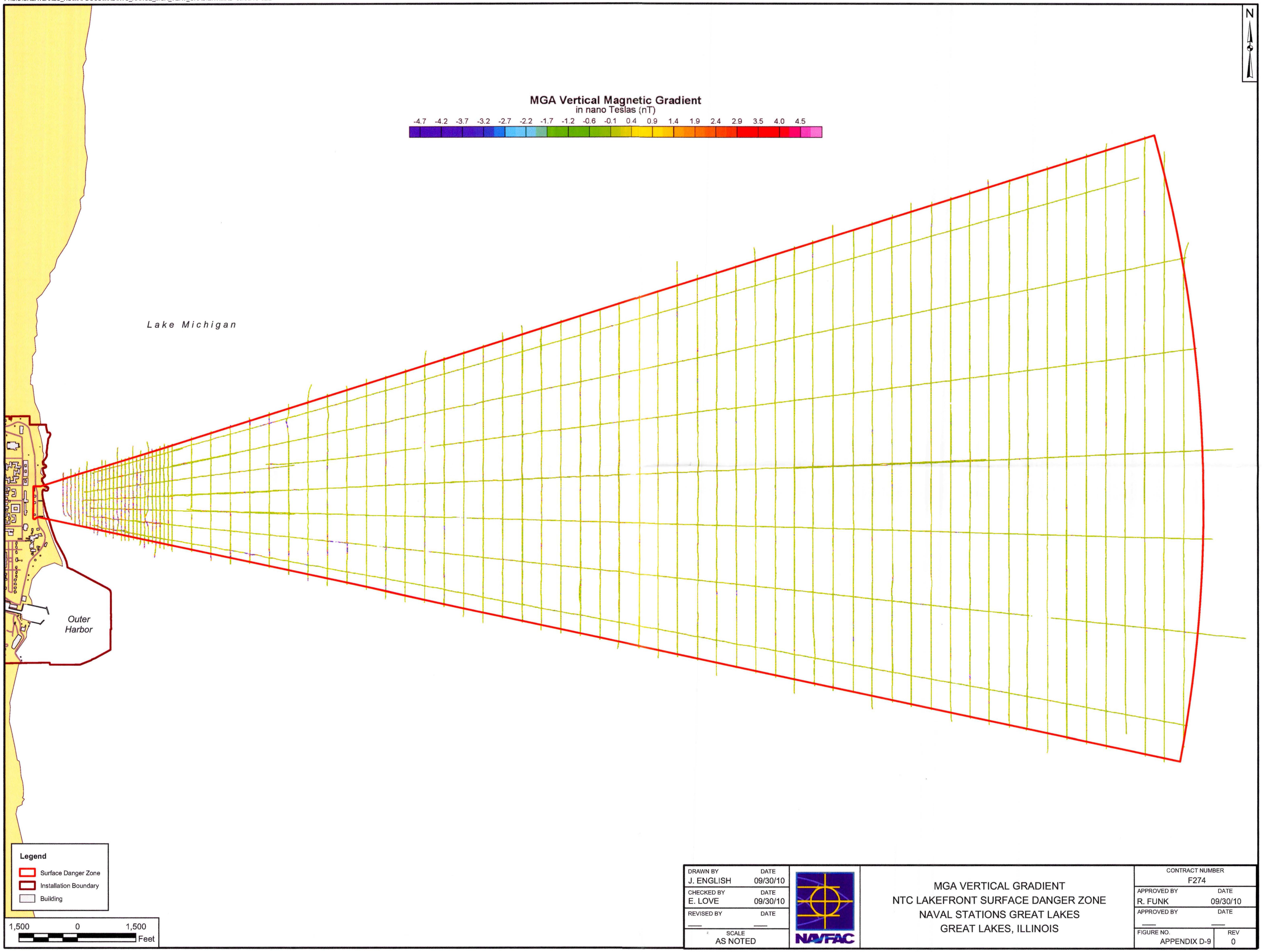
DRAWN BY	DATE
J. ENGLISH	09/30/10
CHECKED BY	DATE
E. LOVE	09/30/10
REVISED BY	DATE
___	___
SCALE AS NOTED	

