FINAL SUBMITTAL

GEOPHYSICAL SURVEY NORTHEAST CAPE FUDS #F10AK096905

ST. LAWRENCE ISLAND, ALASKA

CONTRACT NO. W911KB-05-D-0004
DELIVERY ORDER NO. 0012

Prepared for:

U.S. ARMY ENGINEER DISTRICT, ALASKA
P.O. Box 6898
Elmendorf AFB, Alaska 99506

November, 2007

R&M CONSULTANTS, INC.

F10AK096905_03.10_0500_a
200-1e

R&M CONSULTANTS, INC. (907) 522-1707, FAX (907) 522-3403, www.rmconsult.com
9101 Vanguard Drive, Anchorage, Alaska 99507

November 27, 2007 R&M No. 1209.12

U.S. Army Engineer District, Alaska
ATTN: CEPOA-PM-C-FUDS (Mr. Carey Cossaboom)
P.O. Box 6898
Elmendorf AFB, Alaska 99506

RE: Geophysical Survey
Northeast Cape, FUDS #F10AK096905
St. Lawrence Island, Alaska
Contract No. W911KB-05-D-0004, Delivery Order No. 0012

Dear Mr. Cossaboom:

Enclosed find our final report prepared for the above-referenced project. This work has been completed in accordance with Contract No. W911KB-05-D-0004, Delivery Order No. 0012. This final submittal includes the incorporation of your review comments of November 7, 2007

Please contact us at your convenience if there are questions regarding the information contained herein.

Very truly yours,

R&M CONSULTANTS, INC.

Charles H. Riddle, C.P.G.
Vice President

CHR:KJP*slv

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U.S. ARMY ENGINEER DISTRICT, ALASKA
P.O. Box 6898
Anchorage, Alaska 99506-6898

Attention:
Mr. Carey Cossaboom
CEPOA-PM-C-FUDS

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In association with:

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Corvallis, Oregon 97339

November, 2007

GEOPHYSICAL SURVEY
NORTHEAST CAPE

ST. LAWRENCE ISLAND, ALASKA

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

GEOPHYSICAL SURVEY NORTHEAST CAPE

ST. LAWRENCE ISLAND, ALASKA

1.0 INTRODUCTION

R&M Consultants, Inc. (R&M) and Northwest Geophysical Associates, Inc. (NGA) conducted a geophysical survey as part of the ongoing, phased remedial investigation of the Northeast Cape Air Force Station Formerly Used Defense Site (FUDS). Figure 1 shows the location of the site on the Northeast Cape of St. Lawrence Island, Alaska.

The Northeast Cape site is located on St. Lawrence Island in the Bering Sea, about 135 miles southwest of Nome, Alaska. It is near the northeast end of the island at 63º19' North latitude, 168º58' West longitude, nine miles west of the physical Northeast Cape of St. Lawrence Island. The entire Northeast Cape site originally encompassed 4,800 acres, or 7.5 square miles. It is bounded by Kitnagak Bay to the northeast, Kangighsak Point to the northwest, and the Kinipaghulghat Mountains to the south. The former military installation operated as a surveillance station and a White Alice Communications station from about 1954 until 1972. The entire site is currently jointly owned by two local native corporations, Sivuqaq, Inc. and Savoonga Native Corporation. Demolition of the buildings and all other structures has been completed under multiple U.S. Army Corps of Engineers contracts. The unmaintained runway, improved gravel roads, and concrete slabs of some of the former structures remain intact.

This geophysical survey was limited to two areas. The first area is designated Site 7 Cargo Beach Road and comprises approximately 22 acres, and the second area is designated as Site 10 Buried Drums and comprises approximately one acre. The objective of the geophysical survey, as set forth in the Scope of Work provided by the U.S. Army Corps of Engineers, Alaska District (USACE-AD), was basically two-fold:

- Delineate the extent of landfill debris – potentially including drums and other buried materials – at Site 7.
- Delineate the extent of buried debris at Site 10.

The Scope of Work further set forth the following questions to be answered in the course of meeting the above objectives.

Site 7:

1. Does the Site 7 landfill consist of a natural topographic/geologic feature with debris located along the edges, or is it a constructed mound substantively underlain by buried debris?

2. What is the areal extent of the buried debris and/or drums at Site 7?

3. Does the debris at Site 7 extend beneath the existing gravel road (Cargo Beach Road)?

Site 10:

1. What is the areal extent of the buried debris at Site 10?

The geophysical work included both an electromagnetic (EM) survey utilizing the Geonics EM-31 terrain conductivity meter and a magnetic (MAG) survey utilizing a Geometrics G858G magnetometer/gradiometer. Interpreted results are discussed in Section 4 and presented as Geophysical Interpretation Summary maps in Figures 2 and 3. Data plots are presented in Appendix A. Appendix B includes photographs taken during our site investigation while Appendix C contains various field notes. Basic principles of these geophysical techniques are described in Appendix D, *Geophysical Detection of Buried Objects*.

2.0 FIELD SURVEY

On-site geophysical field work was conducted on August 7 through 10, 2007. Field personnel included Mark Villa a project geophysicist, Zack Oremland a field technician from NGA, and Kevin Pendergast a field technician from R&M. The site map in Figure 1 shows Site 7 Cargo Beach Road and Site 10 Buried Drums, along with selected site features.

Bering Air transported the field crew, geophysical equipment, supplies and two ATVs to the Northeast Cape of St. Lawrence Island on August 7, 2007. The weather was overcast with periods of light rain. After unloading equipment, the weatherport was constructed at the edge of the runway (see Appendix B photos).

Site 10 was surveyed on August 8, 2007. The weather was sunny with cloud cover increasing in the day. Following completion of the MAG and EM survey at Site 10, Site 7 was gridded with survey stakes. Site 7 was started August 9; weather was overcast with periods of heavy rain. Site 7 was completed August 10; the weather was clear and sunny. The weather August 11 was very windy with heavy rain; Bering Air was unable to land and demobilization was postponed for one day.

While onsite, the field crew had several interactions with Savoonga residents who were in the area. Myron Kingeekuk, our designated native observer for this work, was present briefly on 7, 11, and 12 August 2007. Floyd Kingeekuk, also of Savoonga, dropped by the R&M camp each day from 8 August through 12 August. Eugene Toolie was also briefly onsite on 9 and 11 August, on which occasions he provided us helpful information about the history of Sites 7 and 10. Each of these individuals was often accompanied by wives, children, or other relations. After we explained the nature of the work we were engaged upon to our various visitors, the visits became basically social and friendly.

2.1 Global Positioning System Mapping Control

Differential Global Positioning System (DGPS) data were acquired simultaneously with the geophysical data. DGPS data were also acquired to provide position information for the mapping of the site. For the DGPS operation, a local base station was instrumented with a Trimble ProXRS GPS system. The base station was established at National Geodetic Survey (NGS) PID UW3430, a benchmark shown on Figure 1 as BM-B 1951. GPS data from the rovers was differentially corrected in post-processing to the base station data. The equipment and procedures employed provided sub-meter accuracy for the geophysical mapping, as required by the USACE-AD Scope of Work.

Sub-meter accuracy DGPS coordinates were collected for four existing survey monuments, benchmarks BM-B 1951, BM-K, and BM-L, and monument GPS 3201 2002. Coordinates for a fifth existing survey monument – benchmark BM-H – were collected using GPS data without base station correction, so the accuracy of this position is not sub-meter. For quality control purposes, and to confirm sub-meter accuracy, coordinates for base station control point BM-B 1951 were obtained in two ways. The benchmark was mapped with a rover while a GPS base station occupied the position. Also, the coordinates were taken from the NGS data sheet for PID

UW3430, with conversion to Alaska State Plane Zone 9, NAD83 using Corpscon 6 from USACE. The actual DGPS position recorded was two feet to the north of the NGS position.

The following table presents the coordinates for each of the five existing survey monuments described above. Two sets of coordinates are presented for the base station control point, those collected by DGPS methods (BM-B 1951) and those taken from the NGS data sheet (NGS PID UW3430). It should be noted that the coordinates given below differ from those provided in the USACE-AD Scope of Work, which were derived using methods of projection and geo-referencing. This naturally introduces some error. The following coordinates are therefore more accurate and may be considered updated.

MONUMENT	EASTING	NORTHING
BM-B 1951	1814567.8	3405709.2
BM-K	1813438.8	3404147.2
BM-L	1813554.6	3402974.7
GPS 3201 2002	1811030.9	3404027.9
BM-H	1812503.3	3404734.1
NGS PID UW3430	1814566.9	3405705.3

Coordinates are Alaska State Plane, Zone 9, NAD83, and are presented in U.S. Survey Feet.

2.2 Magnetic Data Acquisition

The MAG survey was conducted using a Geometrics G858G cesium magnetometer/gradiometer. This instrument was operated in the continuous sampling mode, recording the magnetic field at 0.2 second intervals (approximately one foot). Two magnetic sensors spaced 1.6 feet (0.5 meters) apart, one above the other, were used to obtain the vertical magnetic gradient. Nominal line spacing for the MAG survey was 20 feet. Magnetic survey lines are shown on Figures 2 and 3, and the magnetometer data plots are included in Appendix A, Figures A1 through A3 and A6 through A8.

2.3 Electromagnetic Data Acquisition

EM data were acquired using a Geonics EM-31 terrain conductivity meter. Both quadrature-phase (apparent conductivity) and in-phase data were recorded. Data were recorded at a 0.2 second interval, corresponding to a distance of approximately one foot. Data were recorded on an Allegro handheld field computer (Windows CE/DOS) running NAV31 software from Geomar of Mississauga, Ontario. Nominal line spacing for the EM survey was 20 feet. EM survey lines are shown on Figures 2 and 3, and the EM data plots are included in Appendix A, Figures A4, A5, A9 and A10.

2.4 Site 7 Cargo Beach Road Landfill

The survey area was approximately 1,050 feet by 1,010 feet, the corners of which were marked with rebar stakes driven to within a few inches of the ground surface. The coordinates for the corners are presented on Figure 2. MAG and EM lines were run in a north-south direction across the survey area. Nominal line spacing was 20 feet. Surface water, metallic debris and topography limited data collection in areas shown on Figure 2.

Concentrations of surface metal (55-gallon drums, conduit, piping, etc.) were apparent in three areas around the edge of the topographic rise located along Cargo Beach Road. Extents of the surface metal were mapped using DGPS. Individual surface metal targets shown on Figure 2 do not reflect the full extent of the surface metal present in the survey area.

2.5 Site 10 Buried Drum Area

The survey area was approximately 300 feet by 200 feet, the corners of which were marked with rebar stakes driven to within a few inches of the ground surface. The coordinates for the corners are presented on Figure 3. MAG and EM lines were run in a north-south direction across the survey area. Nominal line spacing was 20 feet.

Surface metal and a boulder which exhibited a strong magnetic signature were mapped with DGPS (Figure 3).

3.0 DATA PROCESSING

Magnetic and electromagnetic data were gridded and contoured using the Geosoft Data Processing and Analysis software system. Color contour data plots are included in Appendix A.

3.1 Magnetic Field Data

Magnetic data for Site 7 and Site 10 are displayed in Appendix A. The magnetic analytic signal (Figures A1 and A6), total magnetic signal (Figures A2 and A7), and the vertical magnetic field (Figures A3 and A8) are included. The analytic signal is our preferred presentation as it provides a simplified signature and better resolution of the anomalous areas than unprocessed field data. A high in the analytic signal occurs directly over the magnetic source. The analytic signal is discussed in Section 3.2.

The total magnetic field plot shows the data from the top sensor of the G858, which was also used to calculate the analytic signal. The vertical gradient is obtained by taking the difference in the magnetic field as measured by two sensors spaced 1.6 feet (0.5 meters) apart, one above the other.

Anomalies will have both high and low values associated with them.

3.2 Analytic Signal

The analytic signal is derived from the total magnetic field data. It is presented here as a more concise display of that data set. On the color contour plots (Figures A1 and A6), values of the analytic signal below a threshold value are not colored (i.e., are white) and represent areas where little or no metallic material may be present. Higher amplitude anomalies generally indicate stronger source objects. A stronger source object may be more magnetic (generally a larger mass of steel), or it may be closer to the surface, or both. The amplitudes of the anomalies also depend upon the orientation of the source objects in the earth's magnetic field. This is especially true for elongated bodies such as pipes and cables.

The analytic signal is defined as the amplitude of the gradient vector of the total magnetic field data. The gradient (rate of change) of the total magnetic field is a vector field. The analytic signal is the magnitude of that vector, or the rate of change in the direction of maximum rate of change. The color contour plot shows the amplitude of the gradient.

Mathematically, the analytic signal can be expressed as:

$$A = \left[\left[\frac{\partial M}{\partial x} \right]^2 + \left[\frac{\partial M}{\partial y} \right]^2 + \left[\frac{\partial M}{\partial z} \right]^2 \right]^{\frac{1}{2}}$$

where:

A	is the analytic signal
M	is the observed total magnetic field
∂	is the partial derivative operator

Derivatives are calculated in the frequency domain, from the gridded total field data.

