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November 3rd, 2010
File 2010081

Mr. David Sullivan
TRC
Wannalancit Mills
650 Suffolk Street, Suite 200
Lowell, 01854

Re: Geophysical Investigation
Nemasket Street Lot
Corner of Hathaway Avenue and Ruggles Street
New Bedford, MA

Dear Mr. Sullivan:

This letter details the results of a geophysical investigation conducted by Hager GeoScience, Inc. (HGI) for TRC Solutions, Inc. (TRC) at the Nemasket Street Lot site in New Bedford, MA. The purpose of the investigation was to locate buried objects and materials possibly responsible for known ground contamination. The site had previously been used for municipal waste and potentially contains a large number of buried materials.

DATA ACQUISITION AND ANALYSIS

HGI performed the survey over three separate field days, beginning on October 20th and continuing on October 22nd and 29th, 2010. During this period, data were collected using both ground penetrating radar (GPR) and electromagnetic (EM) terrain conductivity techniques. Most of the EM data were collected on the first day, with a small swale area along the western edge of the site surveyed on the third day after obstructions had been removed. GPR data collection was started on the second day, at which time EM anomalies were marked in the field, and completed on the third day. HGI used GPS to mark the corners of the survey grid as well as to determine the locations of EM anomalies marked in the field.

Appendix A at the end of this letter report contains descriptions of the two geophysical techniques and their limitations.

GPR Survey

GPR data were collected using a GSSI SIR-3000 GPR system with both 400-MHz (north-south orientation) and 200-MHz (east-west orientation) antennas, providing data from 8 to 15 feet deep. A survey wheel provided horizontal distance control. The data were recorded with the acquisition time window set at 100 and 200 nanoseconds (ns), respectively. Data were displayed in real time for quality control and initial data review purposes.

All acquired data were stored on the system's flash memory and subsequently transferred to a PC at the HGI office for signal processing and analysis using GSSI's RADAN for Windows XP™ software. The individual data files were used to evaluate utility and obstruction locations.

While evaluation of the GPR data collected on October 22nd was not complete upon HGI's return to the site on October 29th, HGI was able to flag several targets identified from its preliminary analysis.

EM Survey

EM data were collected with a GSSI GEM-300 terrain conductivity profiler, which uses multiple EM frequencies to enhance the detection of targets at varying depths. Multi-frequency EM profiling is routinely employed to delineate zones of varying subsurface materials. This method measures both the in-phase (for metal) and quadrature-phase (for conductivity) response of objects to an induced electromagnetic field.

EM data were collected continuously and simultaneously in a north-south direction at 4 transmitting frequencies (3030, 7030, 10030, 15030 Hertz). After completion of the fieldwork, the EM data were downloaded to a PC. Magmapper® and Excel® software were used to reduce the EM data and incorporate survey geometry, followed by the preparation of filled color contour plots using Golden Software's Surfer for Windows V8® and a kriging interpolation method. EM data collected on October 20th were processed and interpreted for fast turnaround so that potential targets could be identified and marked out for TRC without holding up the planned excavation schedule. Data from the small additional area (swale) surveyed on October 29th has been added to the final EM contour plots, the most informative of which were exported from Surfer into AutoCAD as .dxf files, saved as AutoCAD drawings, and overlaid on an AutoCAD base map provided by TRC.

The readings taken by the EM profiler are relative to a "zero" value calibrated at the site, and the values are in parts per million (ppm). High-conductivity anomalies (red) are typically associated with metal or iron-rich soils. Vegetation, rocks, or other materials can produce low-conductivity anomalies (blue). Concentrations of surface or near-surface metal may produce closely spaced high-low pairs.

GPS Locating

HGI recorded traverse, grid, and target locations using a Sokkia 2700ISX RTK global positioning system. The Sokkia system provided an accuracy of less than 0.164 feet horizontally and 0.328 feet vertically in the Massachusetts State Plane Coordinate system.

RESULTS

The results of the geophysical survey are shown on Plates 1 through 3 and described below.

Plate 1

Plate 1 is a color contour plot for the in-phase EM data collected at the Nemasket Street Lot site. Anomalies produced by metal are shown in red hatch, with surface metal identified where identified at two locations. Targets marked in the field for TRC investigation are cross-hatched.

Plate 2

Plate 2 is a color contour plot for the quadrature-phase EM data collected at the Nemasket Street Lot site. Anomalies produced by conductive soils are outlined in blue, including two large areas oriented approximately north-south possibly associated with changes in fill or disturbed soil. Other anomalies are probably related to vegetation (east edge of the site) and a landfill liner (north edge of the site, also found in the GPR data).

