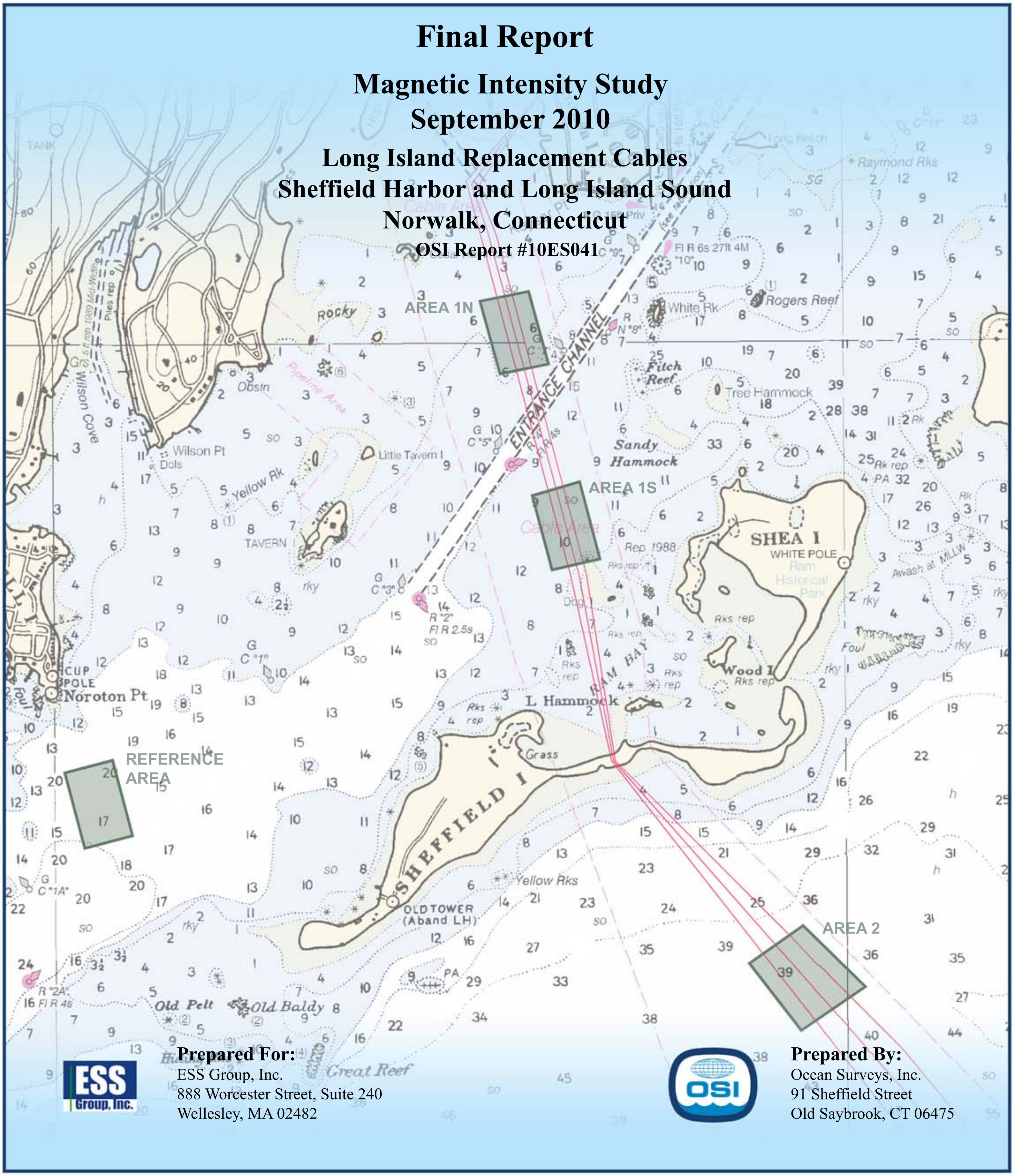
Final Report

Magnetic Intensity Study
September 2010

Long Island Replacement Cables
Sheffield Harbor and Long Island Sound
Norwalk, Connecticut

OSI Report #10ES041



Prepared For:
ESS Group, Inc.
888 Worcester Street, Suite 240
Wellesley, MA 02482

Prepared By:
Ocean Surveys, Inc.
91 Sheffield Street
Old Saybrook, CT 06475

FINAL REPORT

MAGNETIC INTENSITY STUDY
SEPTEMBER 2010

LONG ISLAND REPLACEMENT CABLES
SHEFFIELD HARBOR AND LONG ISLAND SOUND
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1.0 INTRODUCTION

During the period 7 to 9 September 2010, a magnetic field intensity study was conducted by Ocean Surveys, Inc. (OSI) in and around Sheffield Harbor, Norwalk, CT, and in a portion of Long Island Sound. This task was part of a monitoring program designed to assess the potential environmental effects of the Long Island Power Authority (LIPA)/Connecticut Light and Power Company (CL&P) Long Island Replacement Cable Project ("LIRC" or "Project") which extends from Norwalk, CT to Northport, NY in Long Island Sound. The Project involved the replacement of seven fluid-filled submarine transmission cables installed in 1969, with three new solid-core dielectric copper conductor cables.

The results included in this report are a component of the Monitoring and Mitigation Plan required by regulatory agencies overseeing the Project. The Connecticut Department of Environmental Protection (CTDEP) and the Connecticut Siting Council (CSC) have required CL&P to monitor the effect of the Project on the seafloor and shellfish resources by conducting an investigation after the completion of construction. The U.S. Army Corps of Engineers (USACE) also has a parallel requirement.

The study was performed in three previously established monitoring areas and designated reference area, as shown in Figure 1. This project was performed under contract with ESS Group, Inc. (ESS), on behalf of the LIRC owners and operators, as part of the monitoring program. Please refer to OSI Report #07ES077.5A (December, 2009) "Twelve-Month Post-Construction Seafloor Mapping Survey - A Component of the Benthic Monitoring Study for the Long Island Replacement Cable Project Summer 2009" for further information regarding project background and other aspects of the monitoring program.

The objective of this study was to measure the earth's total magnetic field in the vicinity of the LIRC. This survey followed the same methodologies established for a previous study conducted in the same areas in November 2009 (OSI Report #09ES074). The results of these studies may be used in future modeling efforts, along with other information to estimate the local effect, if any, of the power cables as well as monitor changes in the detected magnetic fields over time.

1.1 Project Tasks

To meet the project objective, the following tasks were undertaken:

- **Marine Magnetometer Survey:** to measure the local magnetic field in the area of the LIRC

- **Base Magnetometer Readings:** to measure the earth's background magnetic field, including diurnal variations, during the time of the marine magnetometer survey

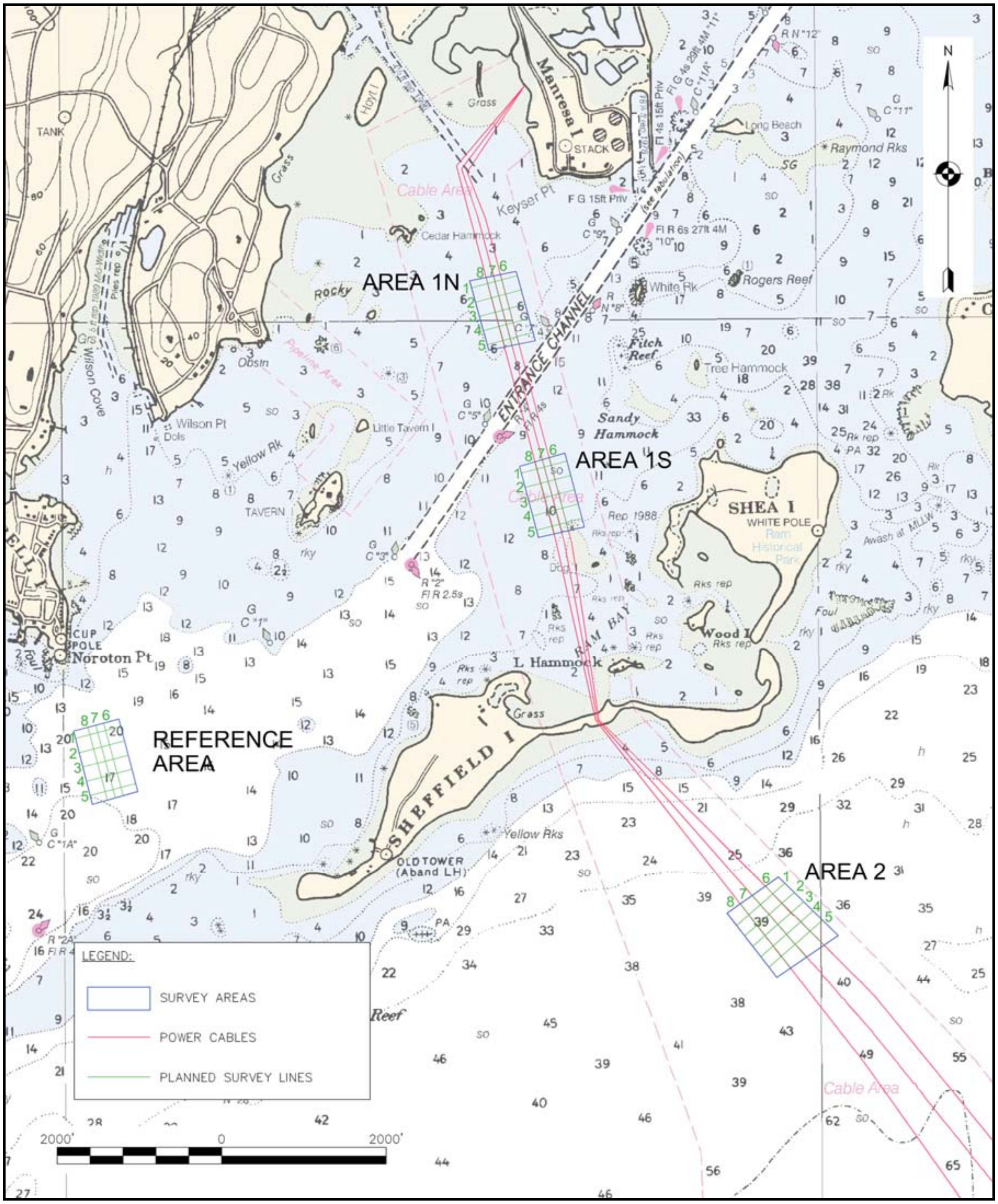


Figure 1. Location map showing the marine magnetometer study areas and generalized survey trackline layout (NOAA Chart #12368 in background).

2.0 SURVEY SUMMARY

2.1 Survey Plan

The four study areas are located in Connecticut waters in the vicinity of Sheffield Island as shown on Figure 1; two areas north of Sheffield Island (Areas 1N and 1S), one area south of Sheffield Harbor in Long Island Sound (Area 2) and one area to the west of Sheffield Island, south of Noroton Point (Reference Area). Areas 1N, 1S, and the Reference Area each measure approximately 600 x 900 feet, and Area 2 is 800 x 1,000 feet. Areas 1N, 1S and 2 are oriented with the long axis parallel to the orientation of the cables through each area. The areas are the same as those surveyed during the November 2009 study.

In Areas 1N, 1S and 2, five tracklines oriented perpendicular to the power cables (Lines 1-5) and three lines oriented along the cable alignments (Lines 6-8) were planned. In the Reference Area, tracklines were run using the same spacing and orientation as the tracklines in Area 1N (Figure 1). Each trackline was surveyed twice, once with the magnetometer sensor towed close to the surface ("shallow tow") and once with the tow depth 8-10 feet deeper ("deep tow"). In an effort to provide a consistent data set, the survey vessel transited along each trackline in the same direction for each tow depth (from the west for Lines 1-5; from the south for Lines 6-8).

2.2 Horizontal Control

Navigation and horizontal positioning of the survey vessel were accomplished using a Differential Global Positioning System (DGPS) interfaced to a navigation computer running HYPACK navigation and logging software. Geodetic position data (latitude, longitude) output by the DGPS were converted by HYPACK in real time to feet referenced to the New York State Plane Coordinate System, Long Island Lambert (Zone 3104), NAD83. Navigation checks were performed periodically to ensure the DGPS navigation met the position accuracy stated by the manufacturer (±1 meter).

2.3 Survey Crew

The following personnel comprised the OSI project team assembled to perform this investigation:

Robert H. Otto	Geophysical Project Manager
John R. Ayer	Electronics Technician

ESS representative Mark Driscoll met the crew onsite on 9 September 2010 and observed field operations.

2.4 Survey Equipment and Vessel

The following summarizes the instrumentation used for this survey. A complete discussion of this equipment, along with the operational procedures employed to collect the data for this project, can be found in Appendix 1.

- Trimble Differential Global Positioning System
- HYPACK Navigation Software
- Geometrics G882 Cesium Marine Magnetometer (10 per second sample rate) equipped with a depth sensor and altimeter
- Geometrics 881 Base Station Magnetometer

The above equipment was mobilized aboard the *R/V Able*, a 27-foot vessel with twin 115 HP outboard engines, electric winch and davit for handling towed sensors, and a watertight cabin for housing survey electronics (Figure 2).

Figure 2. Photograph of the *R/V Able*.

A base station magnetometer was installed at OSI headquarters in Old Saybrook, Connecticut. The base station recorded the earth's background magnetic field once per minute throughout the investigation. The system performance was monitored daily and the data were downloaded following completion of the field investigation.

2.5 Summary of Field Operations

The following information provides a general chronology of events for this study.

Field Program Chronology

Task	2010 Dates	Description
Mobilization	1-3 September	Load, mount, and test all survey equipment
Travel to Site	7 September	Survey vessel and crew transit to Norwalk, CT
Survey Operations	7 September	Field operations begin onsite calibrations. Complete shallow and deep tow surveys, Reference Area
Survey Operations	8 September	Complete shallow and deep tow surveys, Areas 2 and 1S
Survey Operations	9 September	Complete shallow and deep tow surveys, Area 1N
Return Travel	9 September	Vessel and crew travel back to Old Saybrook, CT

3.0 DATA PROCESSING AND PRODUCTS

Upon completion of the field investigation, the marine magnetometer and base station magnetometer data were processed and reviewed. The marine magnetometer data were processed to remove erroneous points and adjusted to remove any diurnal variation based on the base station magnetometer readings. For a more detailed description of the processing methods, see Appendix 2. Profiles were generated for Lines 1-5 in each area and then analyzed to identify anomalies. An anomaly is defined as a local disturbance in the earth's magnetic field, likely caused by the presence of ferrous material. Anomalies as small as 10 gammas, detected over 15 feet (measured along trackline) have been identified in magnetometer data. The following table summarizes the products generated.