Further discussion of the concept of the analytic signal can be found in the following publication:

Roest, W.R., Verhoef, J., and Pilkington, M., 1992, “Magnetic Interpretation Using the 3-D Analytic Signal”, *Geophysics*, Vol. 57(1); p.116-125.

3.3 Electromagnetic Data

Electromagnetic data for Site 7 and Site 10 are displayed in Appendix A. The apparent conductivity (Figures A4 and A9) and the in-phase response (Figures A5 and A10) are included. Appendix D includes a discussion of these two measured parameters of the EM response.

4.0 RESULTS AND INTERPRETATION

EM and magnetic data plots are included in Appendix A. The interpretation of those data, in terms of possible locations of buried objects, is summarized in Figures 2 and 3 and discussed below.

4.1 Site 7, Cargo Beach Road Landfill

The anomaly designations in the following sections refer to anomalies identified on Figure 2, *Geophysical Interpretation Summary Site 7,* and Figures A1 through A5.

4.1.1 Anomaly 7A

The area encompassed by Anomaly 7A lies to the south and east of the surface debris on the northwest slope of the topographic rise located along Cargo Beach Road. Eleven individual surface metal targets (piping, electrical/mechanical parts) were mapped inside the anomaly area, however they do not account for the scale of the anomaly. The anomalous area is typical of a landfill containing metallic targets. The EM and MAG data are not intended to support a definitive interpretation, but it can be said that the amplitude of the targets is sufficient to represent 55-gallon drums.

4.1.2 Anomaly 7B

The area encompassed by Anomaly 7B lies to the south of the surface debris on the northeast slope of the hill at the center of Site 7. The anomalous area is typical of a landfill containing metallic targets. The EM and MAG data are not intended to support a definitive interpretation, but it can be said that the amplitude of the targets is sufficient to represent 55-gallon drums.

4.1.3 Anomaly 7C

The area encompassed by Anomaly 7C lies to the north of the surface debris on the southeast slope of the hill at the center of Site 7. The anomalous area is typical of a landfill containing metallic targets. The EM and MAG data are not intended to support a definitive interpretation, but it can be said that the amplitude of the targets is sufficient to represent 55-gallon drums.

4.1.4 Anomalies 7D through 7G

Each anomalous area consists of more than one target and is consistent with subsurface metallic targets. The data do not support a more detailed interpretation of the nature of the targets.

The interpreted subsurface metallic anomalies underlie the northwest quadrant of the hill and are present in smaller areas across the hill but they do not extend beneath the existing gravel road.

4.1.5 Minor Anomalies – Not Illustrated

Numerous minor anomalies consistent with relatively small surface or subsurface metallic targets were identified scattered over much of Site 7. These anomalies were not typical of MAG or EM anomalies associated with fill material containing significant quantities of metal debris. Illustrating each of these minor anomalies would have obscured the other more significant anomalies on Figure 2.

4.2 Site 10, Buried Drum Area

The anomaly designations in the following sections refer to anomalies identified on Figure 3, *Geophysical Interpretation Summary Site 10*, and Figures A6 through A10.

4.2.1 Anomaly 10A

The anomalous area is consistent with subsurface metallic targets. The EM and MAG data are not intended to support a definitive interpretation, but it can be said that the amplitude of the targets is sufficient to represent 55-gallon drums.

4.2.2 Anomalies 10B through 10I – Minor Anomalies

The anomalies are consistent with individual subsurface metallic targets but not typical of a MAG or EM anomaly associated with 55-gallon drums.

4.3 Conclusions

4.3.1 Site 7

1. The topographic feature is not made up of debris. The geophysical data in this area are consistent with sidecasting debris off the edges of an existing natural topographic mound.

2. The extent of landfill material is shown on Figure 2. Landfill debris is heaviest and most consistent at the northwest and southeast edges of the topographic feature, which supports conclusion #1.

3. Debris does not extend beneath Cargo Beach Road, as it might be expected to do if the topographic feature was actually a mound entirely made up of landfill material. This also supports conclusion #1.

4.3.2 Site 10

1. The extent of the buried debris is shown on Figure 3. It does not appear to be extensive, but rather it is confined to several localized areas.

5.0 CLOSURE

Geophysical surveys performed as part of this site investigation may or may not successfully detect or delineate any or all subsurface objects or features present. Locations, depths and scale of buried objects or subsurface features mapped as a result of this survey are a result of geophysical interpretation only, and should be considered as confirmed, actual, or accurate only where recovered by excavation or drilling.

R&M Consultants, Inc. and Northwest Geophysical Associates, Inc. performed this work in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No warranty, express or implied, beyond exercise of reasonable care and professional diligence, is made. This report is intended for use only in accordance with the purposes of the study described within.

Very truly yours,

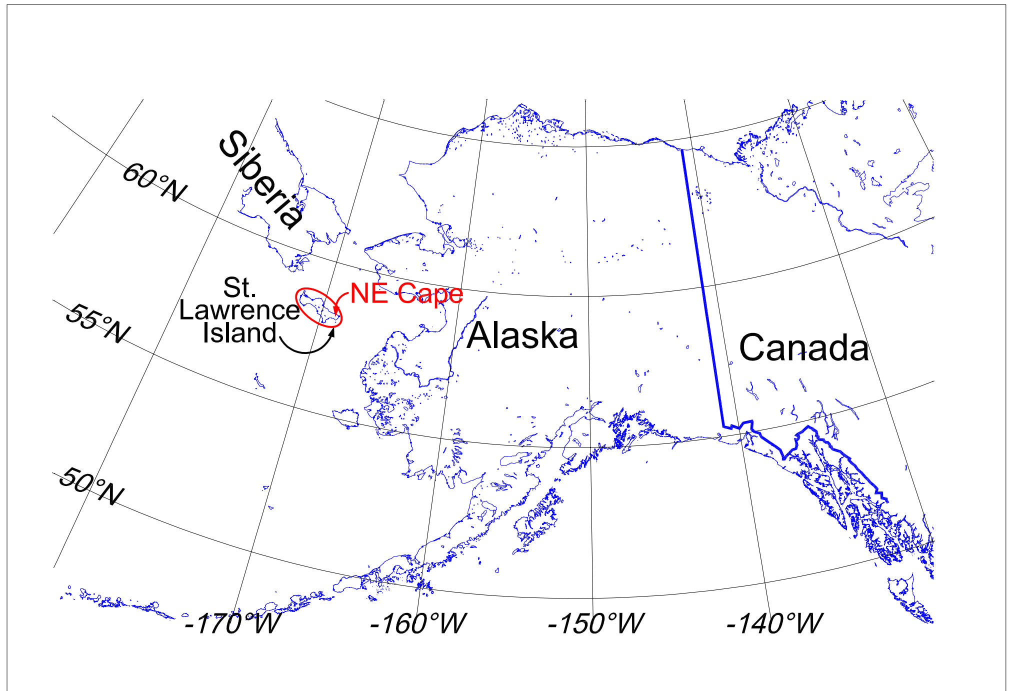
R&M Consultants, Inc.

Charles H Riddle, C.P.G.
Vice President

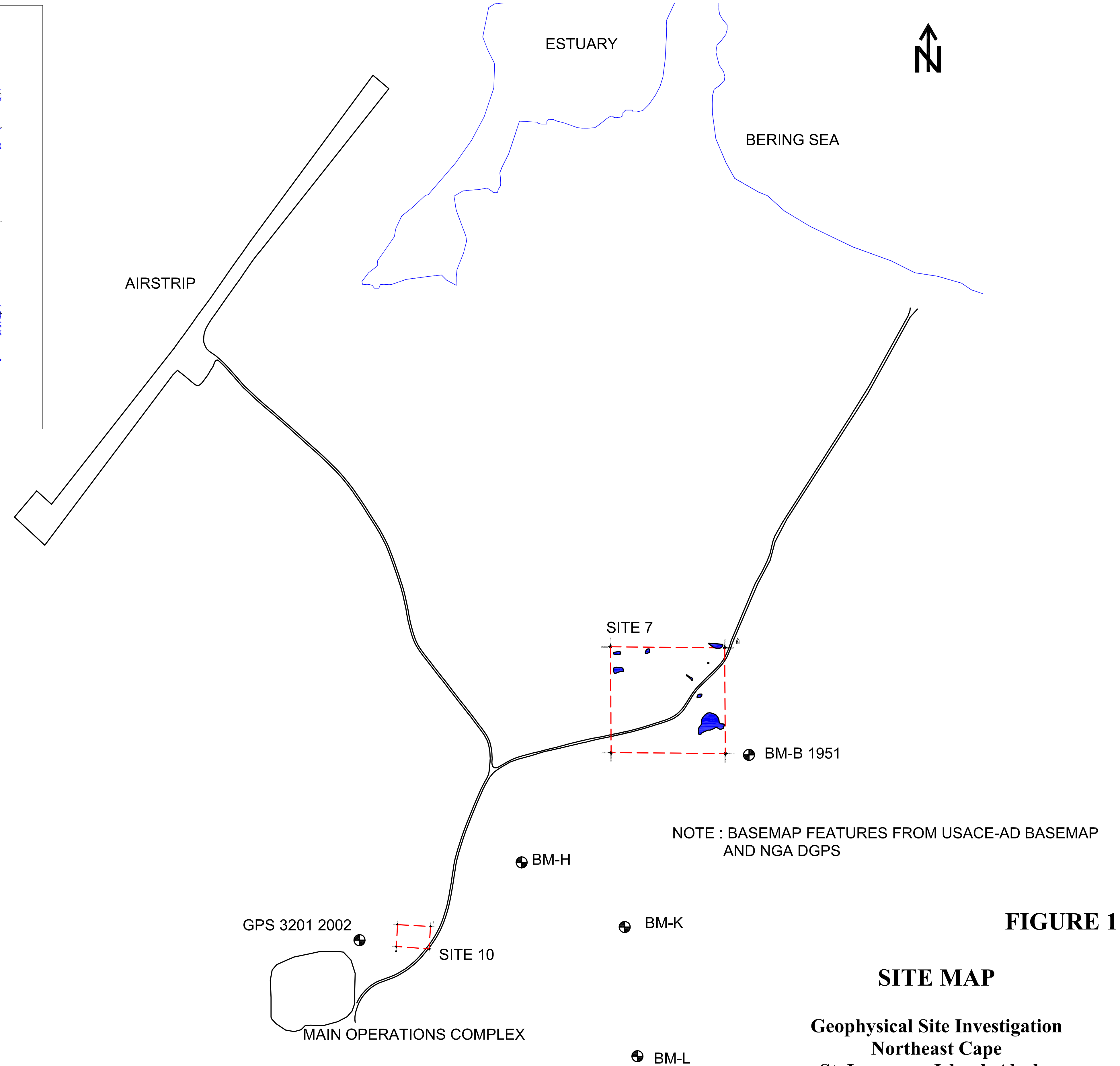
Northwest Geophysical Associates, Inc.

FOR Mark Villa
Project Geophysicist

CHR:MV:KJP *slv



SITE LOCATION



LEGEND

- SURVEY MONUMENT
- BENCH MARK
- GEOPHYSICAL SURVEY AREA

0 500 1000
U.S. SURVEY FEET

ALASKA STATE PLANE ZONE 9
NAD83 (CSRS98)

NOTE : BASEMAP FEATURES FROM USACE-AD BASEMAP AND NGA DGPS

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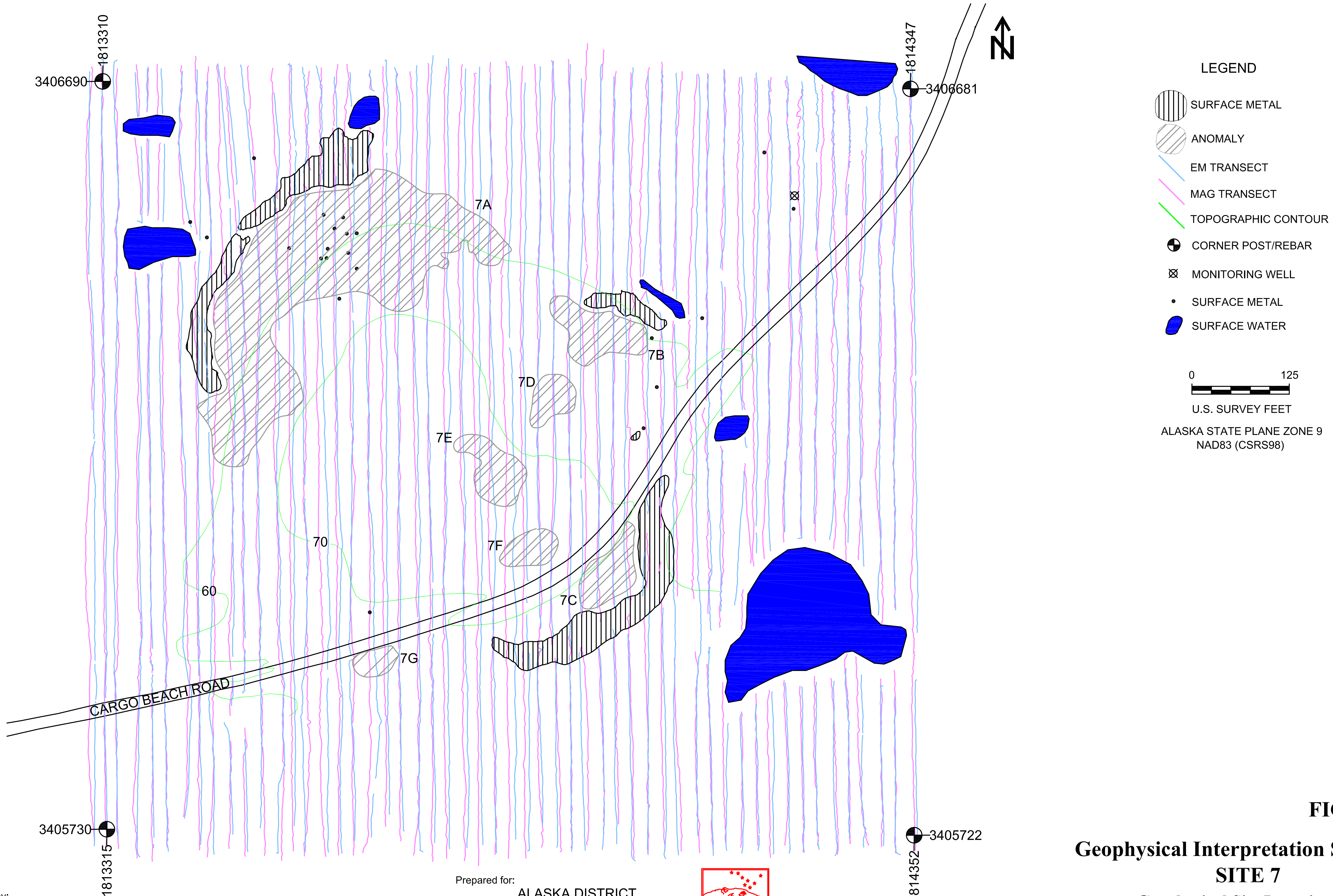
Prepared for:
ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA
CONTRACT # W911KB-05-D-0004 (D.O. 0012)