Plate 3

Plate 3 combines the GPR and EM investigation results. Targets identified from the GPR data are shown in violet-hatched circles. GPR targets marked in the field for TRC investigation are cross-hatched.

Please contact us at (781) 935-8111 if you have any questions or need additional information.

Respectfully yours,
HAGER GEOSCIENCE, INC.

Jutta Hager, Ph.D.
President

APPENDIX A. THE GEOPHYSICAL TECHNIQUES

A.1 GROUND PENETRATING RADAR

A.1.1. Description of the Method. The principle of ground penetrating radar (GPR) is the same as that used by police radar, except that GPR transmits electromagnetic energy into the ground, and the energy is reflected back to the surface from interfaces between materials with contrasting electrical (dielectric and conductivity) and physical properties. The greater the contrast between two materials in the subsurface, the stronger the reflection observed on the GPR record. The depth of GPR signal penetration depends on the properties of the subsurface materials and the frequency of the antenna used to collect radar data. The lower the antenna frequency, the greater the signal penetration, but the lower the signal resolution

A.1.2. Data Collection. We perform our GPR surveys using our Geophysical Survey Systems (GSSI) SIR 2/2000/3000 ground penetrating radar systems. GPR data are digitally recorded on the hard drive of the system, which allows the GPR operator to filter out noise attributed to conductive soil conditions and stack data for better signal penetration. The unit can be completely portable when the operator carries the electronics in a harness and pulls the antenna behind him at the end of a 3-meter attenuated control cable. For shallow surveys, we use a 400- or 1500-megahertz (MHz) antenna. For deeper penetration, we use lower frequency antennas ranging from 100-MHz to 15 MHz, depending on the anticipated depth of the target and the degree of signal penetration. All of these antenna configurations can collect data in continuous mode or as discrete point measurements using stacking techniques. Since there is a tradeoff between signal penetration and resolution, we frequently run test lines using antennas with several frequencies and use the highest frequency antenna that produces the highest quality data.

The horizontal scale of the GPR record shows distance along the survey traverse. In the continuous data collection mode, the horizontal scale on each GPR record is determined by the antenna speed. When a survey wheel is used, the GPR record is automatically marked at specified intervals along the survey line. The vertical scale of the radar records is determined by the recording time window or interval. The recording time interval represents the maximum two-way travel time in which data are recorded. The conversion of two-way travel time to depth depends on the propagation velocity of the GPR signal, which is site specific. When little or no information is available about the makeup of subsurface materials, we estimate propagation velocities from handbook values and experience at similar sites or by CDP velocity surveys with our bi-static antenna.

A.1.3. Data Processing. After completion of data collection, the GPR data are transferred to a PC for review and processing using RADAN for Windows XP™ software. When appropriate, we prepare 3D models of GPR data, which can be sliced in the X, Y, and Z directions. For surveys to map rebar and conduits in concrete, HGI uses the Structure Scan II© system. Data are collected at 2-inch spacing in two directions on a 2x2-foot pad. The StructureScan II© software takes the input radar file and creates a 3D model of the grid area. Given the propagation velocity, the module automatically generates time slices of the developed model at user-chosen depth intervals. Migration techniques included in the module are used to constrain the actual position of rebar and pipe reflections in the records.

The size, shape, and amplitude of GPR reflections are used to interpret GPR data. Metal objects such as USTs and utilities produce reflections with high amplitude and distinctive hyperbolic shapes in GPR records when traverses are made perpendicular to their long axes. Clay or concrete pipes and boulders may produce radar signatures of similar shape but lower amplitude. The boundaries between saturated and unsaturated materials, sand and clay, and bedrock and overburden generally also produce strong reflections.

A.1.4. Limitations of the Method. GPR signal penetration is site specific, determined by the dielectric properties of local soil and fill materials. GPR signals propagate well in resistive materials such as sand and gravel; however, soils containing clay, ash- or cinder-laden fill, or fill saturated with brackish or otherwise conductive groundwater cause GPR signal attenuation and loss of target resolution. Concrete containing rebar or mesh also inhibits signal penetration.

Interpreted depths of objects detected using GPR are based on on-site calibration, handbook values, and/or estimated GPR signal propagation velocities from similar sites. GPR velocities and depth estimates may vary if the medium of investigation or soil water content is not uniform throughout the site.