Data Set	Presentation
Marine magnetometer data along tracklines 1-5 in each area	Profiles are presented in Appendices 3-6 with the shallow tow and deep tow data color-coded. ASCII files containing X,Y, Gamma, Sensor Height for each reading are included on an accompanying data disk.
Marine magnetometer data along tracklines 6-8 in each area	ASCII files containing X,Y, Gamma, Sensor Height for each reading are included on the data disk.
Base station magnetometer data	Time series are presented graphically in Figure 5. ASCII file containing Date/Time, Gamma is included on the data disk.

4.0 LIRC BACKGROUND INFORMATION

The following information is provided to gain a better understanding of the cables and existing on-site conditions.

Cable Composition

The cables are comprised of 3-core AC power cables along with fiber optic elements within a steel tube. These elements are sheathed in lead and semi-conductive layers with an outer diameter of 235 mm (Figure 3). (www.Nexans.com)

Figure 3. Cross section of LIRC Cable.

Cable Burial Depth

Cable burial depth information was provided by Nexans (28536-EIT-XM-203799, Charts 9 and 10) and is included in original PDF format on the accompanying data disk. A tabular listing of burial depths based on stationing, provided by ESS is also included on the data disk.

Cable Armoring

The Connecticut Light and Power Company (CL&P), through ESS, provided information regarding the use and location of split pipe protectors to "armor" the cable. As illustrated in Figure 4, split pipe protectors are present on Cables 2 and 3 in the southern portion of Area 1S but are not present within Area 1N and Area 2. The cable armoring data were originally provided in tabular format by ESS, included as part of the burial depth tables provided on the data disk.

Power Transmission

Power loads in each cable were provided by CL&P as a time series covering the period 7-9 September. These data are included in their original excel spreadsheet format on the accompanying data disk. According to CL&P, Cable 1 was not transmitting power during the survey and has been out of service since May 2009. Average power and electrical current values are summarized in the following table:

	Cable 1[1,2]	**Cable 2[1]**	**Cable 3[1]**
Average Electrical Current in Amperage (AMP)	0.0	175.2	174.1
Average Power in Mega Volt Amperes (MVA)	0.0	43.4	43.2

[1]Power transmission as provided by CL&P
[2]Cable 1 not transmitting power during survey period and was reported as 0 by CL&P

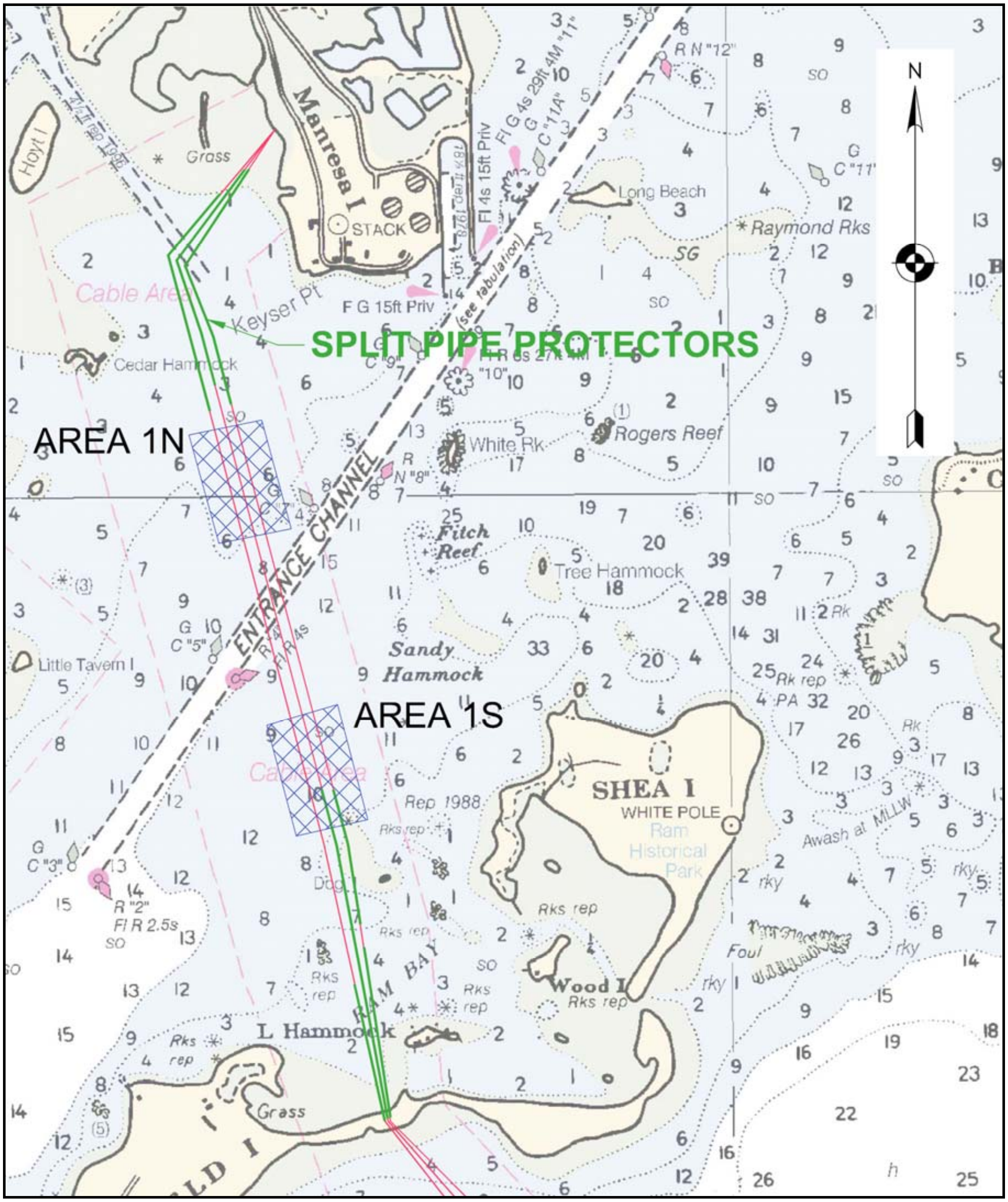


Figure 4. Extent of split pipe protection (shown in green) created from data provided by ESS.

5.0 SURVEY RESULTS

The following sections present the results of the base station magnetometer measurements and the marine magnetometer surveys conducted by OSI as part of the ongoing monitoring program for the LIRC project. Magnetic field measurements are expressed in gammas. It should be noted that 1 gamma = 10^{-5} gauss = 1 nano-tesla.

5.1 Baseline Magnetometer Data

The base station magnetometer was started several days before the marine surveys began and continued recording for several days after field surveys were completed. Figure 5 is a plot of the base station data for an eight-day period. Throughout the entire period the earth's magnetic background field varied by approximately 59 gammas. It took approximately 55-60 minutes to acquire data for a given tow depth, during which, the variation of the earth's magnetic field typically varied less than 15 gammas. These small differences in background are generally related to diurnal variation in the earth's magnetic field and had little to no impact on the survey data.

5.2 Marine Magnetometer Surveys

The main purpose of the marine magnetometer surveys was to measure and document the earth's magnetic field in the vicinity of the LIRC. Survey lines 1-5, run perpendicular to the cable alignments in each site, provided the optimal orientation for detecting short-duration anomalies interpreted to be related to the cables. It is important to note that the amplitude of an anomaly is related to the distance the magnetometer sensor is from the object generating a disturbance in the background magnetic field. For submarine cables, the total distance is equal to the sensor height above the seafloor plus the cable burial depth. Acquiring magnetometer data at two different tow heights allows for comparison of different amplitude anomalies generated by the same mass at two known distances. To maximize the differences in amplitudes of the cable anomalies between shallow and deep tow surveys, particularly at the shallow water sites, surveys were performed around periods of high tide (to enable a greater distance between sensor tow heights). As summarized below, anomalies were detected at the cable locations for each tow depth along Lines 1-5 for Areas 1N, 1S, and 2. Other isolated anomalies, not associated with the cables were also detected along several tracklines. For discussion purposes the cables have been designated Cable 1, Cable 2 and Cable 3 from west to east.

BASE STATION MAGNETOMETER DATA

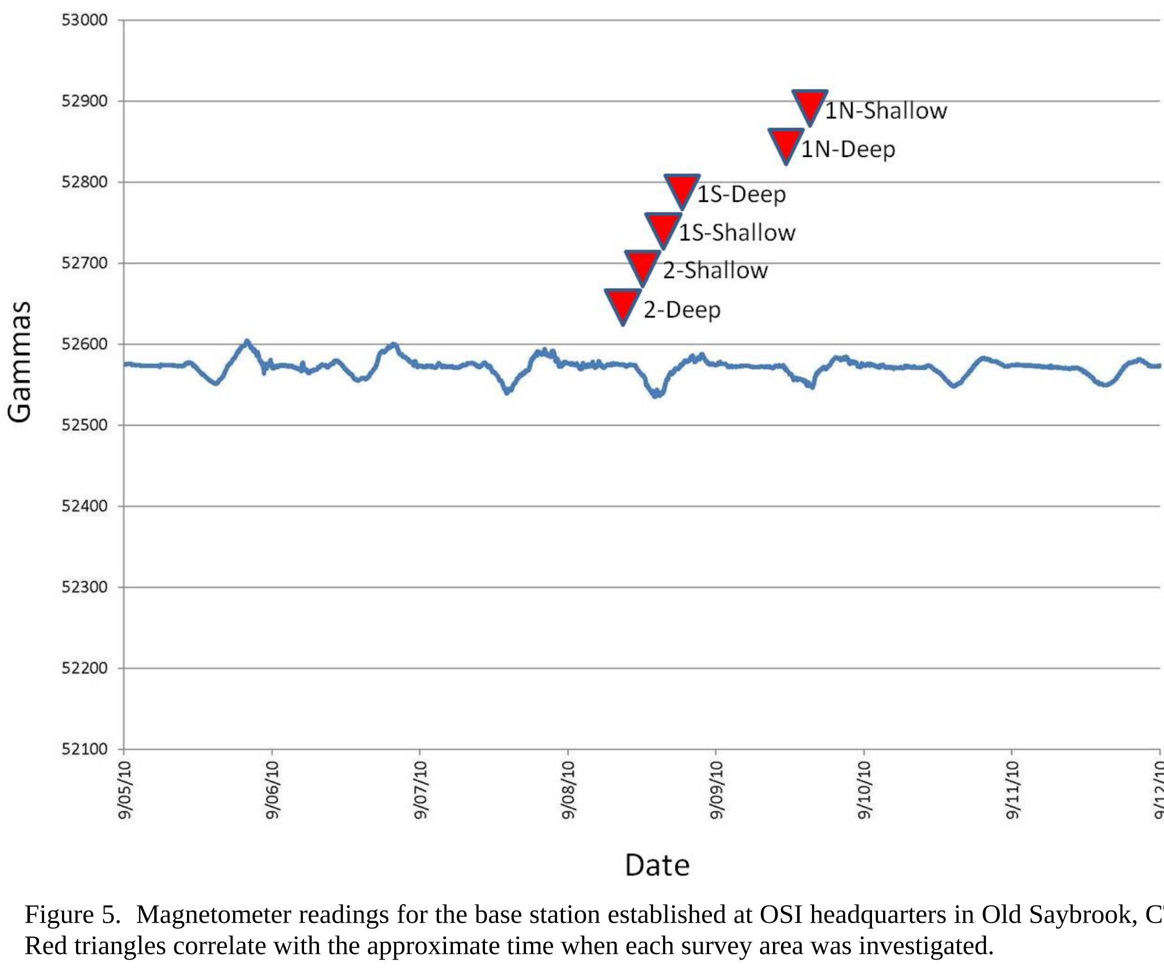


Figure 5. Magnetometer readings for the base station established at OSI headquarters in Old Saybrook, CT. Red triangles correlate with the approximate time when each survey area was investigated.

Area 1N

The charted water depths in this area range from 8 to 13 feet. Because of the shallow water depths, the difference between the two tow depths was limited to 8 feet. Distinct anomalies were detected at each of the three cable locations along all lines. As expected, much larger amplitude anomalies were detected during the deep tow survey. The following table summarizes magnetometer measurements for the area. The profiles for Lines 1-5 are included in Appendix 3. The 10 gamma anomaly detected at the eastern end of Line 5 is believed to be related to the C "7" navigational marker.

Magnetic Anomalies Detected in Area 1N

	Cable 1[1,2]	Cable 2[1,2]	Cable 3[1,2]	Other Anomalies
Shallow Tow	***Average sensor height above seafloor - 15 Feet***			
Line 1	175, Di	290, Di	275, Di	Not Detected
Line 2	170, Di	235, Di	200, Di	Not Detected
Line 3	120, Di	170, Di	175, Di	Not Detected
Line 4	115, Di	160, Di	145, Di	Not Detected
Line 5	130, Di	155, Di	150, Di	Not Detected
Deep Tow	***Average sensor height above seafloor - 7 Feet***			
Line 1	320, Di	570, Di	460, Di	Not Detected
Line 2	215, Di	355, Di	270, Di	Not Detected
Line 3	170, Di	260, Di	250, Di	Not Detected
Line 4	140, Di	230, Di	235, Di	Not Detected
Line 5	215, Di	265, Di	325, Di	10 Di , detected 200 feet E of Cable 3

[1]Amplitudes are rounded to the nearest 5 gammas.
[2]M+ (Positive Monopole), M- (Negative Monopole), Di (Dipole).

Area 1S

The charted water depths in this area range from 7 to 22 feet. The average difference in sensor altitude between the two tow depths was approximately 10 feet. Distinct anomalies were detected at each of the three cable locations along all lines, although the anomalies were generally less prominent than those detected in Area 1N. The anomalies associated with the cables detected during the deep tow survey were larger amplitude than the corresponding anomalies detected during the shallow tow survey. No discernable differences in the characteristics of the interpreted cable anomalies were noted in the areas where cable armoring was reported (Lines 4 & 5). Several isolated anomalies, not believed to be associated with the cables, were detected in this area. In particular, on Line 3, a large anomaly to the east of the Cable 3 location was detected. Smaller anomalies of unknown origin were also detected along Line 5. The following table summarizes magnetometer measurements for the area. The profiles are included in Appendix 4. During the course of both the deep and shallow tows of Line 5, the line was run approximately 20 to 40 feet short of its proposed length to avoid shallow areas.