FIGURE 1

SITE MAP

Geophysical Site Investigation
Northeast Cape
St. Lawrence Island, Alaska

REVISION: B-SEPT20-07
DATE: AUGUST2007
FILE: ST_LAWRENCE.DWG
NGA PROJECT #: 644



REVISION: C-15-NOV-07

DATE: AUGUST2007

FILE: StLawrence.DWG

NGA PROJECT #: 644

FIGURE 2

Geophysical Interpretation Summary
SITE 7

Geophysical Site Investigation
Northeast Cape
St. Lawrence Island, Alaska

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NGA Project #: 644 FILE: STLAWRENCE DATE: AUGUST2007 REVISION: C:19—NOV—07

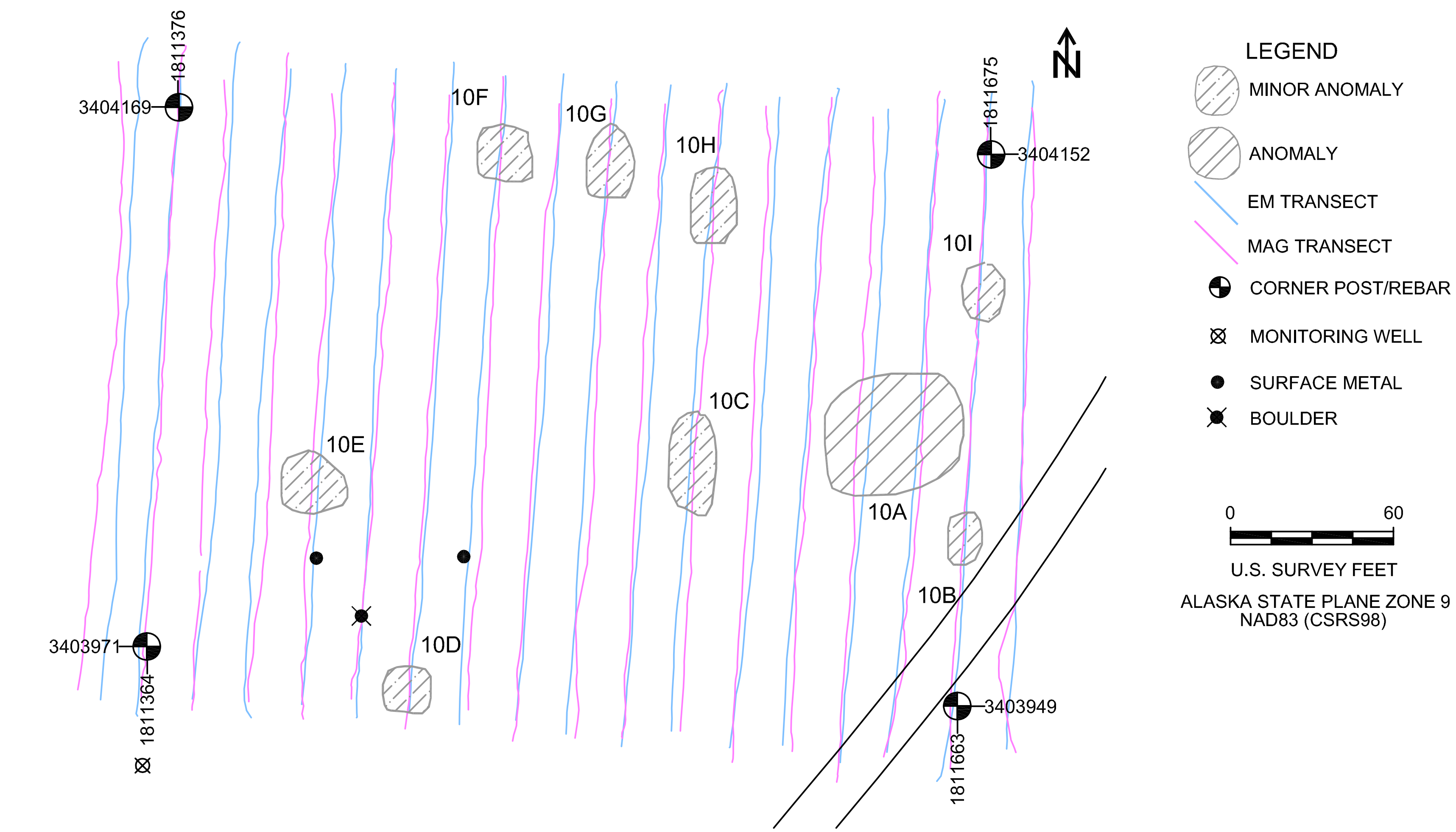

FIGURE 3

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Geophysical Interpretation Summary
SITE 10
Geophysical Site Investigation
Northeast Cape
St. Lawrence Island, Alaska

APPENDIX A

GEOPHYSICAL DATA PLOTS

REVISION: B-07OCTOBER07
DATE: AUGUST2007
FILENAME: SITE7_MAG_AS
NGA PROJECT #: 644

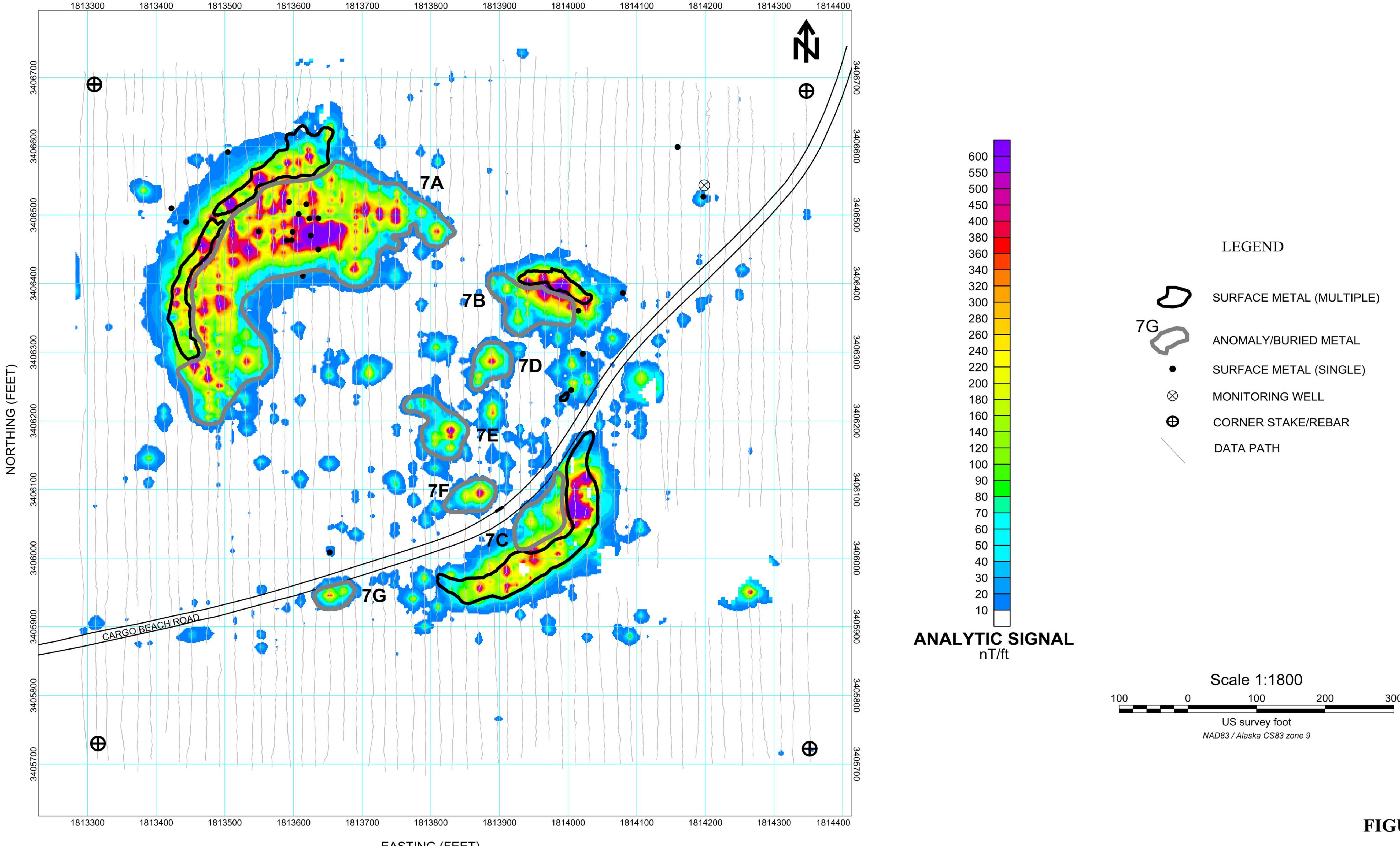

FIGURE A1

SITE 7
MAGNETIC ANALYTIC SIGNAL

Geophysical Site Investigation
Northeast Cape
St. Lawrence Island, Alaska

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REVISION: B-07OCTOBER07
DATE: AUGUST2007
FILENAME: SITE7_MAG_TOP
NGA PROJECT #: 644