Utilities are interpreted on the basis of reflectors of similar size and depth that show a linear trend, but GPR cannot unambiguously determine that all such reflectors are related. Fiberglass USTs or utilities composed of plastic or clay may be difficult to detect if situated in soils with similar electromagnetic properties. Objects buried beneath reinforced concrete pads may also be difficult, but possible, to detect.

Changes in the speed at which the GPR antenna is moved between stations causes slight variations in distance interpolations, and hence in interpreted object positions.

The GPR antenna produces a cone-shaped signal pattern that emanates approximately 45 degrees from horizontal fore and aft of the antenna. Therefore, buried objects may be detected before the antenna is located directly over them, and GPR anomalies may appear larger than actual target dimensions.

GPR is an interpretive method, based on the identification of reflection patterns that may not uniquely identify a subsurface target. Borings, test pits, or site utility plans must be used to verify the results.

A.2 EM TERRAIN CONDUCTIVITY

A.2.1. Description of the Method. The EM technique operates on the principle that secondary electric and magnetic currents can be induced in metal objects and conductive bodies, such as USTs, utilities, and leachate, when an electric field is applied. This instrumentation measures the secondary magnetic field strength relative to the primary magnetic field and converts it directly into a conductivity value. Both the quadrature-phase (conductivity) and in-phase components of the secondary electric field are measured and values plotted in parts per million (ppm). In general, the quadrature-phase (conductivity) data provide information about soil and groundwater conditions, while the in-phase data provide information about metal objects. The instrument response is more affected by near surface than by deeper material.

We collect terrain conductivity data using a GEM-300 multi-frequency electromagnetic profiler. The GEM-300 is field-programmable to operate at simultaneous, multiple frequencies between 325 and 19975 Hz. The GEM sensor contains a transmitter and receiver coil separated by about 5.5 ft, along with a third “bucking coil” that removes the primary field from the receiver coil. All coils are molded into a single board in a fixed geometry.

A removable signal-processing console is attached to the board, from which data are downloaded to a computer and processed. The GEM-300 is capable of detecting underground targets and features to a depth of 26 feet.

A.2.2. Data Analysis and Interpretation. Terrain conductivity surveys are commonly used to determine the lateral extent of fill and detect buried metal objects, utilities, and conductive leachate plumes. Typically, terrain conductivity values measured on fill materials are irregular and highly variable over short distances due to metal and the heterogeneous materials in the subsurface. The edge of fill materials is marked by a change to smoothly varying terrain conductivity values that represent native soils.

At sites free of metal objects and other cultural interference, the soil lithology and/or the conductivity of the ground water control the terrain conductivity measured at a particular location. In the presence of metal, conductivity values are often negative ("polarity reversals") and highly irregular. However, the exact identification of objects cannot be determined from the terrain conductivity data alone. The in-phase component helps confirm the location of metal objects when correlated with conductivity data. Irregular or high positive or negative in-phase values may be caused by metal objects and help define their lateral extent.

Leachate plumes are generally recognized by relatively smoothly varying, but anomalously elevated, conductivity values, compared to background values for a given site. The value of the in-phase component resulting from conductive plumes generally shows little or no variation.