Magnetic Anomalies Detected in Area 1S

	Cable 1[1,2]	**Cable 2[1,2]**	**Cable 3[1,2]**	**Other Anomalies**
Shallow Tow	***Average sensor height above seafloor - 18 Feet***			
Line 1	75, Di	75, Di	70, Di	Not Detected
Line 2	80, Di	90, Di	85, Di	Not Detected
Line 3	80, Di	85, Di	90, Di	100 feet E of Cable 3, 70 Di
Line 4	75, Di	70, Di	70, Di	Not Detected
Line 5	45, Di	115, Di	80, Di	Not Detected
Deep Tow	***Average sensor height above seafloor - 8 Feet***			
Line 1	205, Di	245, Di	205, Di	100 feet E of Cable 3, 15 M-
Line 2	205, Di	180, Di	150, Di	Not Detected
Line 3	135, Di	150, Di	140, Di	100 feet E of Cable 3, 670 Di
Line 4	170, Di	135, Di	150, M+	Not Detected
Line 5	150, Di	290, Di	215, Di	50 feet W of Cable 3, 60 M+, 50 feet E of Cable 3, 65 M+, 200 feet E of Cable 3, 80 M+

[1]Amplitudes are rounded to the nearest 5 gammas.
[2]M+ (Positive Monopole), M- (Negative Monopole), Di (Dipole).

Area 2

The charted water depths in this area range from 39 to 45 feet. The average difference in sensor altitude between the two tow depths was approximately 13 feet. Anomalies were detected at each of the three cable locations; however, these were generally broader and lower amplitude than anomalies detected in Areas 1N and 1S since the magnetometer sensor was further from the cables in both the shallow and deep tow configurations. As expected, larger amplitude anomalies were detected during the deep tow survey than during the shallow tow survey, but the differences were less than observed in the other areas. The following table summarizes magnetometer measurements for the area. The profiles are included in Appendix 5.

Magnetic Anomalies Detected in Area 2

	Cable 1[(1,2)]	Cable 2[(1,2)]	Cable 3[(1,2)]	Other Anomalies
Shallow Tow	***Average sensor height above seafloor - 32 Feet***			
Line 1	40, Di	60, Di	60, Di	Not Detected
Line 2	30, Di	70, Di	70, Di	Not Detected
Line 3	30, Di	60, Di	65, Di	Not Detected
Line 4	40, Di	80, Di	90,Di	Not Detected
Line 5	45, Di	65, Di	50, Di	Not Detected
Deep Tow	***Average sensor height above seafloor - 19 Feet***			
Line 1	95, Di	170, Di	170, Di	Not Detected
Line 2	95, Di	155, Di	145, Di	Not Detected
Line 3	100, Di	220, Di	190, Di	Not Detected
Line 4	135, Di	180, Di	200, Di	Not Detected
Line 5	100, Di	140, Di	125, Di	Not Detected

[1]Amplitudes are rounded to the nearest 5 gammas.
[2]M+ (Positive Monopole), M- (Negative Monopole), Di (Dipole).

Reference Area

The reference area serves as quality control for comparison with the monitoring areas containing the submarine power cables. The magnetometer height was approximately 19 feet above the seafloor during the shallow tow survey and approximately 11 feet above the seafloor during the deep tow survey. The total magnetic gradient along Lines 1-5 was 7 gammas for the shallow tow survey and 16 gammas for the deep tow survey and no significant magnetic anomalies were detected. The profiles for the Reference Area are included in Appendix 6.

5.3 Comparison with 2009 Study Results

An overall decrease of 100 gammas was measured in the regional background magnetic field between the 2009 and 2010 surveys, as documented by the base station and field magnetometer data sets. Other than this slight change in the background field, a comparison of the data from two surveys indicates similar results overall, with detected anomalies at each of the cables for both shallow and deep tows at the three sites (Areas 1N, 1S, 2). As shown in the table below, the amplitude range of anomalies detected over the cables in each of the areas was similar for both surveys. Additional anomalies not associated with the cables were detected during both surveys, with minor differences between surveys.

Area-Tow Configuration	September 2010 Survey Amplitude* Range of Anomalies	November 2009 Survey Amplitude* Range of Anomalies
Area 1N-Shallow	115 – 290	75 – 210
Area 1N-Deep	140 – 570	140 – 745
Area 1S-Shallow	45 – 115	10 – 60
Area 1S-Deep	135 – 290	40 – 195
Area 2-Shallow	30 – 90	25 – 55
Area 2-Deep	95 – 220	65 – 110

*Amplitude are rounded to the nearest 5 gammas.

Variability in the range of amplitudes for magnetic anomalies between the two surveys can be associated with a number of factors related to slight changes in tow height and sensor orientation. Given that the magnetometer sensor was towed on a cable, small variations in tow height and sensor orientation are common and can easily affect the magnitude and type (monopole vs. dipole) of anomaly detected from the same object.

6.0 SUMMARY AND CONCLUSIONS

This is the second study of an ongoing program to measure the earth's total magnetic field in the vicinity of three designated Long Island Replacement Cable Project monitoring areas and one reference site located in and around Sheffield Harbor and Long Island Sound offshore Norwalk, CT.

Magnetic field measurements were made along a series of tracklines oriented perpendicular and parallel to the LIRC alignments within the three monitoring areas and Reference Area using a marine magnetometer. Magnetic data were collected at two different tow heights to provide data regarding field strength versus distance from the cables. In addition to the marine magnetometer surveys, magnetic measurements were also recorded at a base station located in Old Saybrook, CT to adjust the field survey data for any diurnal effects on the total magnetic field. Data acquisition and processing methodologies followed those established for the initial Magnetic Intensity Study, conducted by OSI in November, 2009.

In general, as illustrated on the cross-sectional profiles of the five lines oriented perpendicular to the LIRC orientation in each monitoring area, magnetic anomalies were detected that correlate with the as-built locations of each cable. These anomalies were stronger and more distinct during the deep-tow surveys, especially in Area 1N, where water depth was shallowest and the magnetometer sensor was closest to the buried cables. Several anomalies, not believed to be associated with the cables, were also detected during this investigation. Without further study, the origin of these anomalies is unclear.

In summary, the following observations have been made about the magnetic intensity measurements acquired during the course of this investigation:

- The earth's magnetic background field varied less than approximately 59 gammas throughout the entire survey period.
- In Area 1N, magnetic anomalies related to the cables ranged from 115-290 gammas for the shallow tow and 140-570 gammas for the deep tow survey.
- In Area 1S, magnetic anomalies related to the cables ranged from 45-115 gammas for the shallow tow and 135-290 gammas for the deep tow survey.
- In Area 2, magnetic anomalies related to the cables ranged from 30-90 gammas for the shallow tow and 95-220 gammas for the deep tow survey.
- In the Reference Area, the magnetic field varied less than 7 gammas during the shallow tow survey and 16 gammas during the deep tow survey.
- Cable power transmission data provided to OSI document that Cable 1 (westernmost) was not transmitting power during the surveys while Cables 2 and 3 were transmitting power. Magnetic anomalies associated with Cable 1 did not appear to be significantly smaller than those detected at the other cables; however, the variation in the power transmission may not be detected by the marine magnetometer (10 per second sample rate) because the cables transmit AC power (60 Hz).

- Cable armoring (split pipe protectors) was used on Cables 2 and 3 in the southernmost portion of Area 1S. No discernable differences in the characteristics of the interpreted cable anomalies or amplitude were noted in vicinity of where cable armoring was reported to have been used.

- With the exception of an overall decrease of 100 gammas in the regional background magnetic field between the 2009 and 2010 surveys, the 2010 survey results correlated well with the 2009 survey results, with similar magnetic anomalies detected at each of the cables, with minor variability.

APPENDIX 1

EQUIPMENT OPERATIONS AND PROCEDURES

Trimble Differential Global Positioning System
HYPACK Navigation Software
Geometrics G882 Cesium Marine Magnetometer
Geometrics G881 Base Station Magnetometer

EQUIPMENT OPERATIONS AND PROCEDURES

Trimble DSM 212 Differential Global Positioning System

A Trimble DSM 212 differential global satellite positioning system (GPS) provides reliable, high-precision positioning and navigation for a wide variety of operations and environments. The unique feature of this system is its integration of a standard 12 channel GPS receiver with a U.S. Coast Guard beacon receiver all in one package. Both antennas are combined in a single housing and the receiver electronics are similarly contained within one topside control box. The complete system includes the topside control unit, a GPS volute antenna and cable, RS232 output and input data cables, and a 12 volt DC power cable. The proprietary MSK beacon receiver used in the system has been designed to provide enhanced signal reception at large distances from the reference station and under inclement weather conditions. The low noise MSK receiver also has an automatic, dual channel system providing seamless switching between multiple beacons when necessary. The DSM 212 outputs one position per second to the HYPACK navigation computer. The manufacturer reports sub-meter accuracy of the system under suitable operating conditions.

HYPACK Navigation Software

Survey vessel trackline control and position fixing were obtained by utilizing an OSI computer-based data-logging package running HYPACK navigation software. The computer is interfaced with the DGPS receiver onboard the survey vessel. Vessel position data were updated at one-second intervals and input to the HYPACK navigation system which processes the geodetic position data into State Plane coordinates used to guide the survey vessel accurately along preselected tracklines. The incoming data are logged on disk and processed in real time allowing the vessel position to be displayed on a video monitor and compared to each preplotted trackline as the survey progresses. Digitized shoreline, NOAA charts, and the locations of existing structures, buoys, and control points can also be displayed on the monitor in relation to the vessel position. The OSI computer logging system, combined with the HYPACK software, thus provide an accurate visual representation of survey vessel location in real time, combined with highly efficient data logging capability and post-survey data processing and plotting routines.

<u>Geometrics G882 Cesium Marine Magnetometer</u>

Total magnetic field intensity measurements were acquired along the survey tracklines using a Geometrics G882 cesium magnetometer that has an instrument sensitivity of 0.1 gamma. The G882 magnetometer system includes the sensor head with a coil and optical component tube, a sensor electronics package which houses the AC signal generator and mini-counter that converts the Larmor signal into a magnetic anomaly value in gammas, and a RS-232 data cable for transmitting digital measurements to a data logging system. The cesium-based method of magnetic detection allows a center or nose tow configuration off the survey vessel, simultaneously with other remote sensing equipment, while maintaining high quality, quiet magnetic data with ambient fluctuations of less than 1 gamma. The G882 also features an altimeter which outputs sensor height above the seafloor along with the magnetic intensity readings at a 10-hertz sampling rate. Data were recorded on the OSI data-logging computer by the HYPACK software.

The G882 magnetometer acquires information on the ambient magnetic field strength by measuring the variation in cesium electron energy level states. The presence of only one electron in the atom’s outermost electron shell (known as an alkali metal) makes cesium ideal for optical pumping and magnetometry.

In operation, a beam of infrared light is passed through a cesium vapor chamber producing a Larmor frequency output in the form of a continuous sine wave. This radio frequency field is generated by an H1 coil wound around a tube containing the optical components (lamp oscillator, optical filters and lenses, split-circular polarizer, and infrared photo detector). The Larmor frequency is directly proportional to the ambient magnetic intensity, and is exactly 3.49872 times the ambient magnetic field measured in gammas or nano-Teslas. Changes in the ambient magnetic field cause different degrees of atomic excitation in the cesium vapor which in turn allow variable amounts of infrared light to pass, resulting in fluctuations in the Larmor frequency.

Although the earth's magnetic field does change with both time and distance, over short periods and distances the earth's field can be viewed as relatively constant. The presence of magnetic material and/or magnetic minerals, however, can add to or subtract from the earth's magnetic field creating a magnetic anomaly. Rapid changes in total magnetic field intensity, which are not associated with normal background fluctuations, mark the locations of these anomalies.

Determination of the location of an object producing a magnetic anomaly depends on whether or not the magnetometer sensor passed directly over the object and if the anomaly is an apparent monopole or dipole. A magnetic dipole can be thought of simply as a common bar magnet having a positive and negative end or pole. A monopole arises when the magnetometer senses only one end of a dipole as it passes over the object. This situation occurs mainly when the distance between opposite poles of a dipole is much greater than the distance between the magnetometer and the sensed pole, or when a dipole is oriented nearly perpendicular to the ambient field thus shielding one pole from detection. For dipolar anomalies, the location of the object is at the point of maximum gradient between the two poles. In the case of a monopole, the object associated with the anomaly is located below the maximum or minimum magnetic value.

<u>Geometrics 881 Base Station Magnetometer</u>

In order to record diurnal variations in the earth’s total magnetic field intensity during the marine electromagnetic survey, a Geometrics Model 881 cesium magnetometer was set up as a stationary acquisition system onshore. The base station was installed at a location away from human activity to prevent interference from local ferrous objects such as automobiles and buried pipelines or cables. The 881 digital system was interfaced to a laptop computer running HYPACK to record magnetic intensity every minute, 24 hours per day. The resulting magnetic data can be correlated with the marine magnetometer data collected onboard the survey vessel. Any short period diurnal variations that occurred during the survey period can then be removed from the marine data during the processing phase.

APPENDIX 2

DATA PROCESSING AND ANALYSIS METHODS

Navigation Data

Marine Magnetic Intensity Measurements

Base Magnetometer Measurements

DATA PROCESSING AND ANALYSIS METHODS

Navigation Data

Vessel navigation files were continuously processed and analyzed in HYPACK to verify survey coverage and assist with the onsite review of geophysical data.

Upon completion of the field work, vessel position data were processed and exported as a DXF file using HYPACK, then entered into an AutoCAD drawing file to show survey coverage in each area.

Marine Magnetic Intensity Measurements

Digital records of the magnetic data were reviewed and interpreted using HYPACK to characterize the nature of the electromagnetic field in each area. The HYPACK single beam editor program was utilized to process and export magnetic data along tracklines to Excel for tabulation. Each trackline was checked for erroneous magnetic data points then adjusted based on normalized magnetic intensity readings from the base station data. The Cross Sections and Volumes module of HYPACK was used to generate profiles of the marine magnetometer data.

For discrete anomalies, determination of the location of an object producing a magnetic anomaly depends on whether or not the magnetometer sensor passed directly over the object and if the anomaly is an apparent monopole or dipole. A magnetic dipole can be thought of simply as a common bar magnet having a positive and negative end or pole. A monopole arises when the magnetometer senses only one end of a dipole as it passes over the object. This situation occurs mainly when the distance between opposite poles of a dipole is much greater than the distance between the magnetometer and the sensed pole, or when a dipole is oriented nearly perpendicular to the ambient field thus shielding one pole from detection. For dipolar anomalies, the location of the object is at the point of maximum gradient between the two poles. In the case of a monopole, the object associated with the anomaly is located below the maximum or minimum magnetic value.