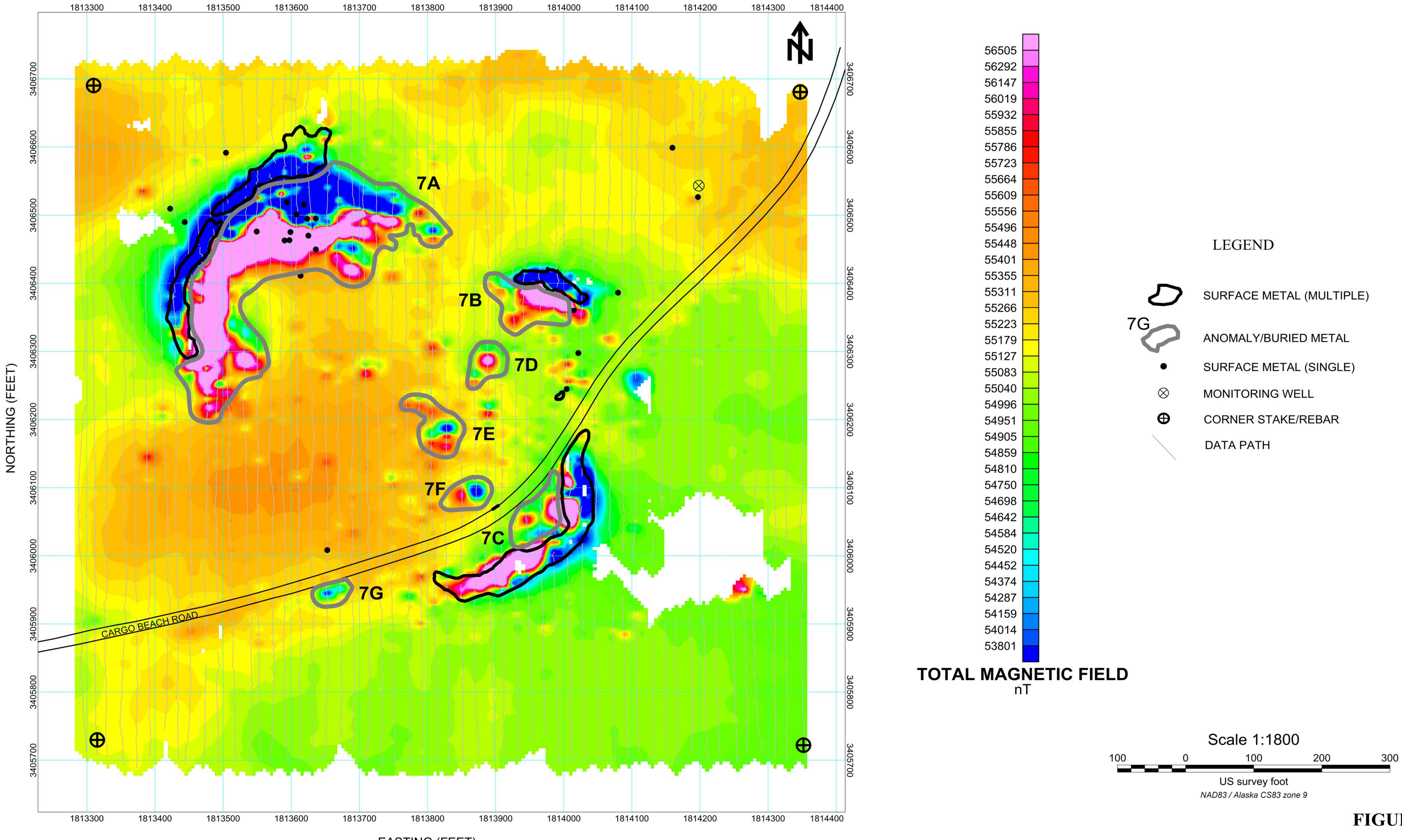

FIGURE A2

SITE 7
TOTAL MAGNETIC FIELD

Geophysical Site Investigation
Northeast Cape
St. Lawrence Island, Alaska

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DATE: AUGUST2007

FILENAME: SITE7_MAG_VG

NGA PROJECT #: 644

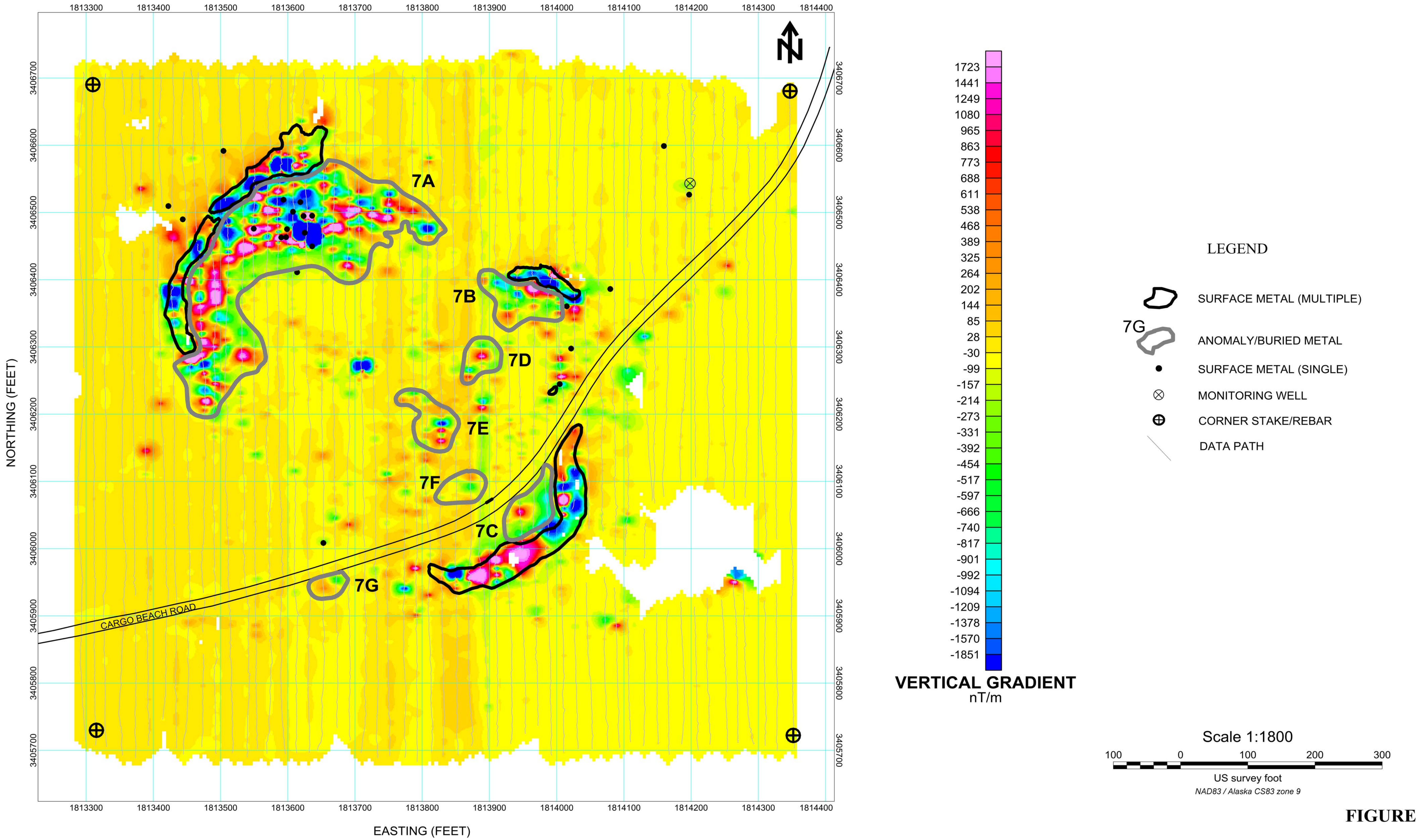

FIGURE A3

SITE 7
VERTICAL MAGNETIC GRADIENT

Geophysical Site Investigation
Northeast Cape
St. Lawrence Island, Alaska

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REVISION: B-7OCTOBER07
DATE: AUGUST2007
FILENAME: SITE7_EM_IP
NGA PROJECT #: 644

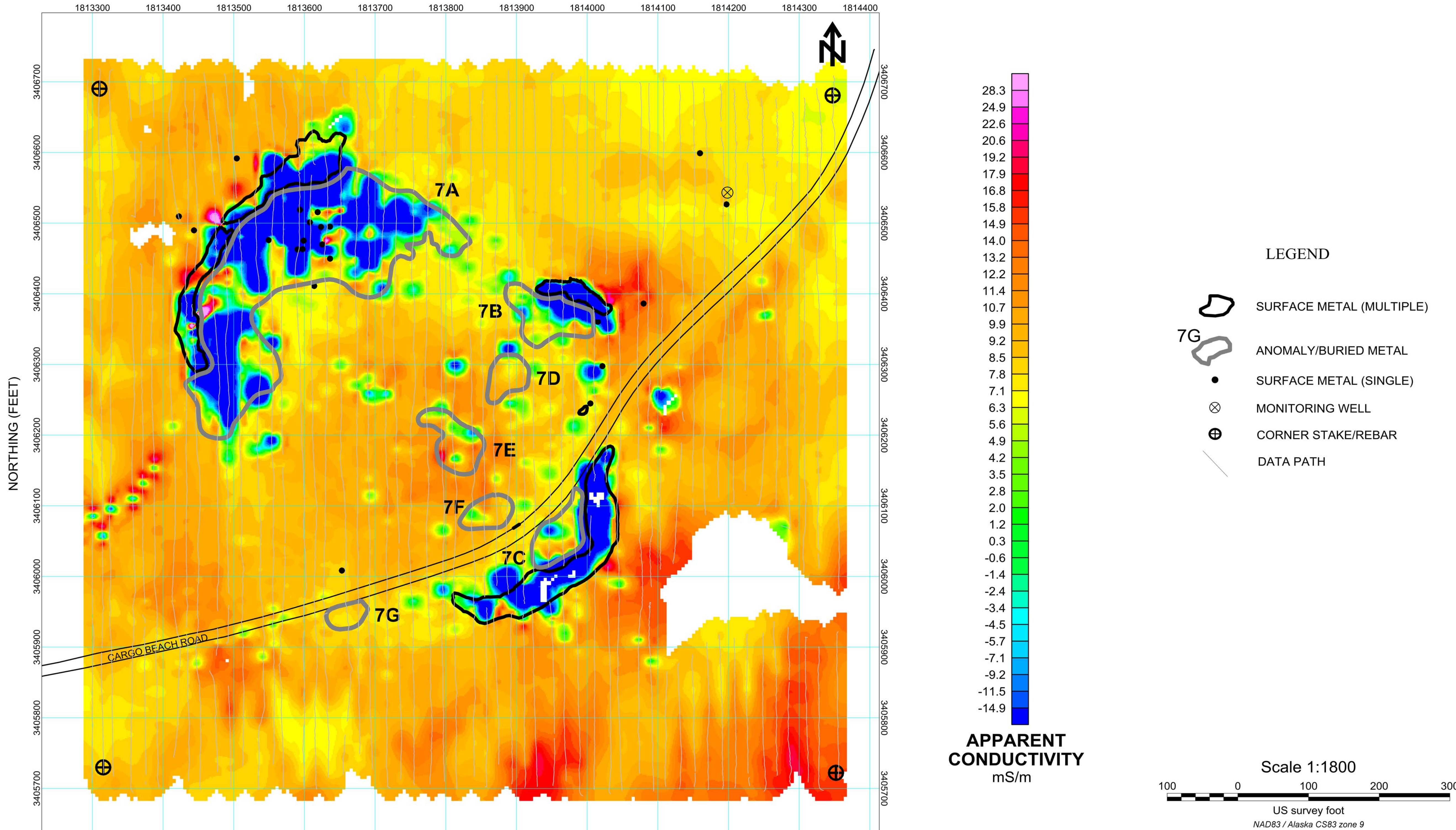

FIGURE A4

SITE 7
APPARENT CONDUCTIVITY

Geophysical Site Investigation
Northeast Cape
St. Lawrence Island, Alaska

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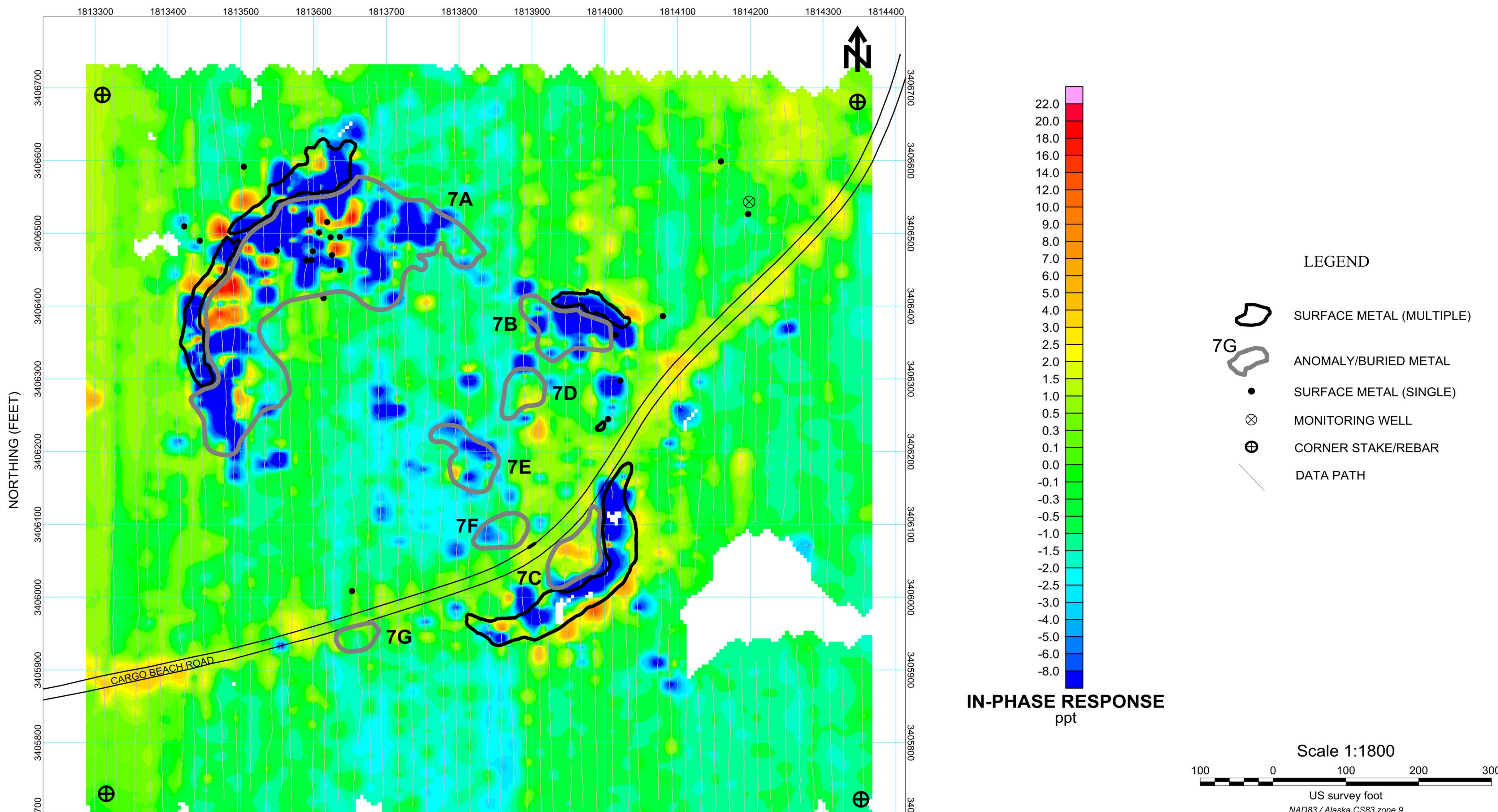