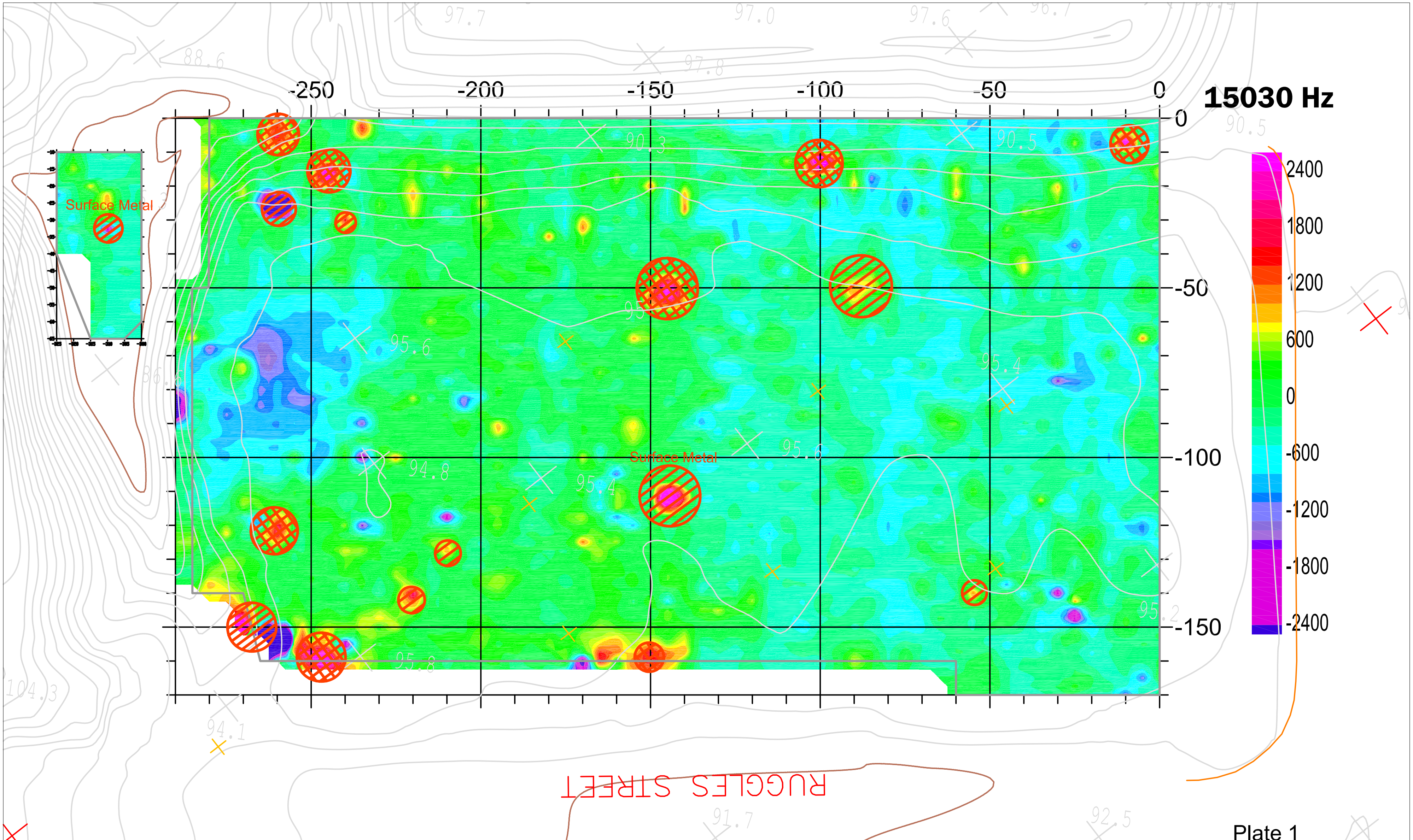
A.2.3. Limitations of the Method. EM conductivity values are influenced by proximity to aboveground metal objects, such as fences, vehicles, or buildings. Magnetic fields produced along overhead power lines also interfere with terrain conductivity readings.

The shape and amplitude of conductivity and in-phase anomalies do not uniquely describe a buried object or material. Rather, they are influenced by the orientation of EM survey lines and the buried object(s) relative to north, and the orientation of the EM sensor relative to this buried object(s). To better locate the source(s) of EM conductivity and in-phase anomalies, data are frequently collected in two perpendicular directions.

High ambient conductivity readings (from a conductivity plume, sludge, or naturally occurring geologic condition) may mask anomalous conductivity values caused by metal objects. Evaluating the in-phase component of the data minimizes this effect.

Closely spaced buried utilities may produce anomalies that interfere with each other. Hence, in areas where numerous utilities are present, the observed anomaly may result from an interference pattern and may not uniquely describe the location of a specific utility. Further, anomalies often appear larger than the object that produces them.

Smaller utilities, or utilities constructed from reinforced concrete, may be masked by larger utilities constructed of metal. Nonmetallic fill such as unreinforced concrete rubble and utilities constructed from PVC, clay, or unreinforced concrete may not be detected.



LEGEND

Survey Extent

EM Metal Anomaly

EM Metal Anomaly Marked in Field

Notes:
1) The GPR and EM results are overlaid as a best fit on a base map provided by TRC.
2) The "GPR Anomaly" category contains anomalies differentiated from the background due to their geometry and/or signal strength.
3) The "EM Anomaly" category contains anomalies differentiated from the background due to their electromagnetic properties.