Types of anomalies include a positive deviation from the ambient field (positive monopole), a negative deviation from the ambient field (negative monopole), one positive and one negative deviation associated with the same ferrous object (dipole), or a combination of the above (complex monopole or dipole). Amplitude (strength) of the anomaly is measured from the ambient level to the maximum deviation point for a monopole, and from the lowest to the highest deviation point for a dipole. Duration is defined as the distance between the onset of magnetic deviation to the return to background magnetic levels.

Base Magnetometer Measurements

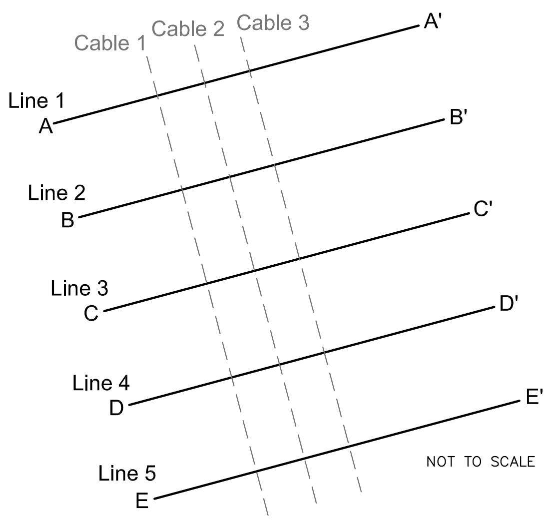
The base station magnetometer data were imported to EXCEL and processed to generate a time-series of the earth's total background field intensity. The average magnetic reading at the base station during each survey period was calculated, and the value of each reading was "normalized" by subtracting the average base station reading for that survey period from each individual base station reading. HYPACK-format 'tide files' were generated from the normalized base magnetometer values.

APPENDIX 3

AREA 1N

MAGNETIC INTENSITY PROFILES

AREA 1-NORTH



LEGEND:

SHALLOW TOW (~15 FEET ABOVE SEAFLOOR)

DEEP TOW (~7 FEET ABOVE SEAFLOOR)

NOTES:

1. PRELIMINARY AS–BUILT POWER CABLE LOCATIONS WERE PROVIDED BY NEXANS.
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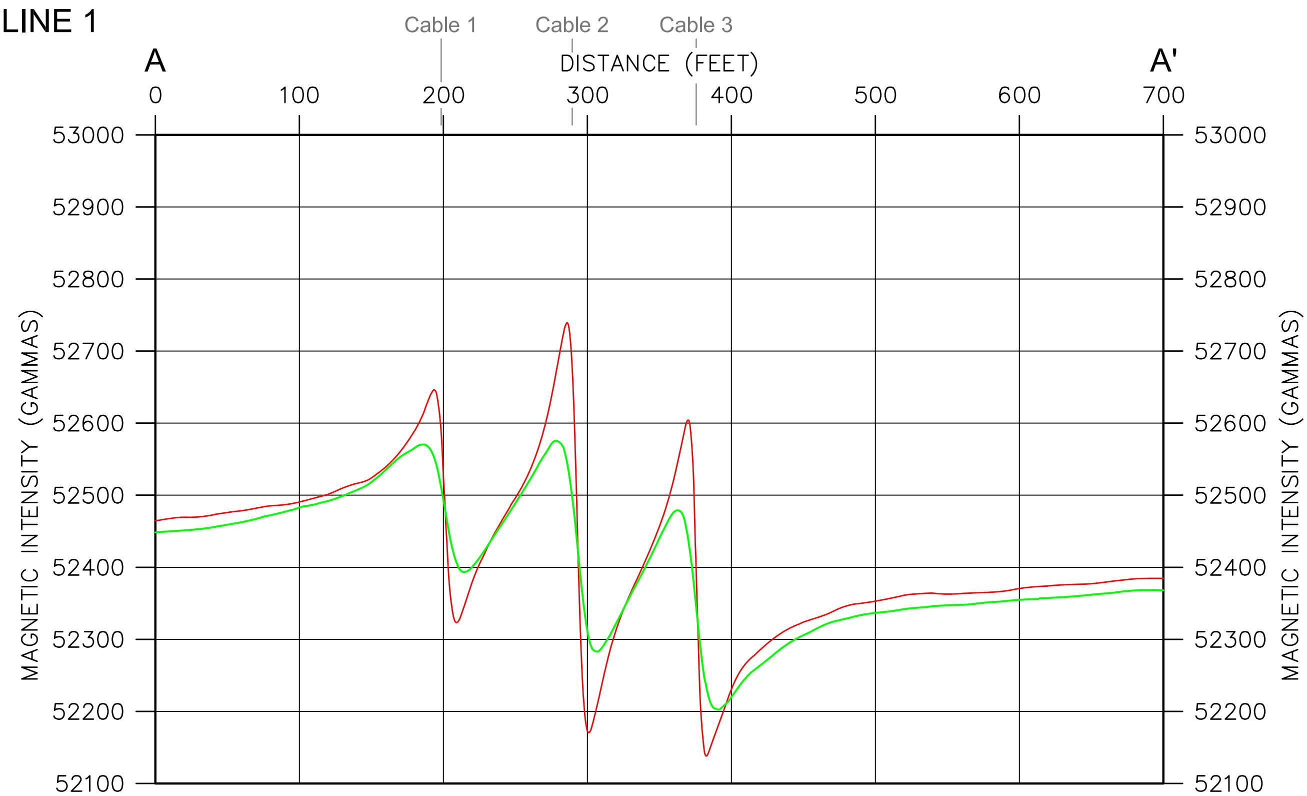
LINE 1



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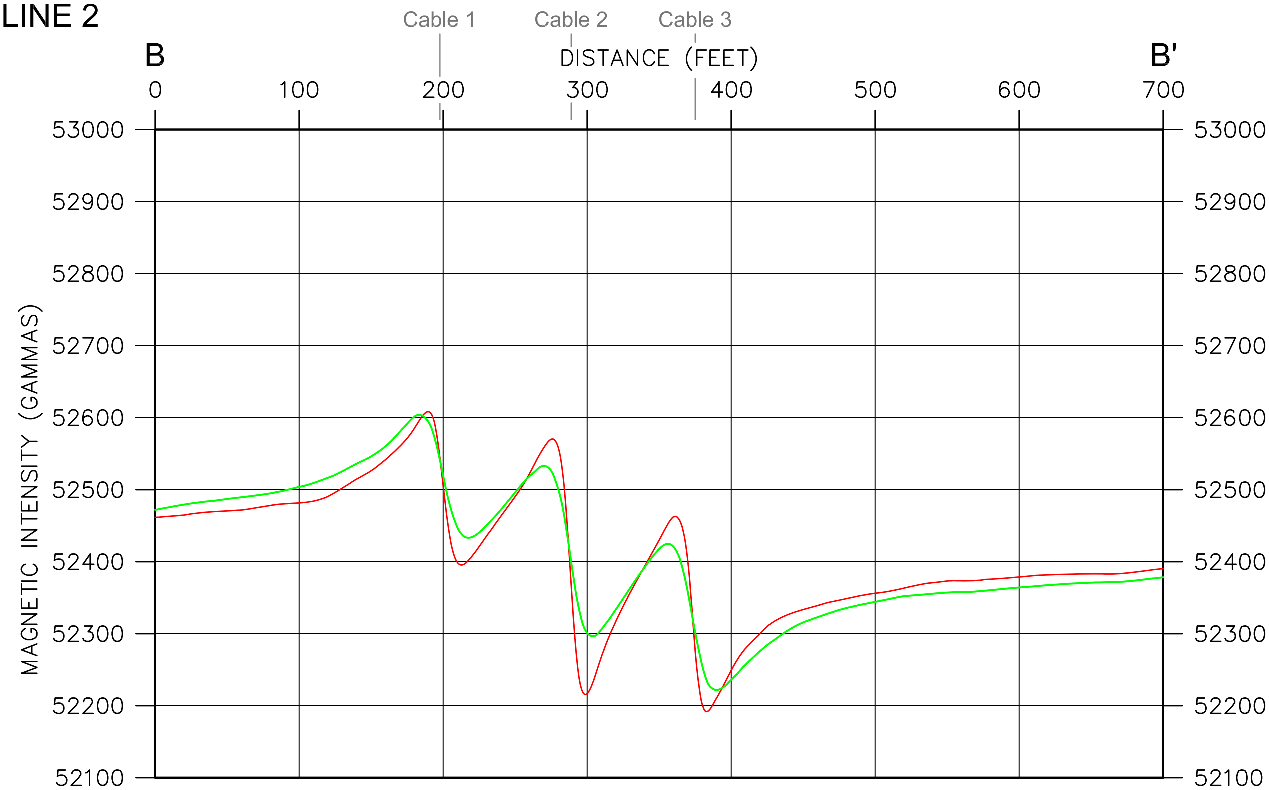
Area 1 North - Sheet 1 of 3
Long Island Replacement Cable Project
Long Island Sound, Norwalk, Connecticut

LINE 2



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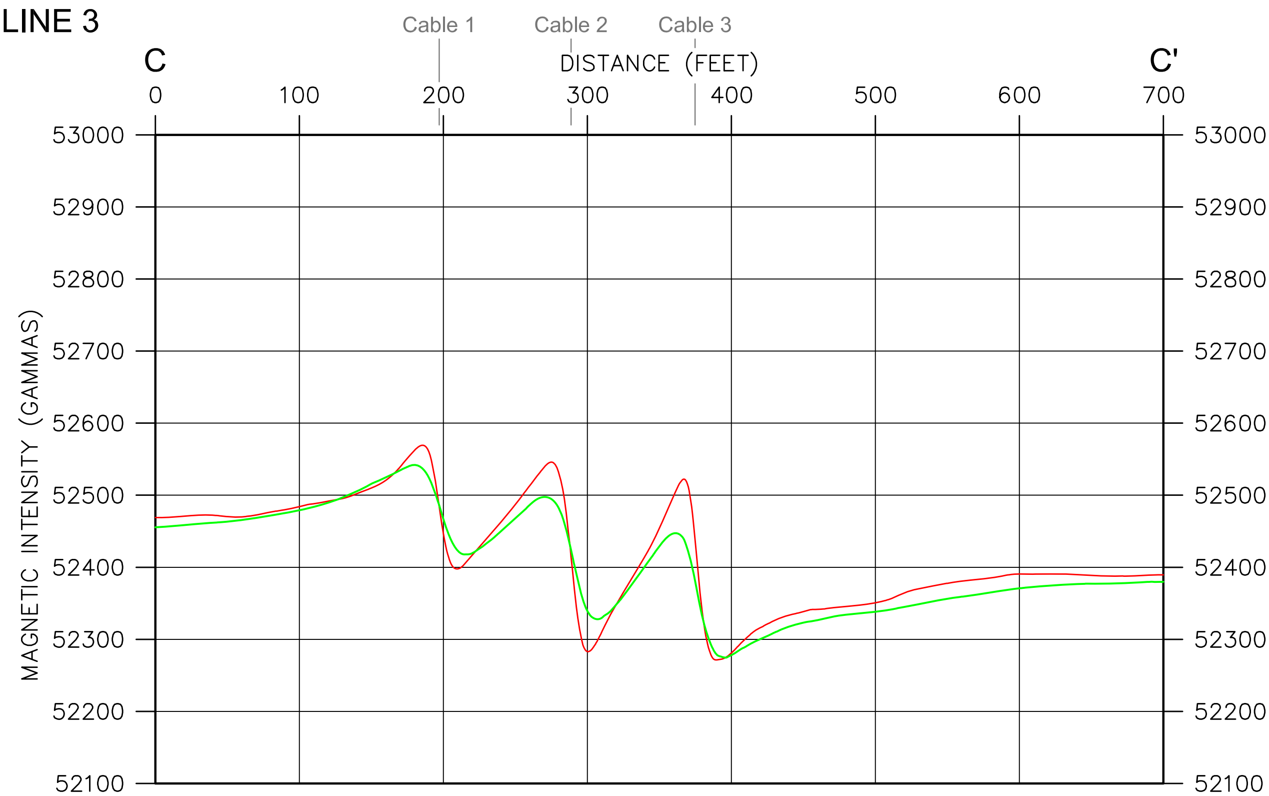

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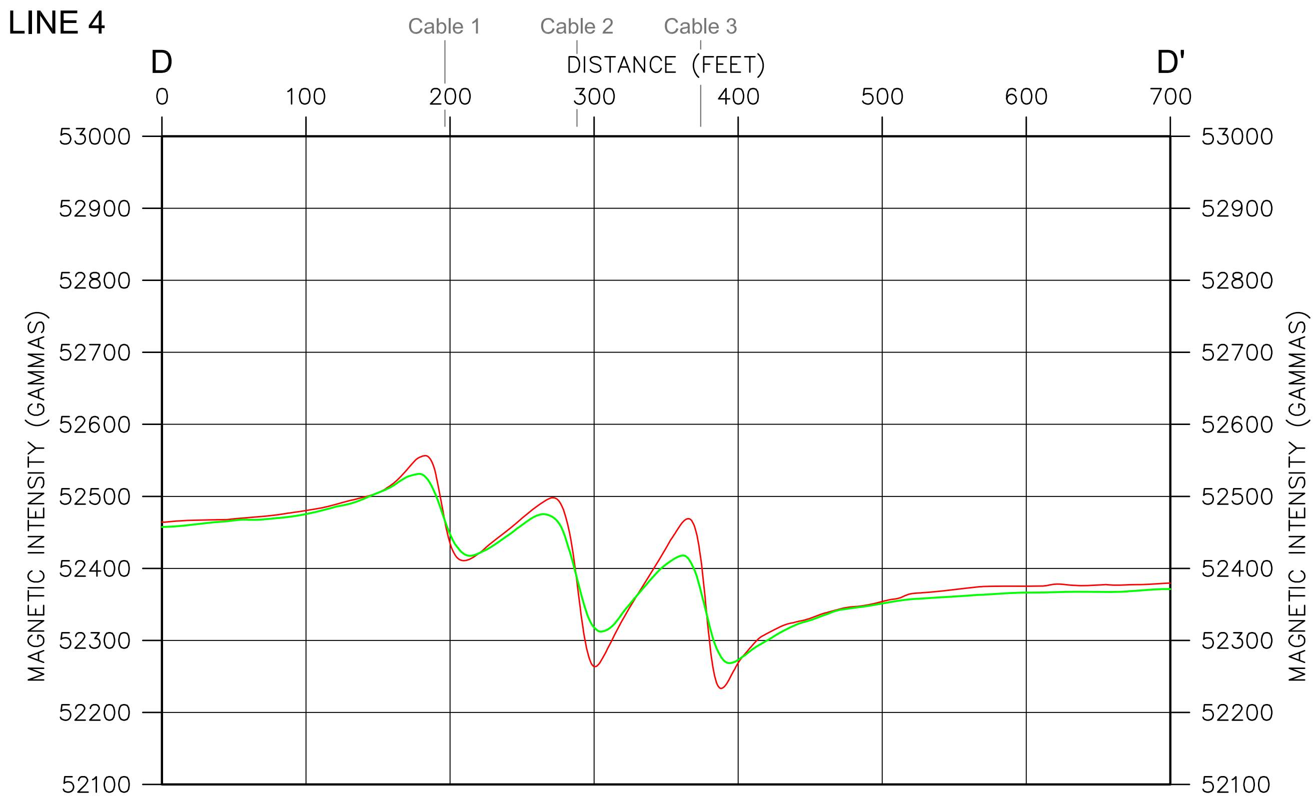