REVISION: B-07OCTOBER07
DATE: AUGUST2007
FILENAME: SITE7_EM_IP
NGA PROJECT #: 644

FIGURE A5

SITE 7
IN-PHASE RESPONSE

Geophysical Site Investigation
Northeast Cape
St. Lawrence Island, Alaska

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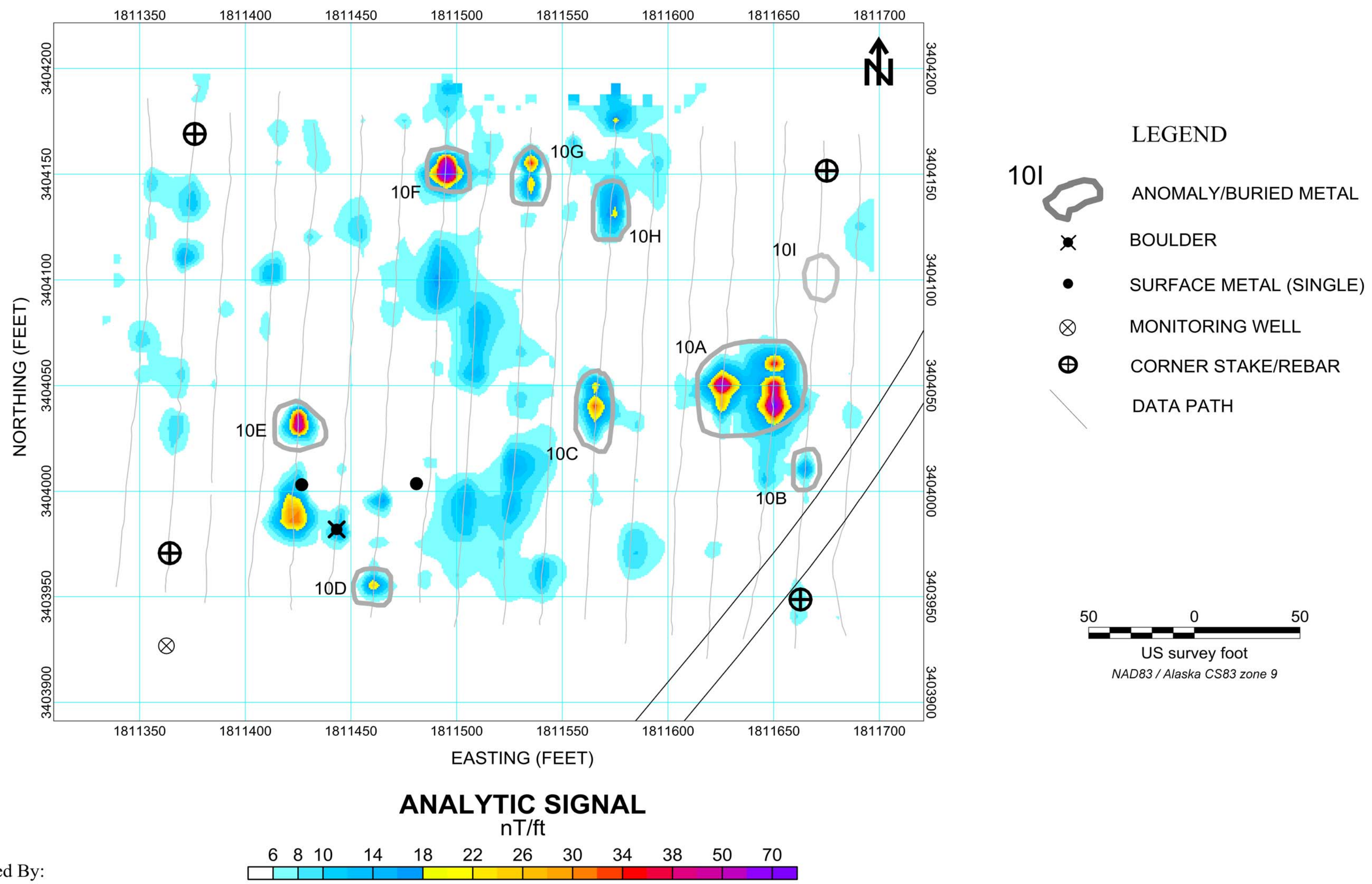
REVISION: B-07OCTOBER07
DATE: AUGUST2007
FILENAME: SITE10_MAG_AS
NGA PROJECT #: 644



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ALASKA DISTRICT
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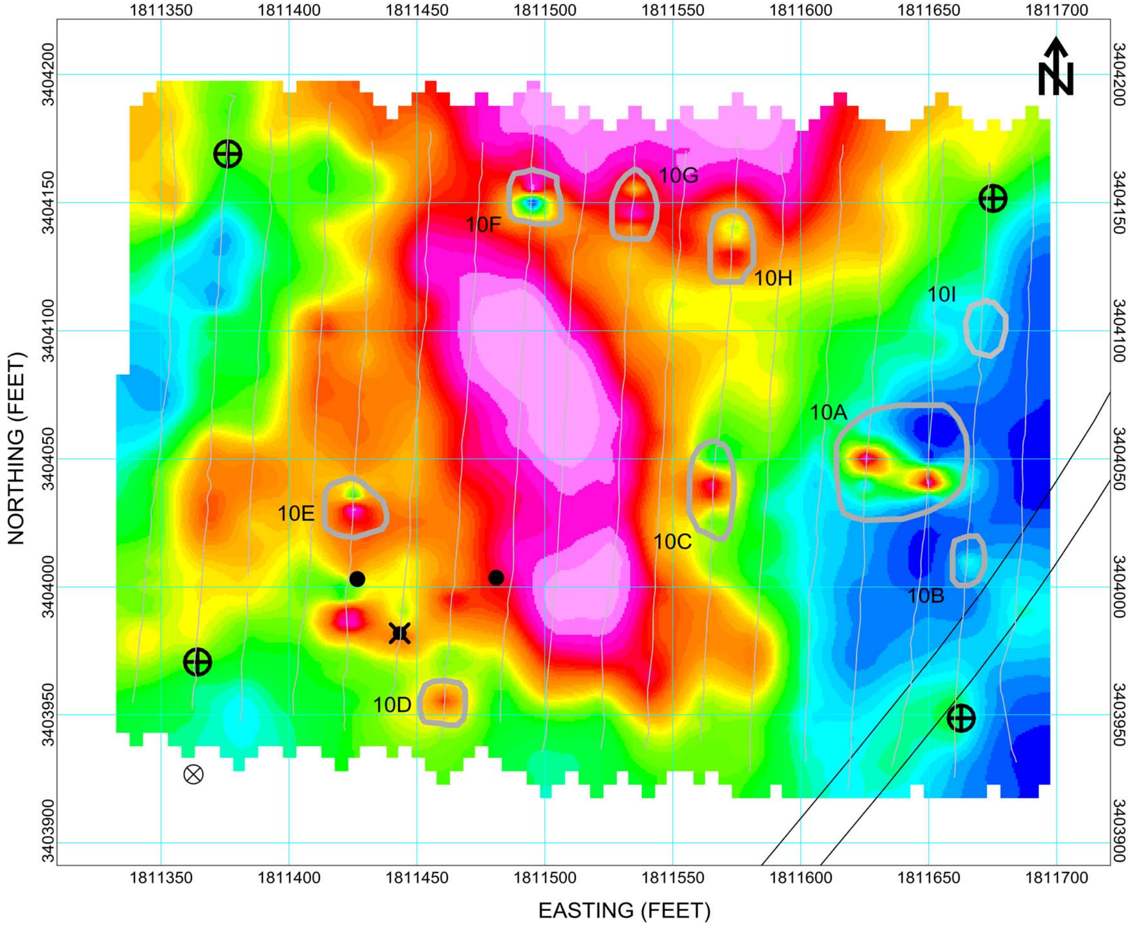
ANCHORAGE, ALASKA
CONTRACT # W911KB-05-D-0004 (DO 0012)

FIGURE A6

SITE 10
MAGNETIC ANALYTIC SIGNAL

Geophysical Site Investigation
Northeast Cape
St. Lawrence Island, Alaska

REVISION: B-07OCTOBER07
DATE: AUGUST2007
FILENAME: SITE10_MAG_TOP
NGA PROJECT #: 644



LEGEND

10I ANOMALY/BURIED METAL
BOULDER
SURFACE METAL (SINGLE)
MONITORING WELL
CORNER STAKE/REBAR
DATA PATH

50 0 50
US survey foot
NAD83 / Alaska CS83 zone 9

TOTAL MAGNETIC FIELD

nT

55051 55140 55183 55216 55250 55290 55361

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Northwest Geophysical Associates, Inc.

Submitted By:

R&M CONSULTANTS, INC.

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ALASKA DISTRICT
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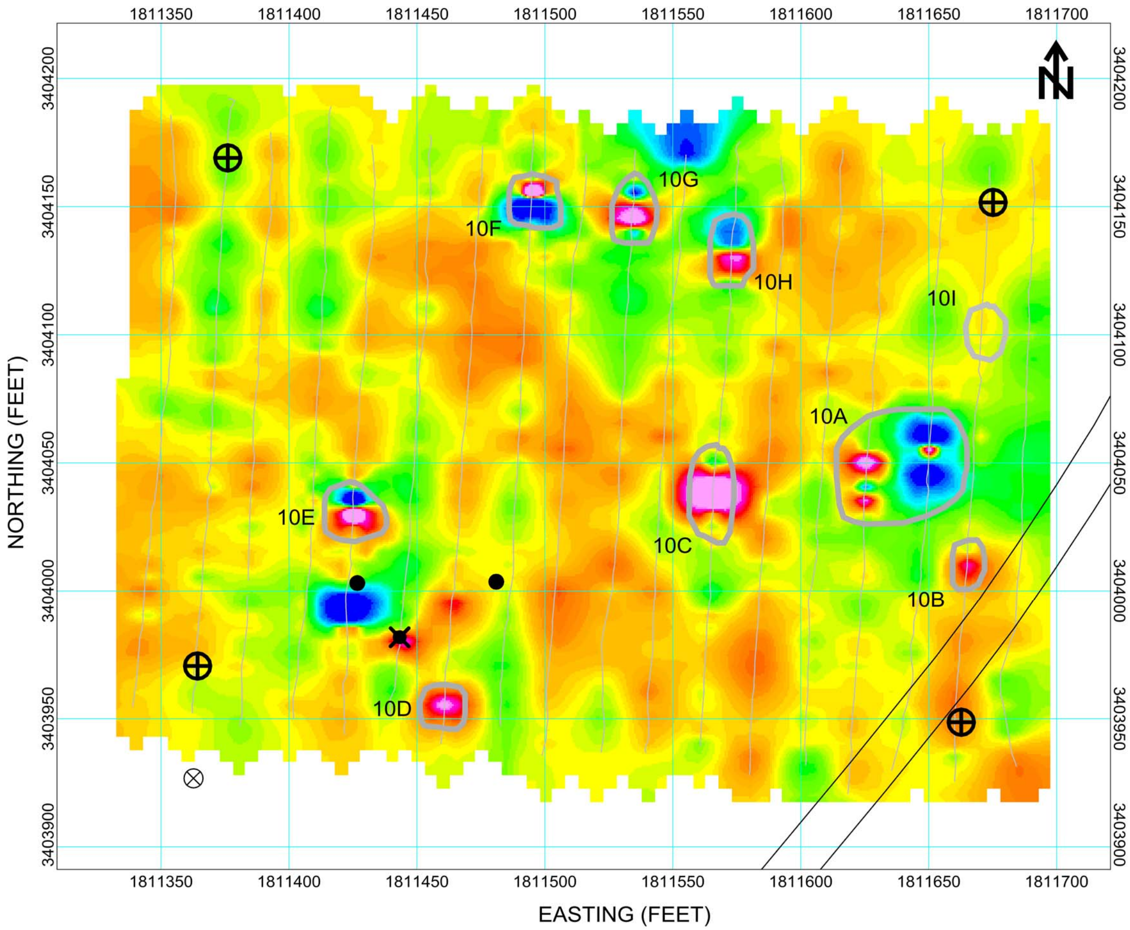
ANCHORAGE, ALASKA
CONTRACT # W911KB-05-D-0004 (DO 0012)

FIGURE A7

SITE 10
TOTAL MAGNETIC FIELD

Geophysical Site Investigation
Northeast Cape
St. Lawrence Island, Alaska

REVISION: B-07OCTOBER07
DATE: AUGUST2007
FILENAME: SITE10_MAG_VG
NGA PROJECT #: 644



LEGEND

10I ANOMALY/BURIED METAL

BOULDER

SURFACE METAL (SINGLE)

MONITORING WELL

CORNER STAKE/REBAR

DATA PATH

50 0 50

US survey foot

NAD83 / Alaska CS83 zone 9

VERTICAL GRADIENT

nT/m

-104 -48 -28 -11 4 12 25 39 52 67 83 103 159

Prepared By:

Northwest Geophysical Associates, Inc.