NAVFAC

MGA HORIZONTAL GRADIENT
NTC LAKEFRONT SURFACE DANGER ZONE
NAVAL STATIONS GREAT LAKES
GREAT LAKES, ILLINOIS

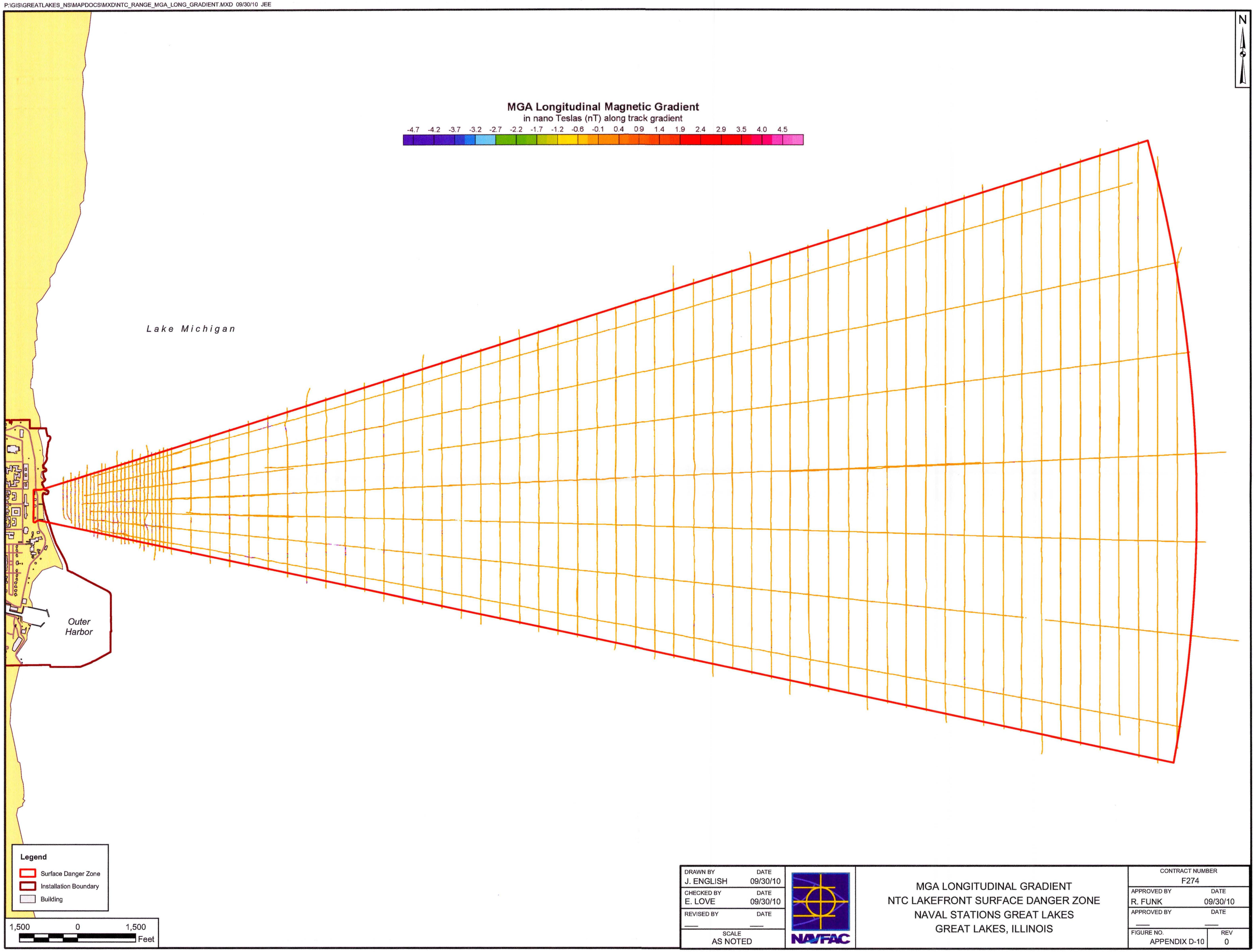
CONTRACT NUMBER	
F274	
APPROVED BY	DATE
R. FUNK	09/30/10
APPROVED BY	DATE
___	___
FIGURE NO.	REV
APPENDIX D-8	0

P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\NTC_RANGE_MGA_VERT_GRADIENT.MXD 09/30/10 JEE



DRAWN BY J. ENGLISH	DATE 09/30/10	MGA VERTICAL GRADIENT NTC LAKEFRONT SURFACE DANGER ZONE NAVAL STATIONS GREAT LAKES GREAT LAKES, ILLINOIS	CONTRACT NUMBER F274
CHECKED BY E. LOVE	DATE 09/30/10		APPROVED BY R. FUNK — DATE 09/30/10
REVISED BY ___	DATE ___		APPROVED BY ___ — DATE ___
SCALE AS NOTED		NAVFAC	FIGURE NO. APPENDIX D-9 — REV 0

P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\NTC_RANGE_MGA_LONG_GRADIENT.MXD 09/30/10 JEE



DRAWN BY J. ENGLISH — DATE 09/30/10	NAVFAC	MGA LONGITUDINAL GRADIENT	CONTRACT NUMBER F274
CHECKED BY E. LOVE — DATE 09/30/10		NTC LAKEFRONT SURFACE DANGER ZONE	APPROVED BY R. FUNK — DATE 09/30/10
REVISED BY ___ — DATE ___		NAVAL STATIONS GREAT LAKES	APPROVED BY ___ — DATE ___
SCALE AS NOTED		GREAT LAKES, ILLINOIS	FIGURE NO. APPENDIX D-10 — REV 0