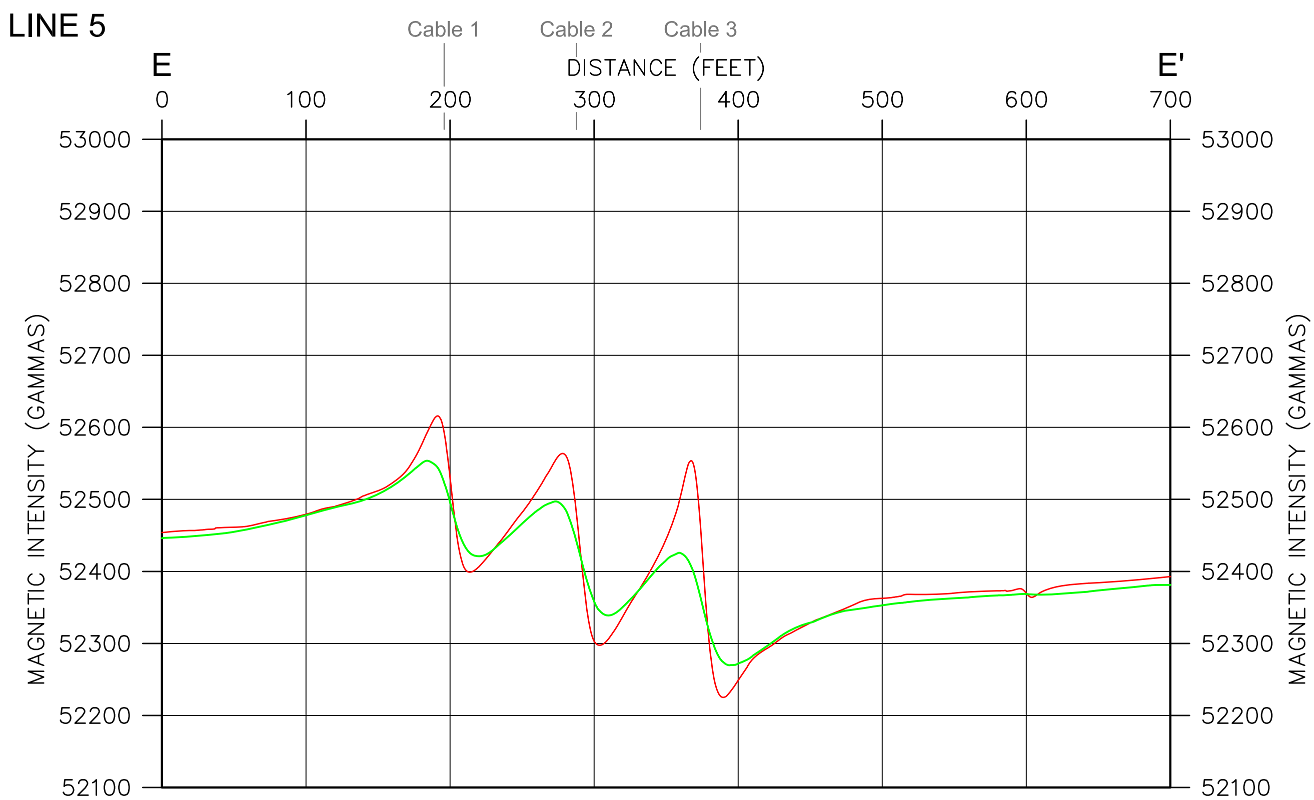

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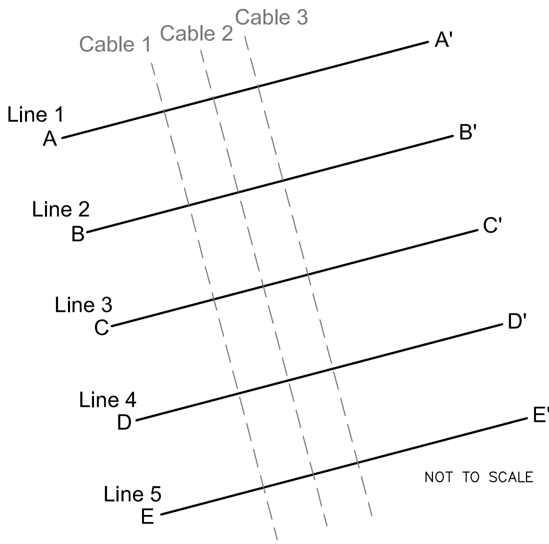
APPENDIX 4

AREA 1S

MAGNETIC INTENSITY PROFILES

AREA 1-SOUTH



LEGEND:

SHALLOW TOW (~18 FEET ABOVE SEAFLOOR)

DEEP TOW (~8 FEET ABOVE SEAFLOOR)

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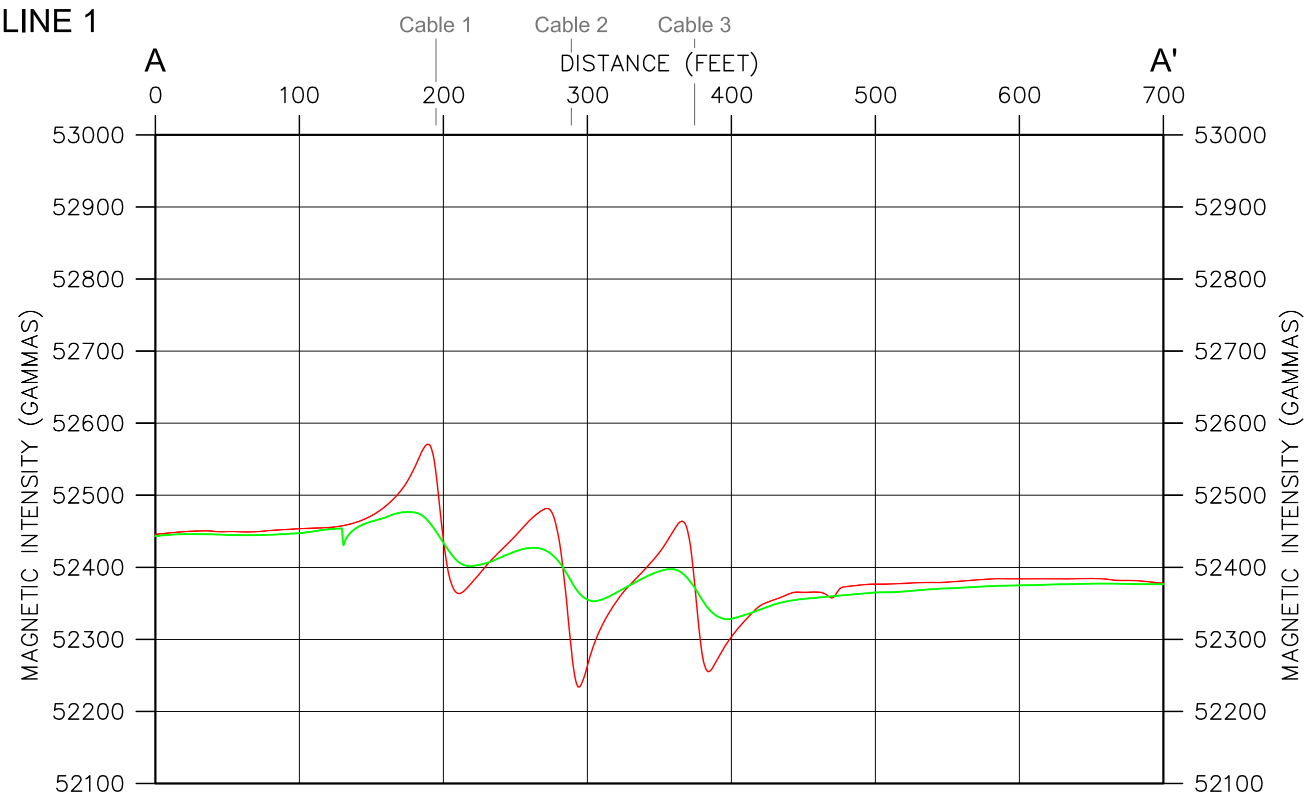
LINE 1



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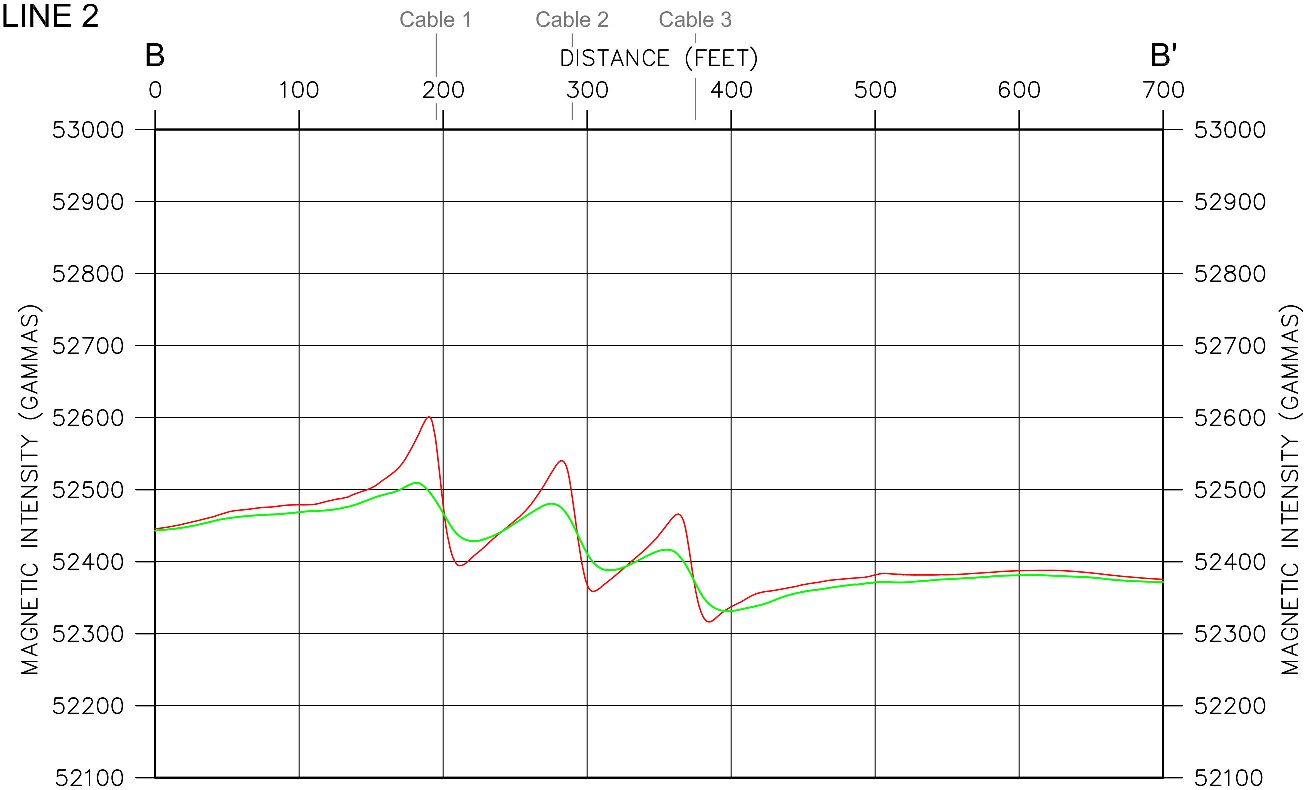
LINE 2



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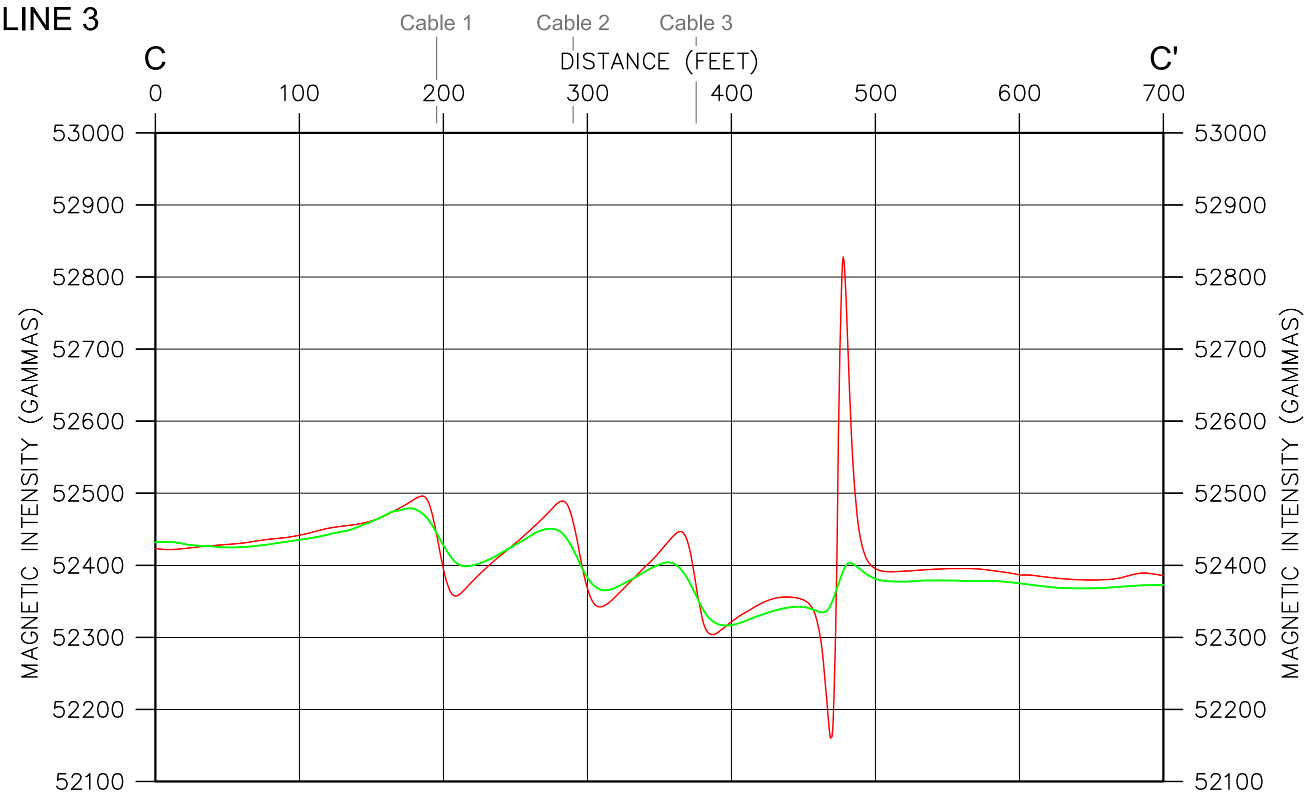