Submitted By:

R&M CONSULTANTS, INC.

Prepared For:

ALASKA DISTRICT
CORPS OF ENGINEERS
ANCHORAGE, ALASKA
CONTRACT # W911KB-05-D-0004 (DO 0012)

FIGURE A8

SITE 10
VERTICAL MAGNETIC GRADIENT

Geophysical Site Investigation
Northeast Cape
St. Lawrence Island, Alaska

REVISION: B-07OCTOBER07
DATE: AUGUST2007
FILENAME: SITE10_EM_Q
NGA PROJECT #: 644

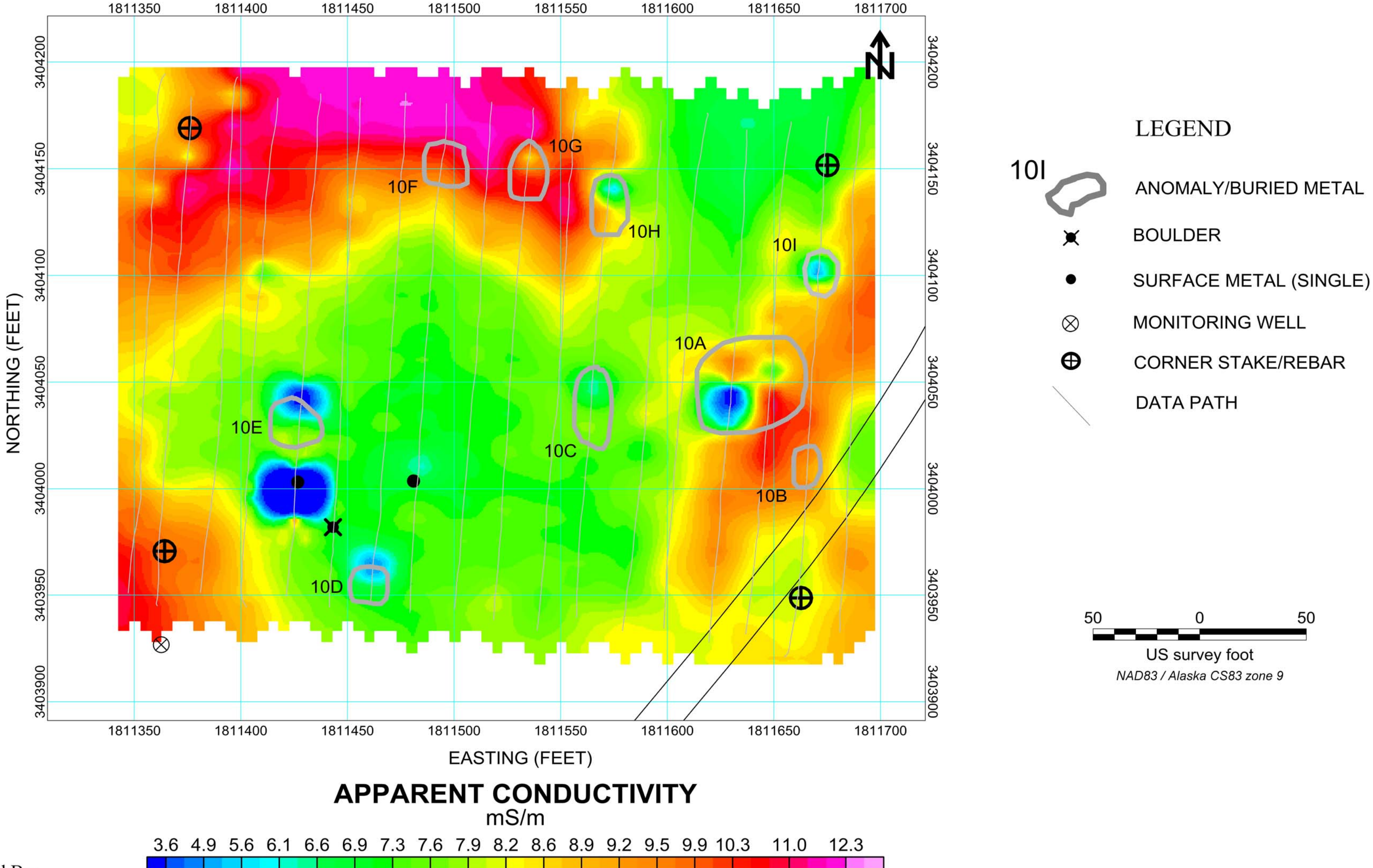


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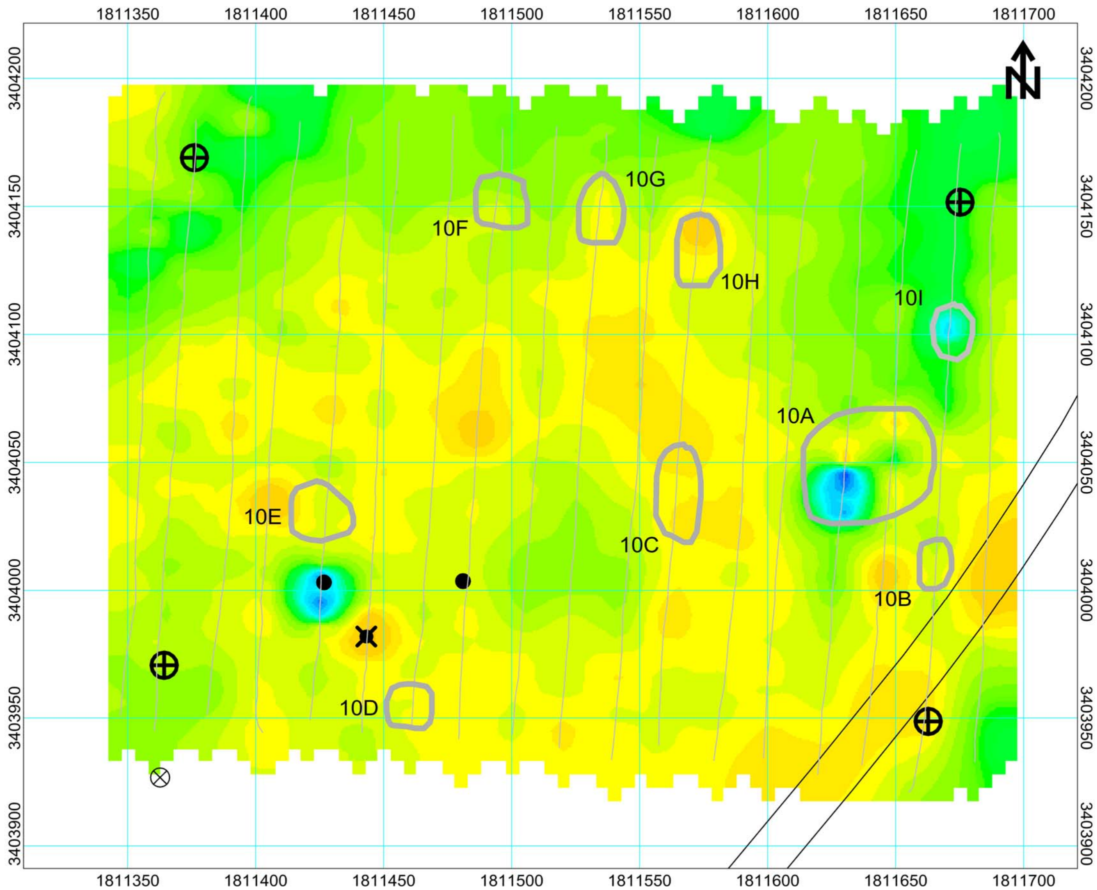
FIGURE A9

SITE 10
APPARENT CONDUCTIVITY

Geophysical Site Investigation
Northeast Cape
St. Lawrence Island, Alaska

REVISION: B-07OCTOBER07
DATE: AUGUST2007
FILENAME: SITE10_EM_IP
NGA PROJECT #: 644



LEGEND

10I ANOMALY/BURIED METAL

BOULDER

SURFACE METAL (SINGLE)

MONITORING WELL

CORNER STAKE/REBAR

DATA PATH

50 0 50

US survey foot

NAD83 / Alaska CS83 zone 9

IN-PHASE RESPONSE

ppt

-8.0 -4.0 -2.0 -0.5 0.0 0.3 1.0 2.0 3.0 5.0 7.0 9.0 12.0 18.0

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FIGURE A10

SITE 10
IN-PHASE RESPONSE

Geophysical Site Investigation
Northeast Cape
St. Lawrence Island, Alaska

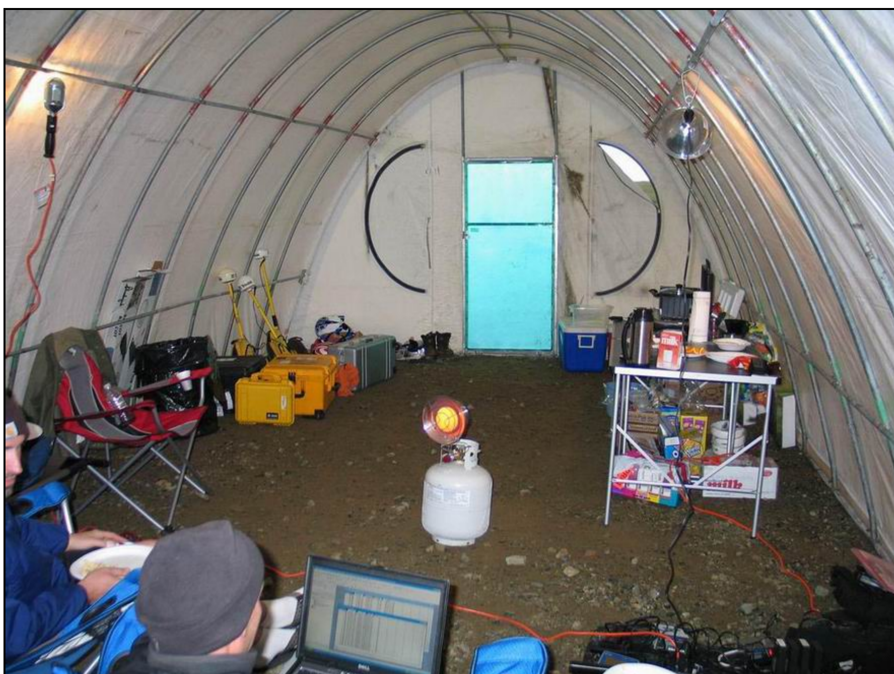
APPENDIX B

PHOTOGRAPHS

Mobilizing equipment and supplies in Nome.
(7 August 2007)

Ready to unload gear upon arrival at base camp.
(7 August 2007)

Erecting the Weatherport structure at base camp.
(7 August 2007)



Working and living conditions inside the Weatherport.
(9 August 2007)

GPS base station set up on Benchmark BM-B 1951.
(10 August 2007)

Performing time calibration of geophysical data loggers to GPS.
(8 August 2007)

Electromagnetic data collection underway at Site 10.
(8 August 2007)

Magnetic data collection underway at Site 10.
(8 August 2007)

Electromagnetic data collection underway at Site 7, looking south.
(9 August 2007)

Magnetic data collection underway at Site 7, looking southeast.
(9 August 2007)

Existing debris on the south side of the Site 7 mound, looking east.
(9 August 2007)

Simultaneous data collection underway at Site 7, looking southeast.
(9 August 2007)

APPENDIX C

FIELD NOTES

0809 TCAL 2

18:42:

	MAG	GPS
18:42: [redacted]	19	10
	:34	~~20~~ 25
	:	30
	:	45
	:	50
43	:	62

44:	15	10
	25	20
	35	30
	50	45
	55	50
45:	07	62

MAG needs

14 secs add

08/10/07 TCAL

MAG	GPS
18:40:09(.5)	10
:19	20
:29	30
:44	45
:49	50
18:41:01	62

Mac lags by :14 s.