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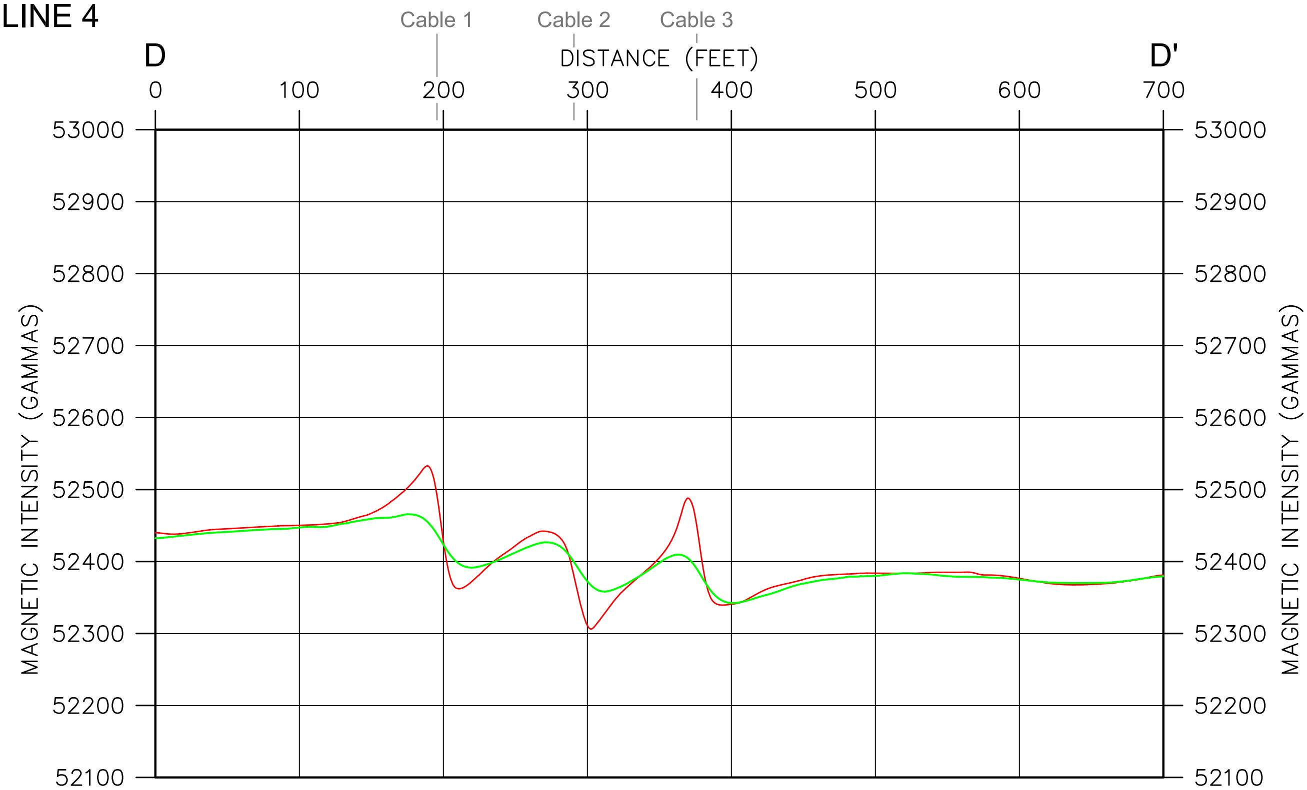
LINE 4



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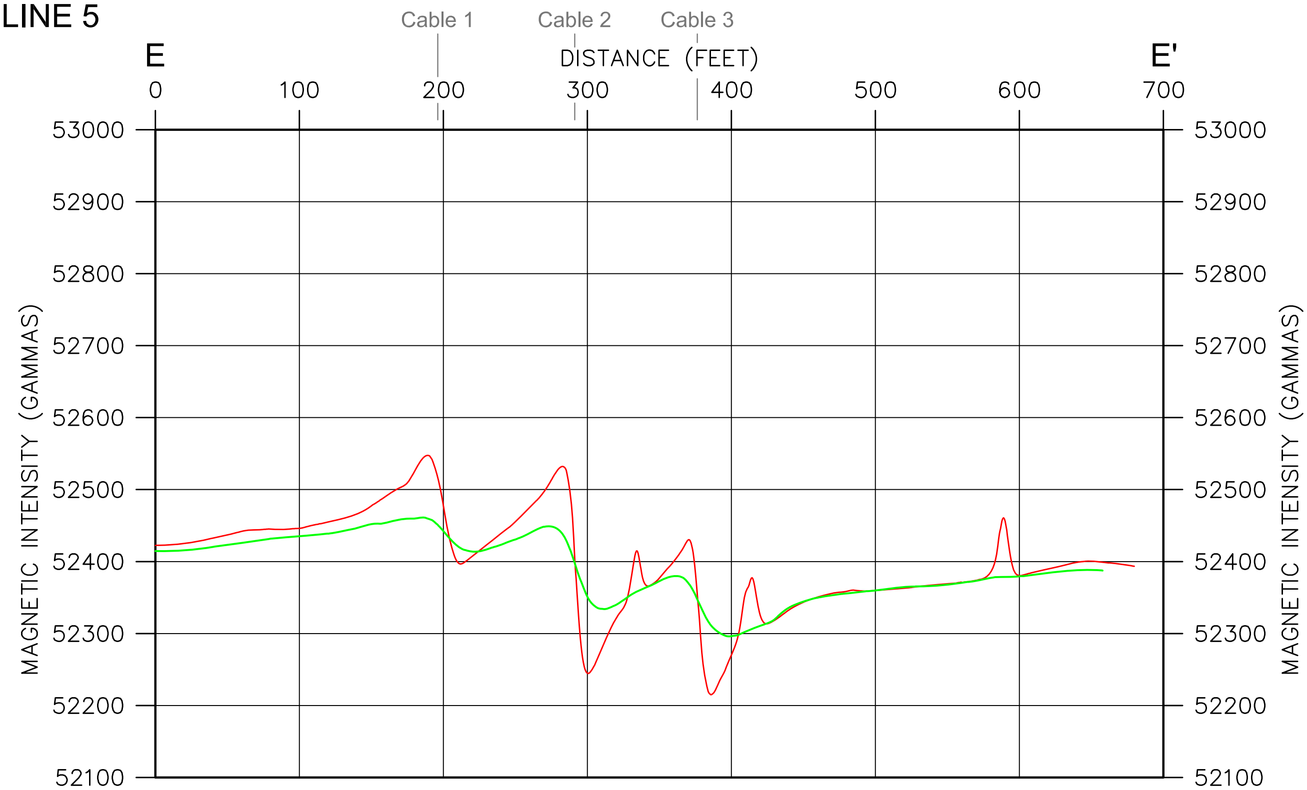

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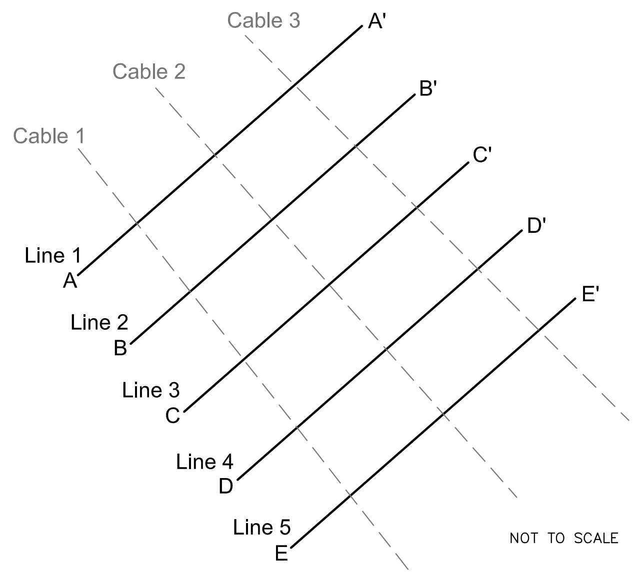
APPENDIX 5

AREA 2

MAGNETIC INTENSITY PROFILES

AREA 2



LEGEND:

SHALLOW TOW (~32 FEET ABOVE SEAFLOOR)

DEEP TOW (~19 FEET ABOVE SEAFLOOR)

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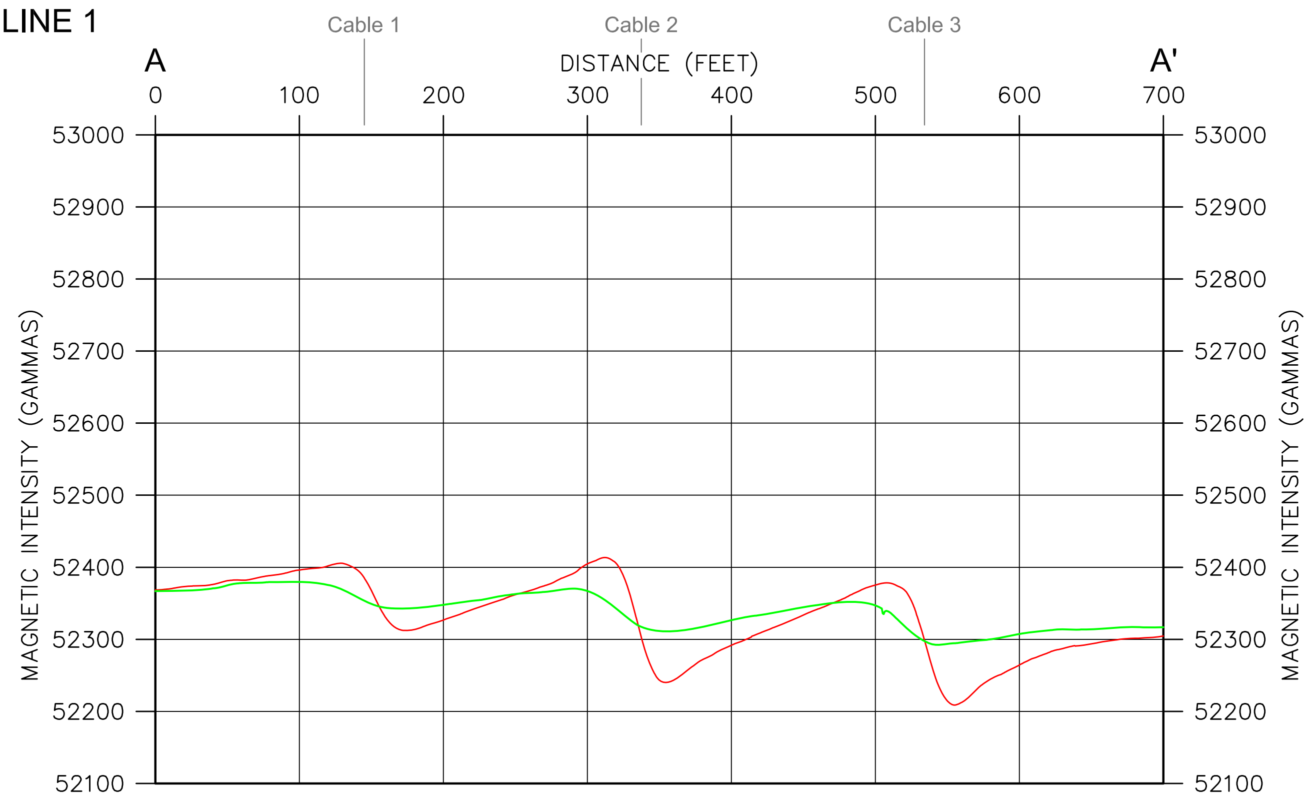
LINE 1



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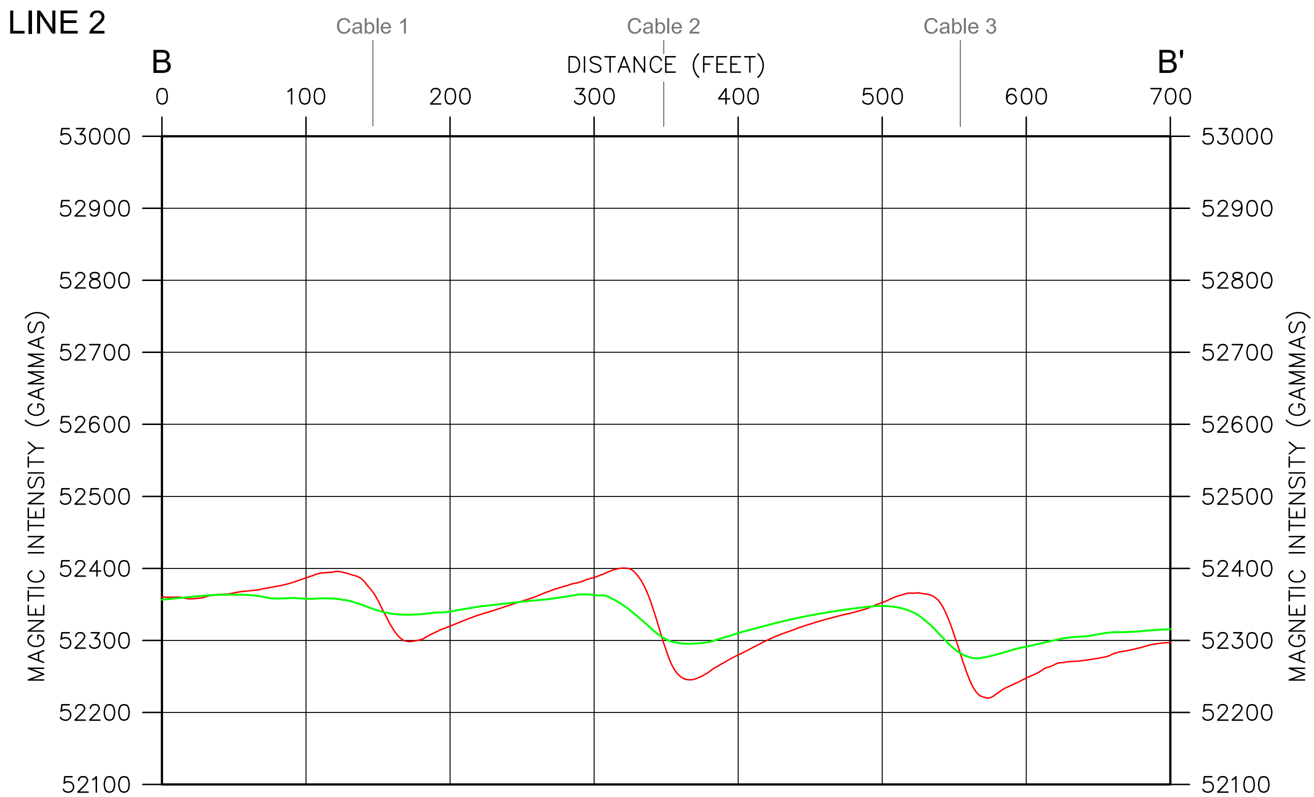
LINE 2



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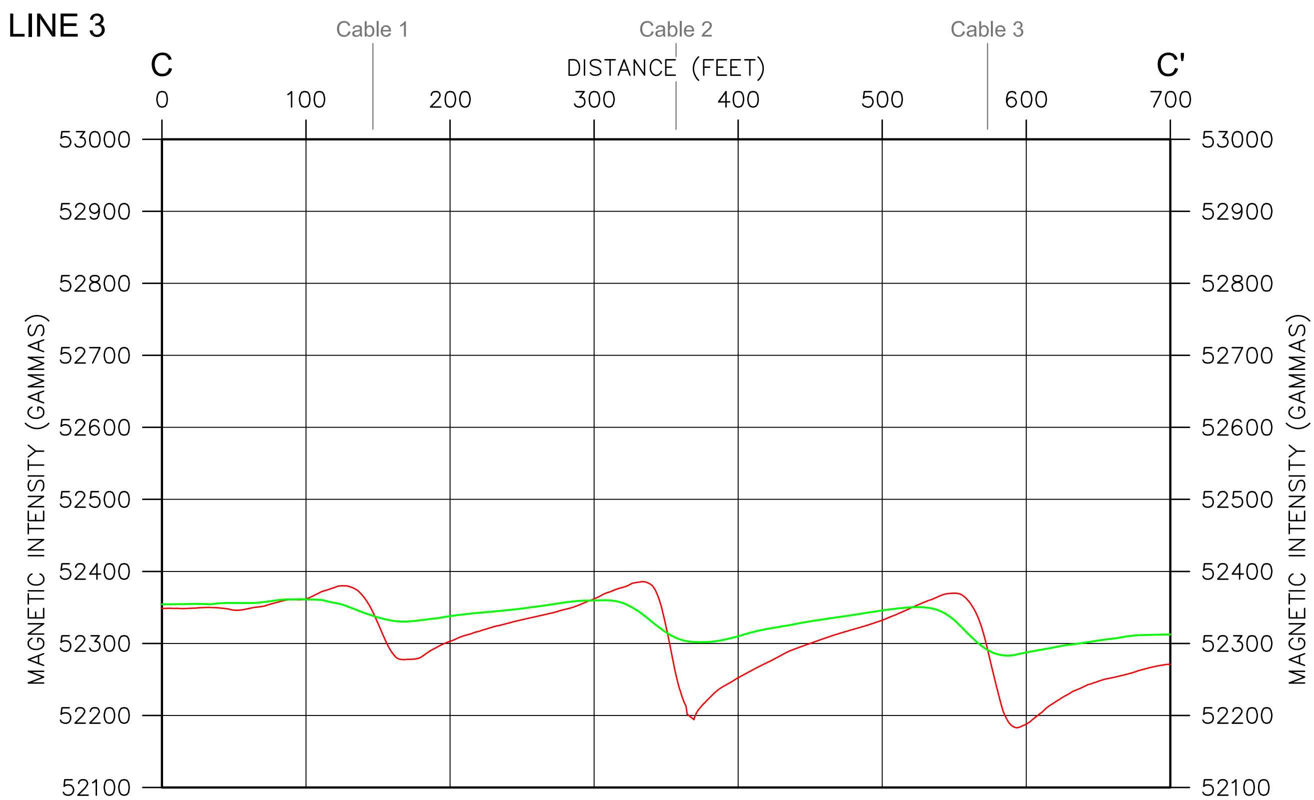

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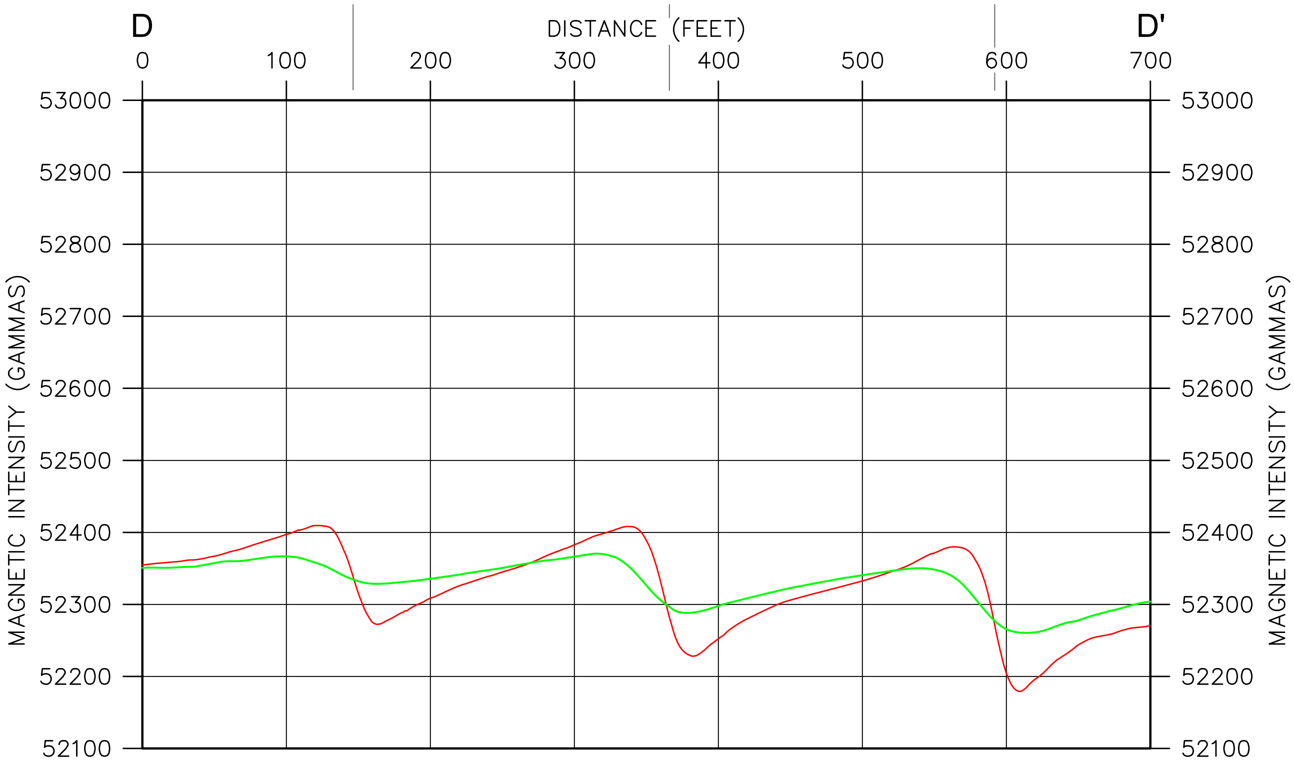
LINE 4



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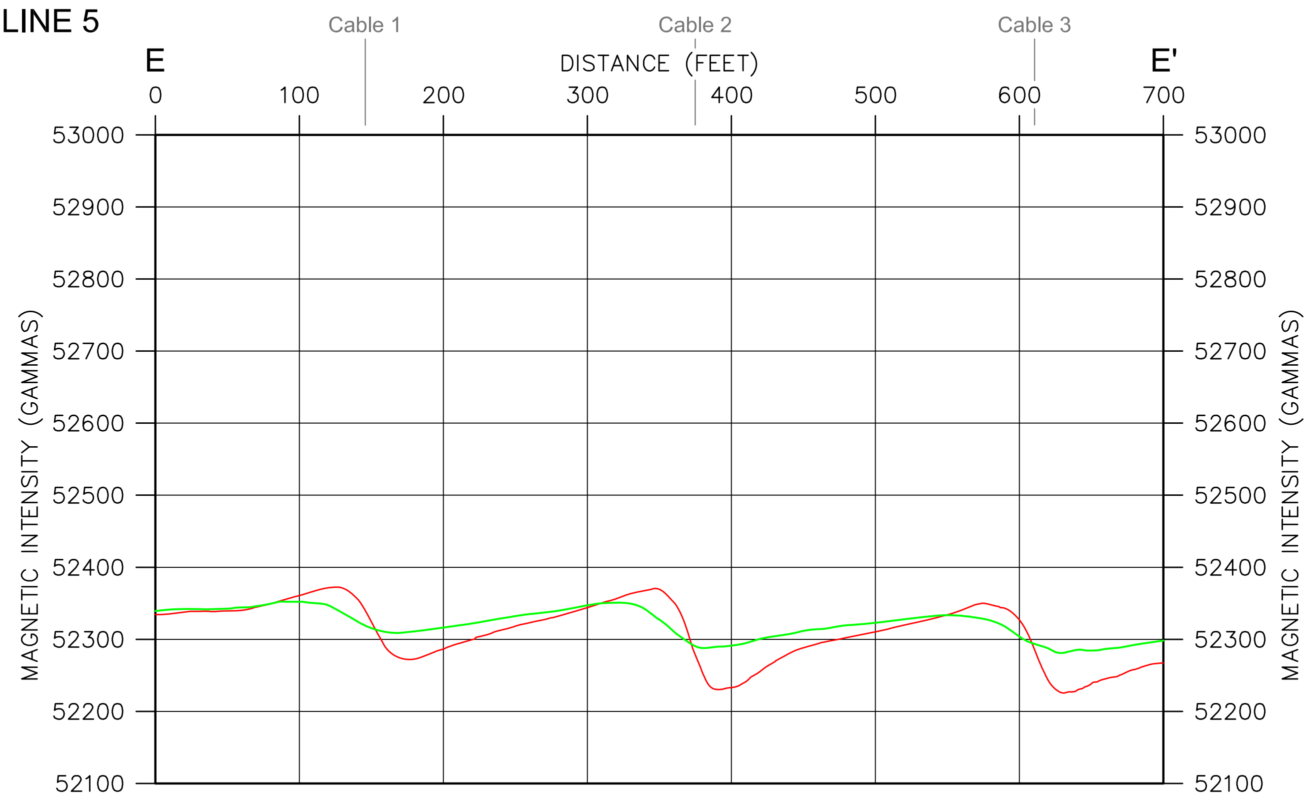

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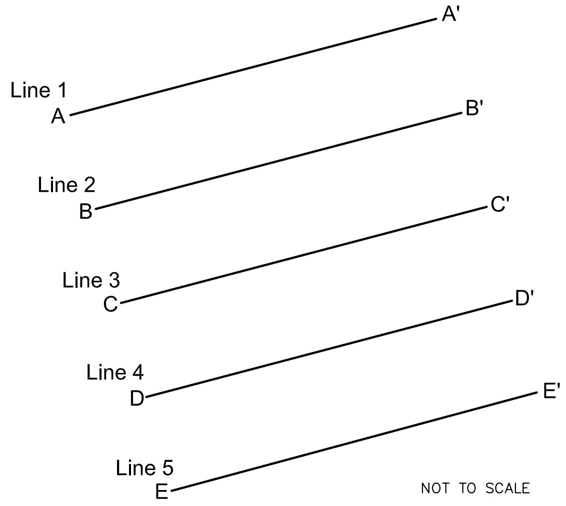
APPENDIX 6

REFERENCE AREA

MAGNETIC INTENSITY PROFILES

REFERENCE AREA



LEGEND:

- (green line) SHALLOW TOW (~19 FEET ABOVE SEAFLOOR)
- (red line) DEEP TOW (~11 FEET ABOVE SEAFLOOR)