SETTING UP BASE STATION
- NEW FILE SUBSECTION
  - NEW BASE DATA FILE
    - ANTENNA SETTINGS
    - LOGGING & GPS SETTINGS
    - REFERENCE POSITION

ANTENNA: 33580-50
0.85m TO BOTTOM MOUNT

LOGGING INTERVALS
1 SEC

REAL-TIME OUTPUT
OFF

REFERENCE POSITION
- COORDINATE SYSTEM

GPS 3201 2002
X 1810490.24
Y 3403890.97

3201
N 3404021.772
E 1811021.918
ALT 66.351

GPS BASE
GEOPLANE PROXRS W/ALLEGRO
012814

GPS ROVER 1
GEOPLANE PROXRS W/ALLEGRO
012627

GPS ROVER 2
NGA GPS #3

ROVER 2 TCAL 0808TCAL

10	15:24:09
20	:19
30	:29
40	:39
50	:49
60	:59

BASE SITE ∇10

~~080818A~~

BASE 080819A

RESET BASE TO

BENCHMARK B-195'

SEE PAGE 7

FOR R & M NOTES

FILE: BASE 080820B

SITE ∇10

EM: 31 FILE: SITE ∇10B

GPS FILE: SITE ∇10B

MAG:

GPS 80807SITE10B

BMB 1951

~~N [illegible]~~
~~E [illegible]~~

N 3405705.33
E ~~[illegible]~~814566.93
1

Lat. = N63° 18' 58.73795"
Long. = ~~E~~ 168°56' 27.08604"
W

Do ΔX, ΔY @ BMB
& apply those to corners
to get correct coordinates

Scale: 1 square=______

0809

0809ETCAL

10	11:49:10
20	:20
30	:30
40	:40
50	:50
62	50:63

0810

0810ETCAL

10	11:36:10
20	:20
30	:30
40	:40
50	:50
62	37:62

APPENDIX D

TECHNICAL NOTE

Geophysical Detection of Buried Objects

Ground Penetrating Radar

Electromagnetics *EM31*

Magnetics

Electromagnetics - *EM61-MK2*

COVER rev.4, JUNE 2006

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GEOPHYSICAL DETECTION OF BURIED OBJECTS

Revision June 2006

INTRODUCTION

Several geophysical techniques are used for locating buried objects such as underground storage tanks, pipes, utilities, drums and other debris. These techniques are used routinely, and are often recommended or required by state agencies, funding institutions and/or the EPA, particularly on sites where underground burial of steel drums or other debris may have occurred or where underground storage tanks are suspected.

Geophysics is generally used in the early reconnaissance phase of these investigations as a guide to sampling, excavation and/or placement of monitoring wells. In this paper we discribe three of the most common geophysical techniques, electromagnetics (EM), magnetics (MAG) and ground penetrating radar (GPR).

UTILITY OF GEOPHYSICS:

First, a few words about "geophysics" as used for environmental and geotechnical engineering applications. Surface geophysical techniques probe subsurface materials (soils and rock) using surface instruments. This is done by measuring physical signals which have interacted with the earth materials. These signals may be electrical, magnetic, acoustic (seismic) or electromagnetic.

Surface geophysics offers several advantages over other exploration techniques:

1) Surface geophysical methods are *"non-intrusive"* in that they do not disturb the ground surface, or stir up any contaminants which might be in the soil.

2) Geophysical methods *measure earth properties over a large volume*. Whereas drilling only samples the earth at the point of the borehole, the measured geophysical response is affected by earth materials several feet, or tens of feet, away from the instrument sensor. This allows broad areas to be effectively "screened" with a series of surface measurements.

3) Most geophysical equipment used in environmental and geotechnical applications *can be hand carried*. Geophysical surveys do not require vehicular access, but only a walking path, clear of brush and obstacles.

4) Geophysical surveys are relatively *inexpensive* and can be performed quickly.

TYPICAL OBJECTIVES:

Geophysics may be used in either the reconnaissance mode, or in a detailed survey mode. In the reconnaissance mode, geophysics is used to "screen" large areas to determine the presence or absence of buried objects. In more detailed surveys, the location and extent of the object is mapped in greater detail. This facilitates the efficient excavation of tanks or debris, aids the effective placement of monitoring wells, or improves the design of a sampling program.

The techniques discussed here are also useful for objectives other than identifying buried objects. Electromagnetic induction (EM) is especially useful in mapping changes in soil (e.g. sand or gravel channels), mapping clay aquitards and mapping contaminant leachate plumes in groundwater. GPR can be used to map shallow stratigraphy or to map zones of disturbed soils.

GEOPHYSICAL METHODS:

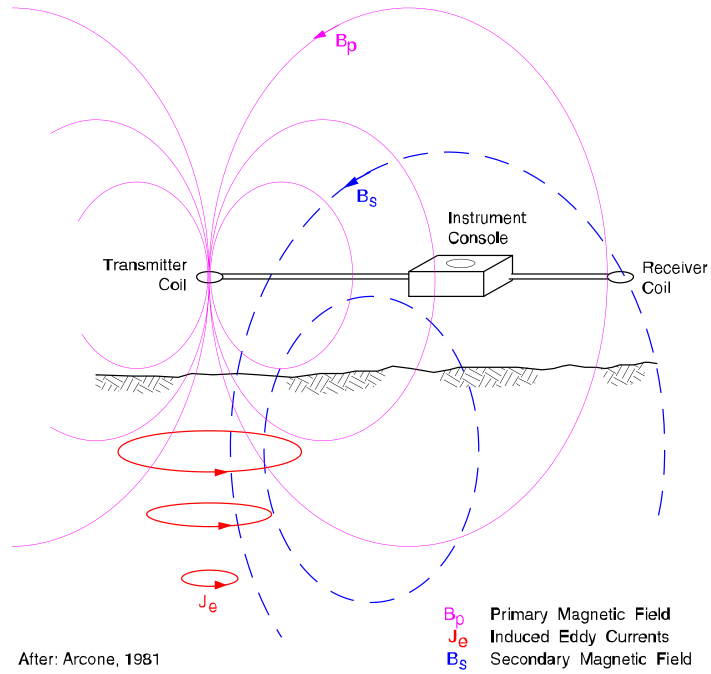
Three geophysical methods are commonly used in the search for buried objects: 1) electromagnetic induction (EM), 2) magnetics (MAG), and 3) ground penetrating radar (GPR). EM and magnetics are complementary methods, most effective in the reconnaissance mode but also useful for more detailed work. GPR is most effective for detailed work, but may also be used in reconnaissance surveys.

Electromagnetic Methods:

The electromagnetic induction (EM) technique measures the electrical conductivity of the earth by inducing a time varying electric current in the earth. This is shown schematically in Figure 1. The EM technique was developed to measure natural soil conductivity to aid in identifying soil types and to measure rock conductivity in order to identify zones of conductive mineralization.

FIGURE 1

PRINCIPLES OF ELECTROMAGNETIC INDUCTION



Man-made metallic objects are generally orders of magnitude more conductive than natural soils. Thus, the electric currents induced in the ground by EM instruments will be dramatically affected by the presence of any man-made metallic object. Examples include pipes, tanks, cables, concrete reinforcing steel, or steel drums. By looking for anomalous signals which cannot be attributed to natural soils, buried metallic objects can readily be identified.

Frequency-domain EM – EM31

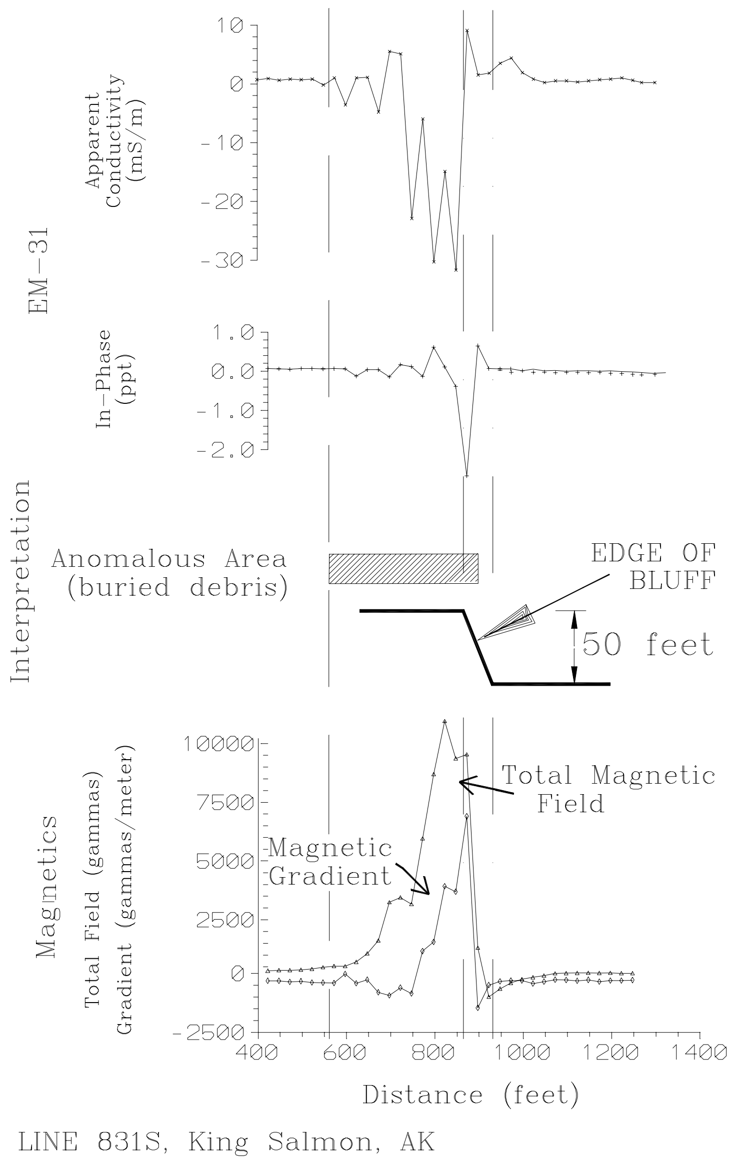
Frequency domain EM systems transmit a sinusoidal waveform at a fixed frequency, or multiple frequencies. The resulting secondary magnetic field may be phase shifted, depending on the nature of the target. Both the in-phase component (in phase with the primary magnetic field) and the quadrature phase component (shifted 90° from the primary field) can be measured to provide the phase shift information.

The Geonics EM-31 is a common frequency domain EM instrument, often used for buried object detection. The upper left photo on the cover shows the EM-31 in a field situation. A transmitter coil is in one end of the boom and a receiver coil in the other end. Depth of investigation is generally 10-15 feet, but the EM-31 may detect large metal objects at a somewhat greater distance. The instrument can quickly cover a wide area, mapping anomalous areas (metallic object locations) as well as changes in the soil character.

Figure 2 shows some sample data over a disposal site where 55 gallon steel drums had been dumped on the edge of a bluff and then covered with soil, extending the bluff for tens of feet (cross hatched block in Figure 2). The noisy and/or negative "apparent" conductivity is a clear indicator of metallic objects. The EM-31 also records an "in-phase response" which aids in identifying metallic conductors. Data in Figure 2 indicate the zone of burial extends from 560 feet to 940 feet along the line of the profile.

FIGURE 2

SAMPLE EM31 & MAGNETIC PROFILES



Time-domain EM – EM61

Time-domain EM systems transmit a magnetic pulse, with a duration in the order of 10s of micro-seconds (μs). That magnetic pulse induces electric currents in the ground as well as in any metallic object which is buried (or on the surface) within its range of influence. Currents induced in metallic conductors decay at a much slower rate than currents induced in the ground. Hence, metallic conductors can be easily identified.

The EM61-MK2 is a time domain metal detector manufactured by Geonics, Ltd., of Toronto, Canada. The EM61-MK2 instrument consists of two horizontal air cored coils, 1.0 meter by 0.5 meters in size. The bottom coil acts as a receiver and transmitter and the top coil as a receiver. The top coil is mounted 28 centimeters above the bottom coil. The instrument weighs about 75 lbs. and is pulled by one operator.

The Geonics EM61-MKII has 4 time gates, to measure the rate of decay of the signal, and two receiver coils, to measure the field gradient. The rate of decay is dependant on the size, shape, and orientation of the metallic object. Generally, they are used to estimate gross target parameters, but can be used for more detailed discrimination of targets, particularly in identifying unexploded ordnance (UXO) materials.

The two receiver coils are very helpful in the recognition of near surface objects from deeper objects. Since the amplitude of the response is highly dependent on the distance between the coil assembly and target, small near surface targets often produce a response orders of magnitude larger than targets having greater size at deeper depths. This masking effect form the near surface materials is drastically reduced by processing output of the two coils, essentially subtracting the bottom coil data from the top coil data. This is referred to as the differential mode or the differential signal.

Figure 3 shows some sample data over a 55 gallon steel drums partially buried, essentially flush with the surface of the ground. The response from the top and bottom coils is indicative of a substantial metallic presence. The relatively weak differential response is indicative of a shallow target.