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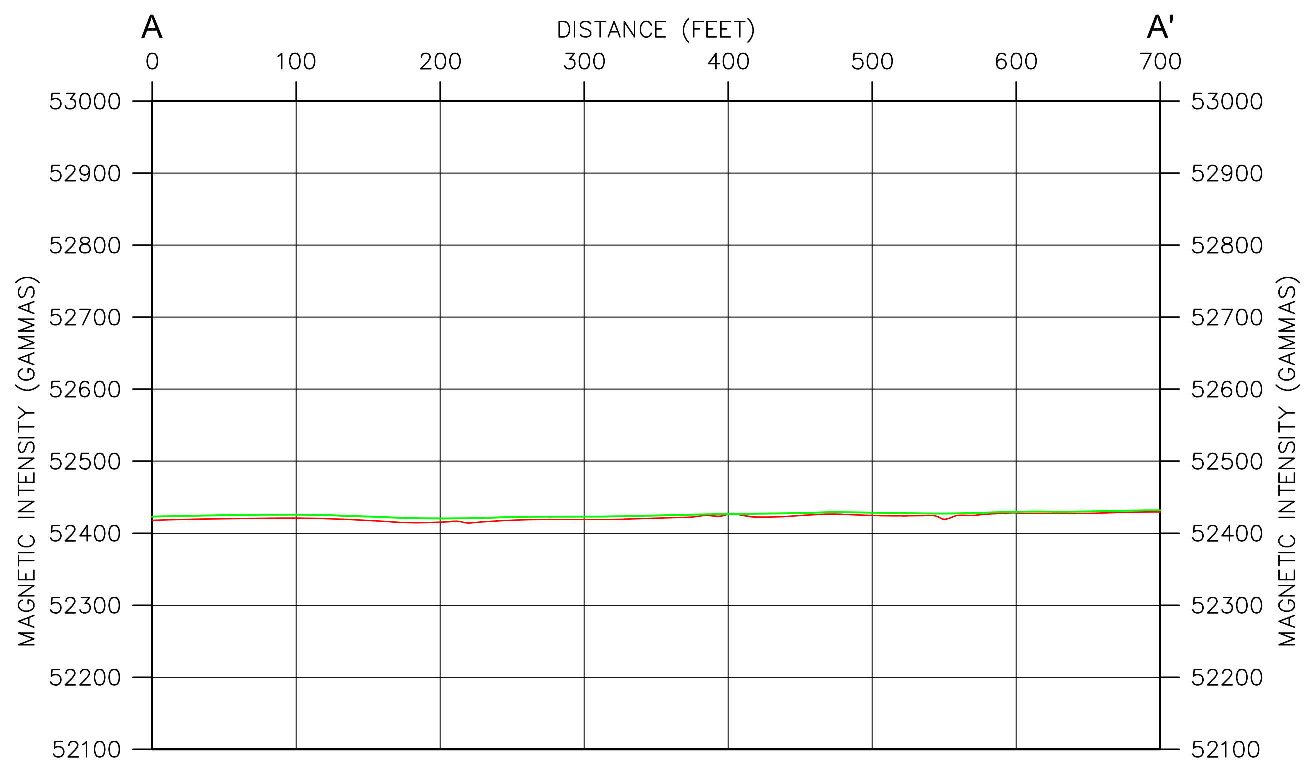
LINE 1



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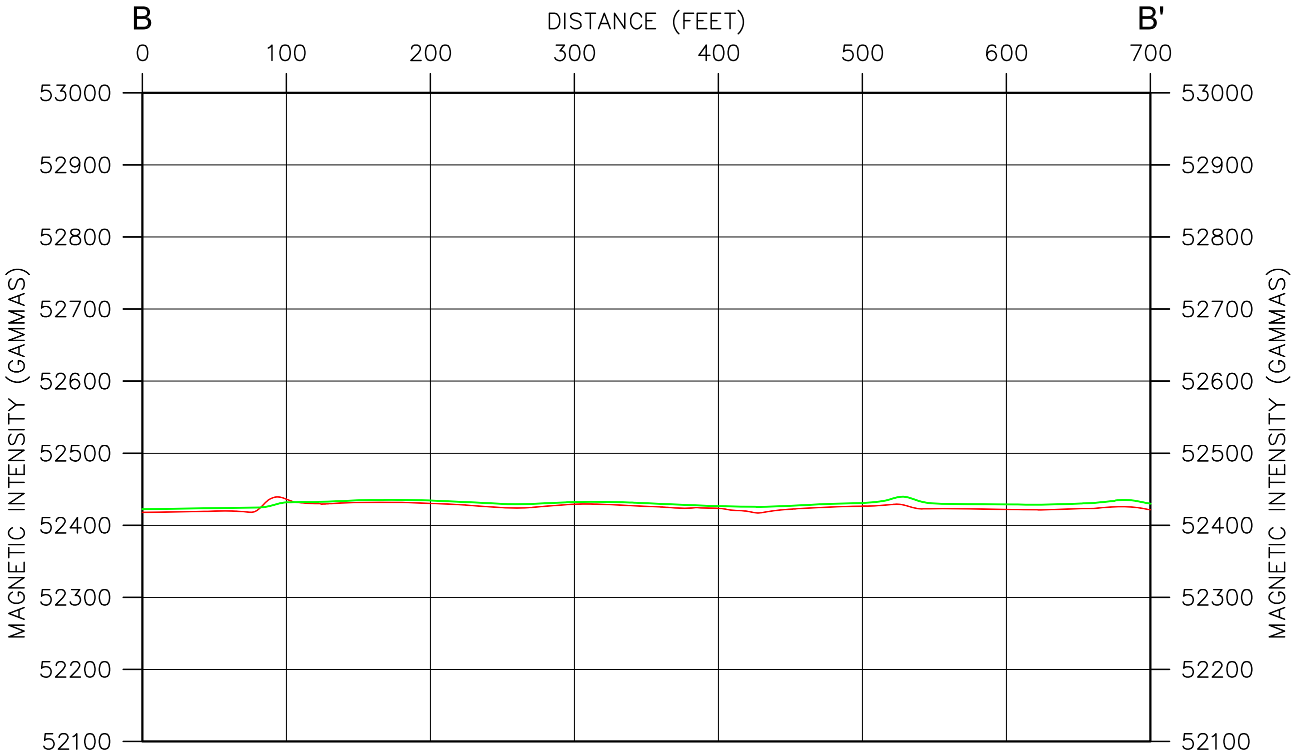
LINE 2



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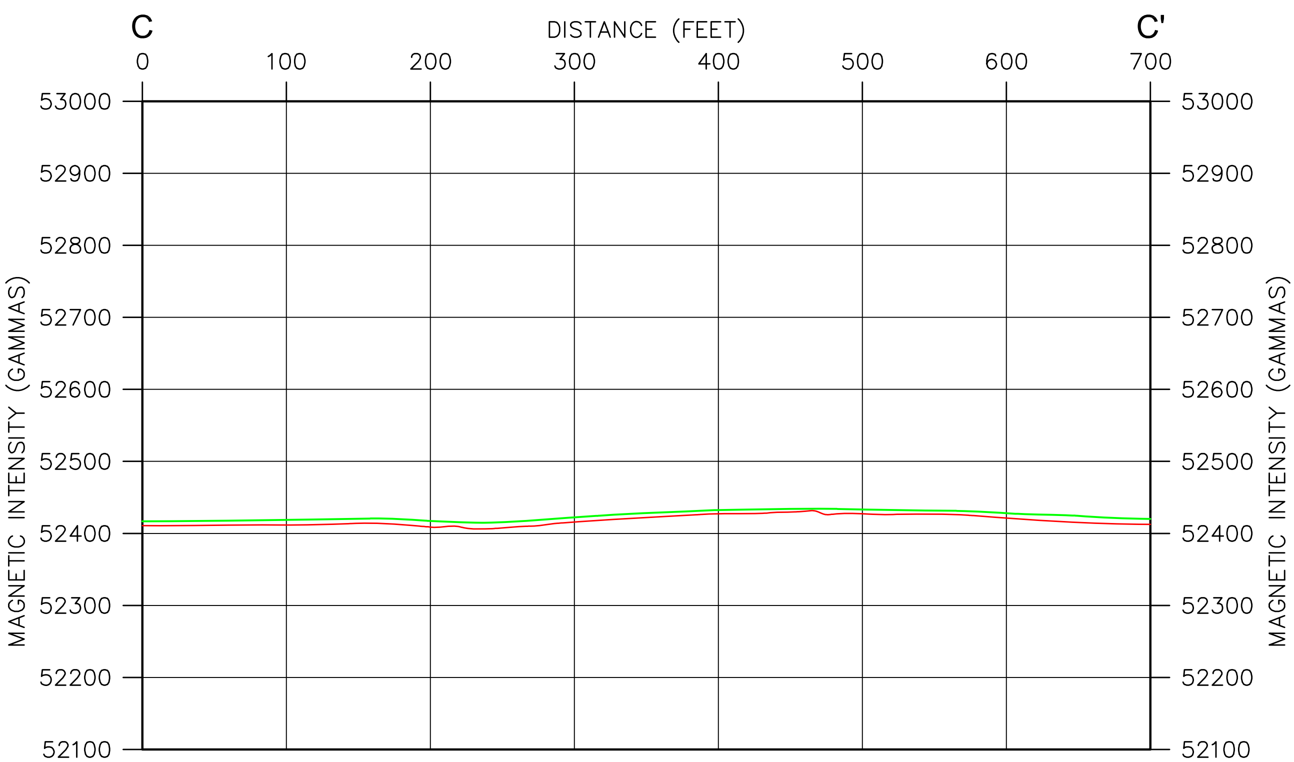

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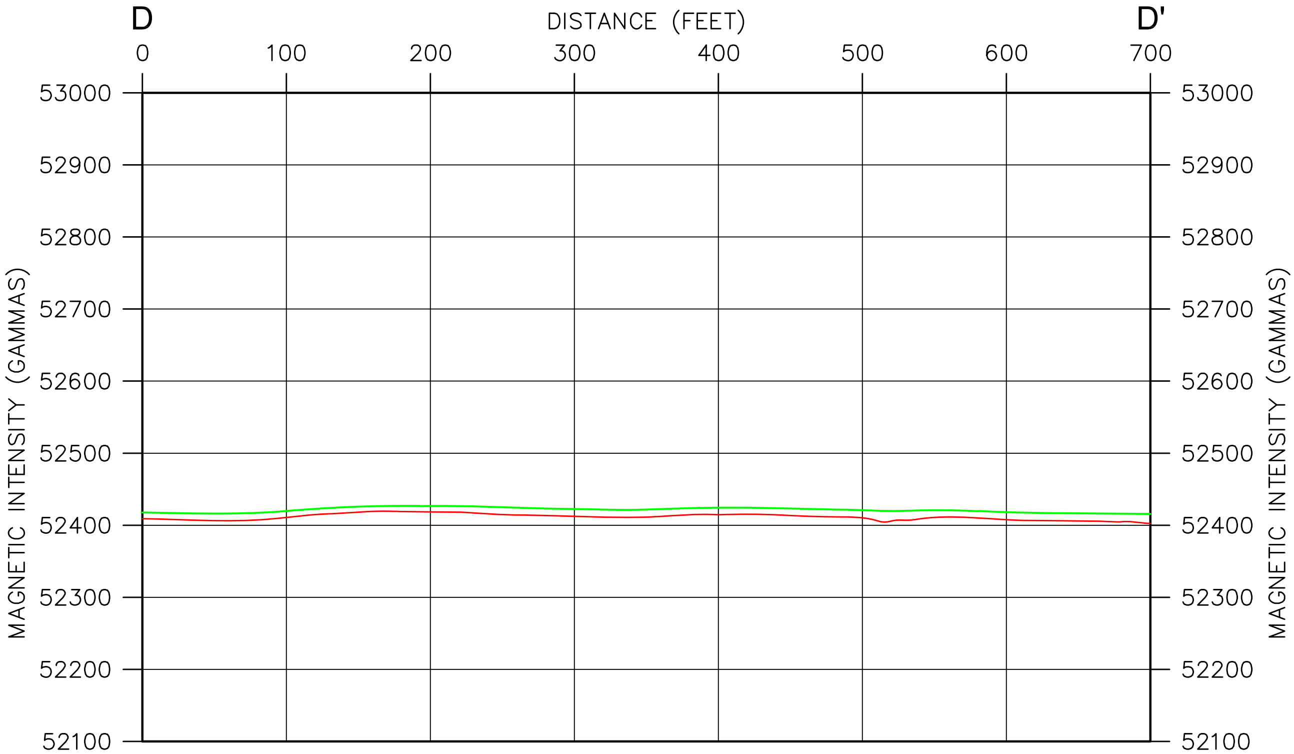
LINE 4



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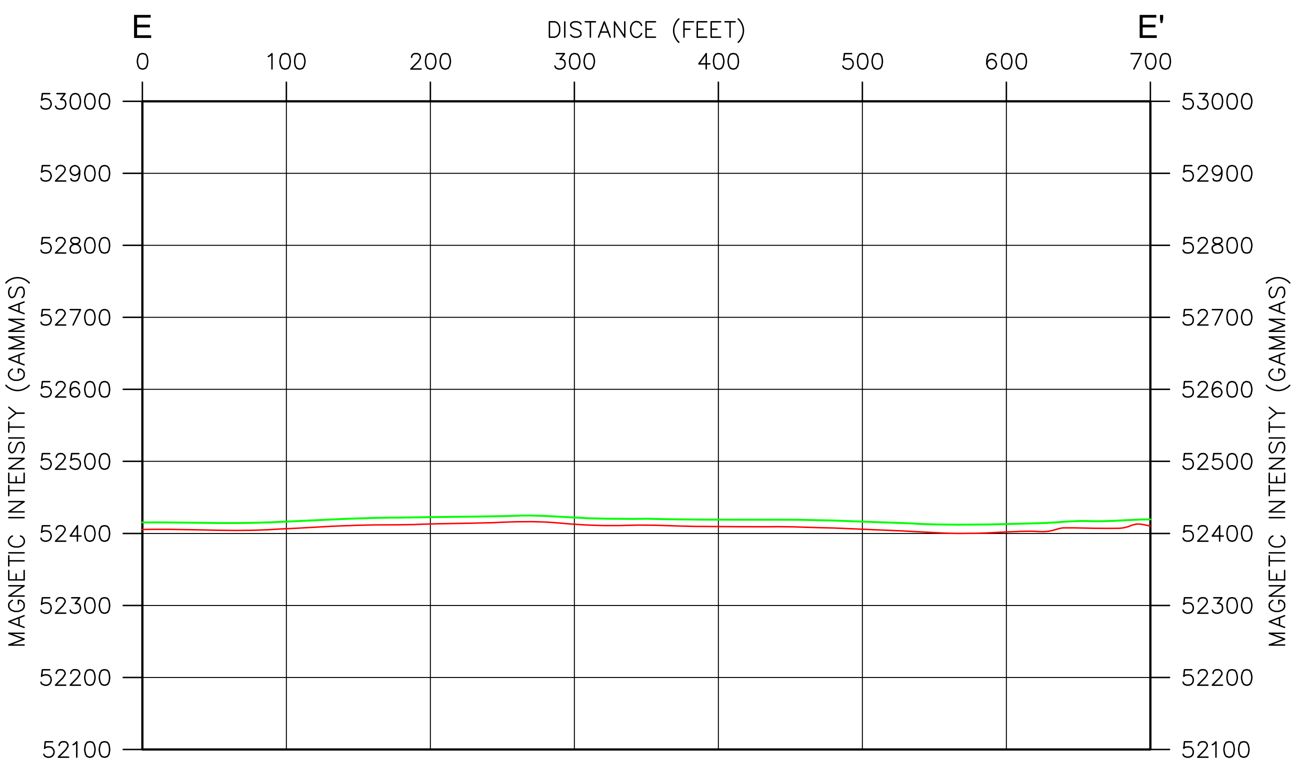

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