FIGURE 3

EM61 & MAGNETIC PROFILES OVER PRATIALLY BURRIED 55 GALLON DRUM

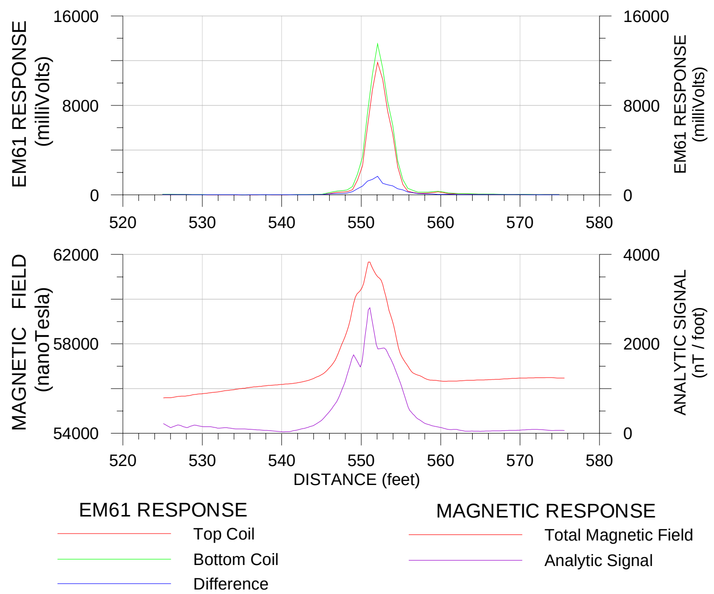
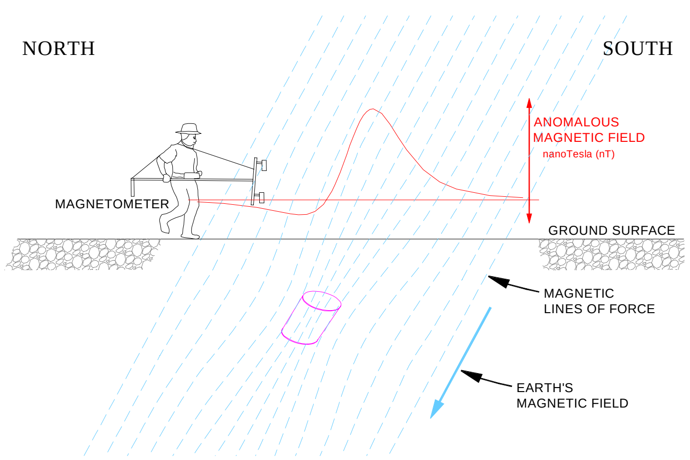


FIGURE 4

PRINCIPLES OF MAGNETIC EXPLORATION



Magnetic Methods:

Magnetic methods measure disturbances in the earth's natural magnetic field. These disturbances are caused by magnetic materials, either magnetic rocks, or man made objects containing iron or steel. This is shown schematically in Figure 4. Most soils have negligible magnetization (both induced and remanent). Thus, most magnetic disturbances from shallow sources can be attributed to iron or steel objects which have been placed there by man's activities.

Magnetometers used for buried object detection usually measure the gradient of the magnetic field. This is done by measuring the difference between the magnetic field at two sensors separated vertically by two or three feet. This configuration is more sensitive to nearby disturbances, and is less effected by disturbances caused by distant objects or shallow bedrock.

The upper right photo on the cover shows a magnetometer/gradiometer. This instrument can also cover wide areas quickly, providing complementary data to the EM. Figure 2 includes total magnetic field data and gradiometer data over the barrel disposal area. The large deviations in both total field and gradient are indicative of steel objects in close proximity.

Ground Penetrating Radar:

Ground penetrating radar (GPR), like other radar techniques, sends out an electromagnetic pulse (radio wave or microwave) which is reflected off a "target" and returns to the receiver. GPR operates at lower frequencies (80-500 MHz) than other radar to obtain better penetration in the earth materials. The antenna is pulled slowly along the ground surface to produce a continuous subsurface profile.

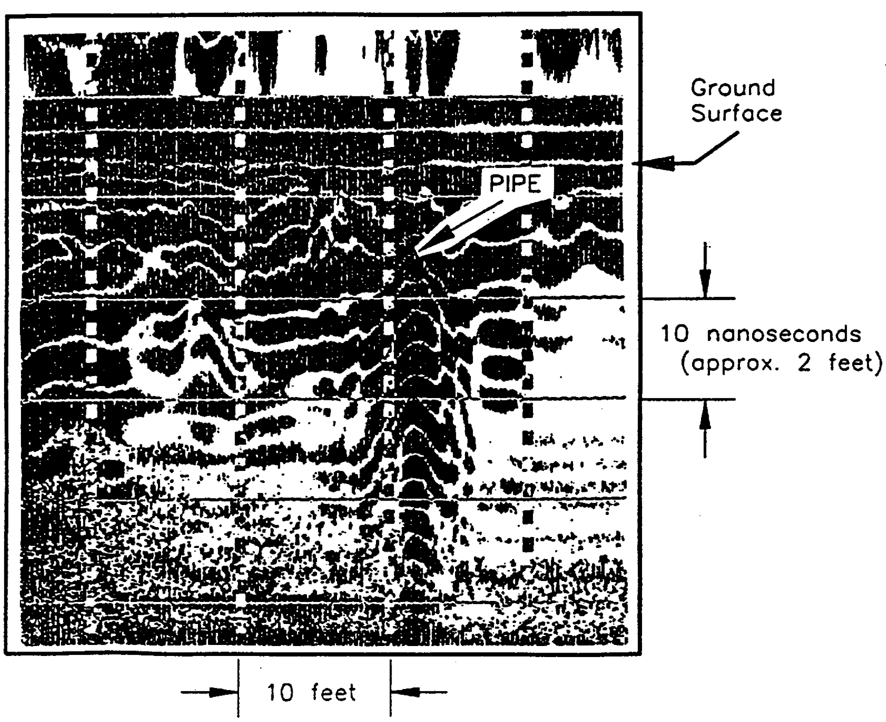
The lower photo on the cover shows a GPR unit in operation. The 500 MHz antenna shown is being pulled along the sidewalk. The control and recording unit, on the tailgate of the truck, is powered by a 12 volt automobile battery.

Figure 4 is an example GPR profile over a shallow pipe. The vertical scale is a time scale, giving the time for the radar pulse to travel down to the reflector and return to the receiver. Knowing the pulse velocity in the soils, we can convert this to depth. The horizontal scale corresponds to distance along the surface. Fiducial time marks on the record are placed at ten foot intervals. The pipe reflector shown appears as a hyperbola on the record. The pipe produces a strong reflection with a characteristic ringing of the electronics, which appears as a dark band below the first arrival from the pipe.

GPR is a tool for looking at selected areas in detail. Its continuous subsurface profiles give a graphic portrayal of subsurface conditions, and often provide an excellent means of accurately locating pipes and tanks. However, the GPR depth of exploration is strongly dependent on soil conductivity and subsurface conditions. In dry, sandy soils useful data may be obtained from depths down to 15 feet, whereas in conductive clay soils, investigation depth is often limited to two or three feet.

FIGURE 4

SAMPLE GPR PROFILE



DISCUSSION:

As we have stressed, EM and magnetics are effective in screening large areas quickly to identify areas where buried objects may be present. Often these techniques can provide a rough estimate of the size and depth of the object causing the anomalous readings.

The choice of frequency domain EM (i.e. EM31) versus time-domain EM (i.e. EM61) depends on the objectives and the site. The EM61 is very effective at identifying small pieces of metal (e.g. unexploded ordnance), and offers some depth and discrimination capability. It is also less sensitive to cultural noise (e.g. buildings, vehicles, etc.) than the EM31. The EM61 can often resolve anomalies which are close together, where the EM31 could not. However, the EM61 requires a tight line spacing, typically 1 meter, to assure the area is covered. Also, the wheeled cart is difficult or impossible to operate on some sites (the EM61 can also be carried on a shoulder harness but is very awkward).

The EM31 is favored over the EM61 on more open sites where the objective is to locate underground tanks, drums, or collections of debris. The broader sphere of influence of the EM31 allows it to be run on a coarser line spacing, typically 5-20 feet depending on the target.

A major limitation of both EM and MAG is their sensitivity to "cultural noise". Buildings, fences, metallic surface debris, and vehicles all create cultural noise. The EM and magnetic instruments respond to any metallic objects, whether buried or in plain view above ground. Thus, areas within 20 to 40 feet of buildings, vehicles or pipelines will be masked by the strong response from those objects. EM and magnetics will not be able to definitively identify other buried objects within that masked zone.

GPR on the other hand is fairly immune to those forms of cultural noise. The radar signal is confined to a broad beam, spreading at roughly a 45° angle, beneath the antenna. Most antennas are well shielded with little upward propagation of the pulse. Thus GPR can be run next to buildings, fences and parked vehicles. GPR may be run inside buildings and even over reinforced concrete.

Because the GPR beam is directional, it does not have the same utility as a reconnaissance tool as the EM and magnetics. Whereas the latter techniques would readily detect a large tank 10 or 20 feet off the survey line, GPR would not detect the tank unless the survey line passed directly over the tank.

CONCLUSIONS

No geophysical technique should be used without some form of "ground truth" by drilling, excavation, or some other form of sampling. The geophysical signature of an underground storage tank may be very similar to that of a buried automobile. However, geophysics can eliminate random drilling or extensive excavation when searching for underground tank or other materials.

To conclude, EM, magnetic and GPR techniques are effective, complimentary techniques used in the detection and delineation of subsurface metallic objects. The choice of technique or techniques depends very much on both site conditions and the survey objective.

FURTHER READING:

Benson, R.C., Glaccum, R.A., and Noel, M.R., 1982, Geophysical techniques for sensing buried wastes and waste migration: Report prepared by TECHNOS, Inc. for EPA, Advanced Monitoring Systems Division, Las Vegas, pp.235.

Evans, R.B., 1982, Currently avail-able geophysical methods for use in hazardous waste site investigations: from Risk Assessment at Hazardous Waste Sites, ACS symposium series No.204, p.93-115.

French, R.B., Williams, T.R., and Foster, A.R., 1988, Geophysical surveys at a superfund site, Western Processing, Washington: Proc. of SAGEEP, March 1988, Golden, Colorado, p.747-753.

McNeill, J.D., 1990, Use of electro-magnetic methods for groundwater studies: in Geotechnical and Environmental Geophysics, ed.: S.H.Ward, SEG, IG#5, p.191:218.

Romig, Phillip, 1992, Engineering and Environmental Geophysics Get Top Billing at SAGEEP.: The Leading Edge Vol. 11, No. 11, P.36-37.

Steeples, Don, 1991, Uses and Techniques of Environmental Geophysics: The Leading Edge, Vol.10, no.9, P.30-31.

DISCUSSION OF GEOPHYSICAL TECHNIQUES

GEOPHYSICAL DETECTION OF BURIED OBJECTS

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Revision: June 2006

Printed :July 14, 2006
File: b_b_teq_2006B.doc

APPENDIX E

REVIEW COMMENTS AND RESPONSES

PROJECT: Northeast Cape- FUDS **DOCUMENT:** Draft Geophysical Survey Report, October 2007
REVIEW COMMENTS **LOCATION:** Northeast Cape, St. Lawrence Island, Alaska

DATE: 10/18/07 **REVIEWER:** Carey Cossaboom **PHONE:** (907) 345-0401

Item No.	Location (page, par., sen.)	COMMENTS	Review A – Comment Accepted W – Comment Withdrawn N - Noted	R&M Consultants Response
1.	Pg. 3, Sec. 2.0	Please identify personnel. Naming visitors would be useful as well.		This will be included in the final report.

REVIEW COMMENTS **PROJECT: Northeast Cape F10AK096905** **DOCUMENT: *Draft* Geophysical Survey**
LOCATION: St. Lawrence Island, Alaska

REVIEWER: Lisa Geist, US Army Corps of Engineers, Environmental Engineering **PHONE: 907-753-5742** **DATE: October 29, 2007**

Item/ Code.	Page/Para	COMMENTS	REVIEW CONFERENCE	RESPONSE	USAED RESPONSE
1.	General	Photographs of the actual field work should be provided in an appendix. Field notes should also be provided in an appendix.		Photographs will be included in an appendix. NGA's field notes will be included in an appendix. Copies of R&M's hand written daily field reports will be included with the submittal, but not appended to the report.	
2.	General	Figures 2 and 3 should be provided electronically in native format, such that the interpreted polygons (surface metal and anomalies) can be plotted independently by USACE. Are these features available as a georeferenced AutoCAD drawing file, or ESRI ArcGIS shapefile? The surface area of the combined features will be needed for estimating purposes during a feasibility study. The addition of topographic contours lines or an outline of the raised areas would be helpful on Figure 2.		AutoCAD drawing files, and shape files will be included in the final submittal. Topographic contour will be added to Figure 2.	
3.	Section 2.0	A brief summary of field conditions and logistics should be provided in the opening paragraph of section 2.0. E.g. – site access (charter plane, ATVs, etc), camp setup (weatherport, tents, etc), weather (sunny, rain, fog, etc), site visitors, etc. Any major deviations from the workplan should be noted.		This will be added to the final report	
4.	Section 4.1, Page 7	The cardinal directions referred to throughout this discussion appear wrong. Please verify the correct Anomaly # and descriptive locations (south, west, northeast, etc.). Examples: Anomaly 7A appears to lie south and *east* of the surface debris on the *northwest* slope of the topographic rise located along (*west*) of Cargo Beach Road. Anomaly 7B lies to the south of the surface debris on the *northeast* slope of the hill at the center of Site 7. Anomaly 7C lies to the north of the surface debris on the *southeast* slope of the hill on the *eastern* side of Site 7.		These corrections will be made in the final report.	
5.	General, and Section 4.2	It may be useful to indicate in the text some magnitude of size for the various anomalies at both Site 7 and 10. Approximate surface area, width, etc. The characterization of Anomaly 10A as a major anomaly seems inconsistent with the descriptions when compared to Site 7. Suggest deleting the word "major".		The data do not support further quantification of the size of the anomalies. The magnitude of the anomalies is a function of the size, mass and depth of the object.	

Item/ Code.	Page/Para	COMMENTS	REVIEW CONFERENCE	RESPONSE	USAED RESPONSE
				The word major will be deleted, and we will add: "the amplitude of the target is sufficient to represent one or more 55-gallon drums"	