HGI

Approximate

0 20 40 80

Scale in Feet

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Electromagnetic Interpretation
In-Phase Results
Nemasket Street Lot
New Bedford, MA

Hager GeoScience, Inc.
596 Main Street, Woburn, MA 01801
(781)-935-8111 hgi@hagergeoscience.com

NOT ALL SUBSURFACE FEATURES MAY BE DEPICTED ON THIS MAP

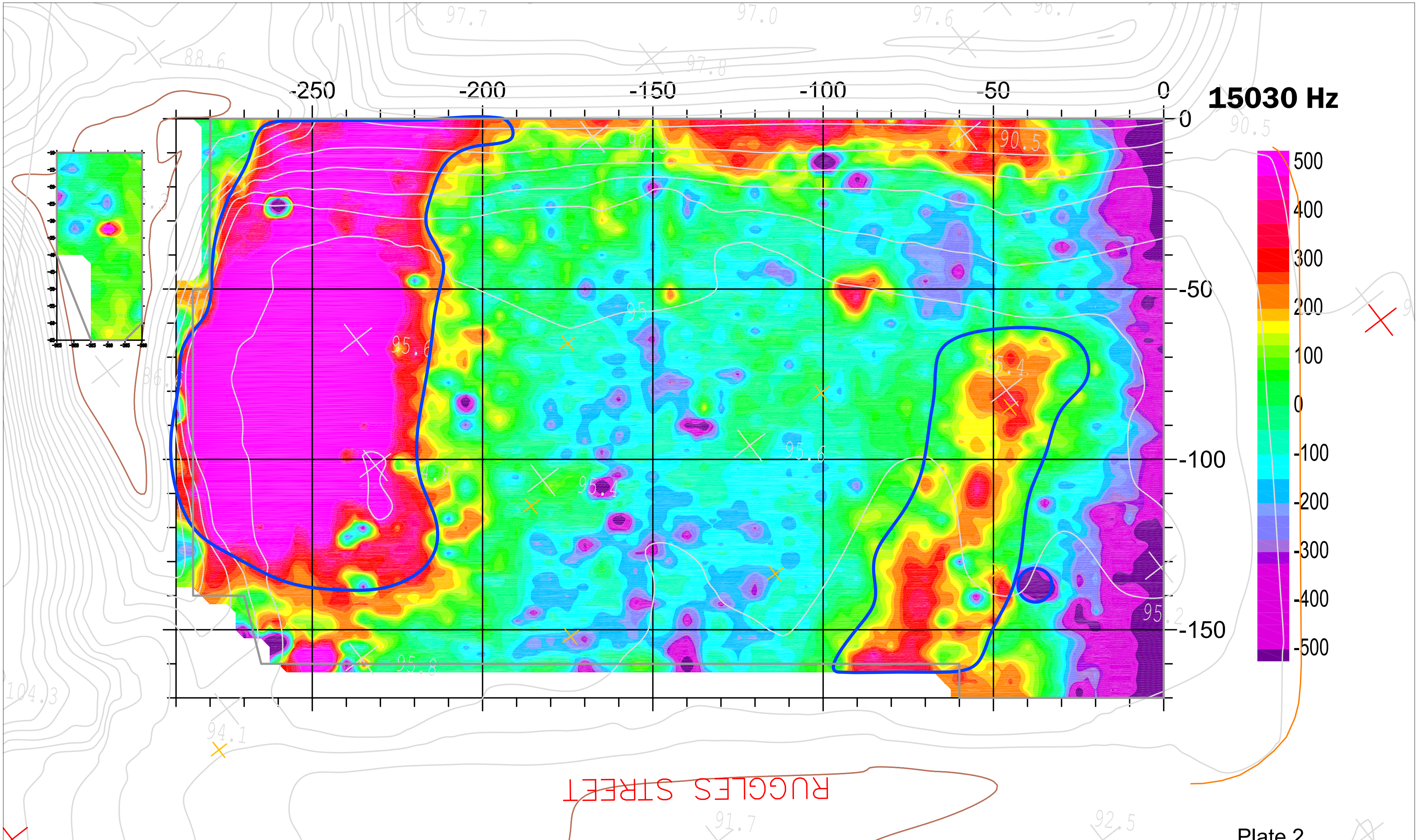

Plate 2

LEGEND

Survey Extent

EM Soil Conductivity Anomaly

Notes:
1) The GPR and EM results are overlaid as a best fit on a base map provided by TRC.
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3) The "EM Anomaly" category contains anomalies differentiated from the background due to their electromagnetic properties.

HGI

Approximate

0 20 40 80

Scale in Feet

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Electromagnetic Interpretation
Quadrature-Phase Results
Nemasket Street Lot
New Bedford, MA

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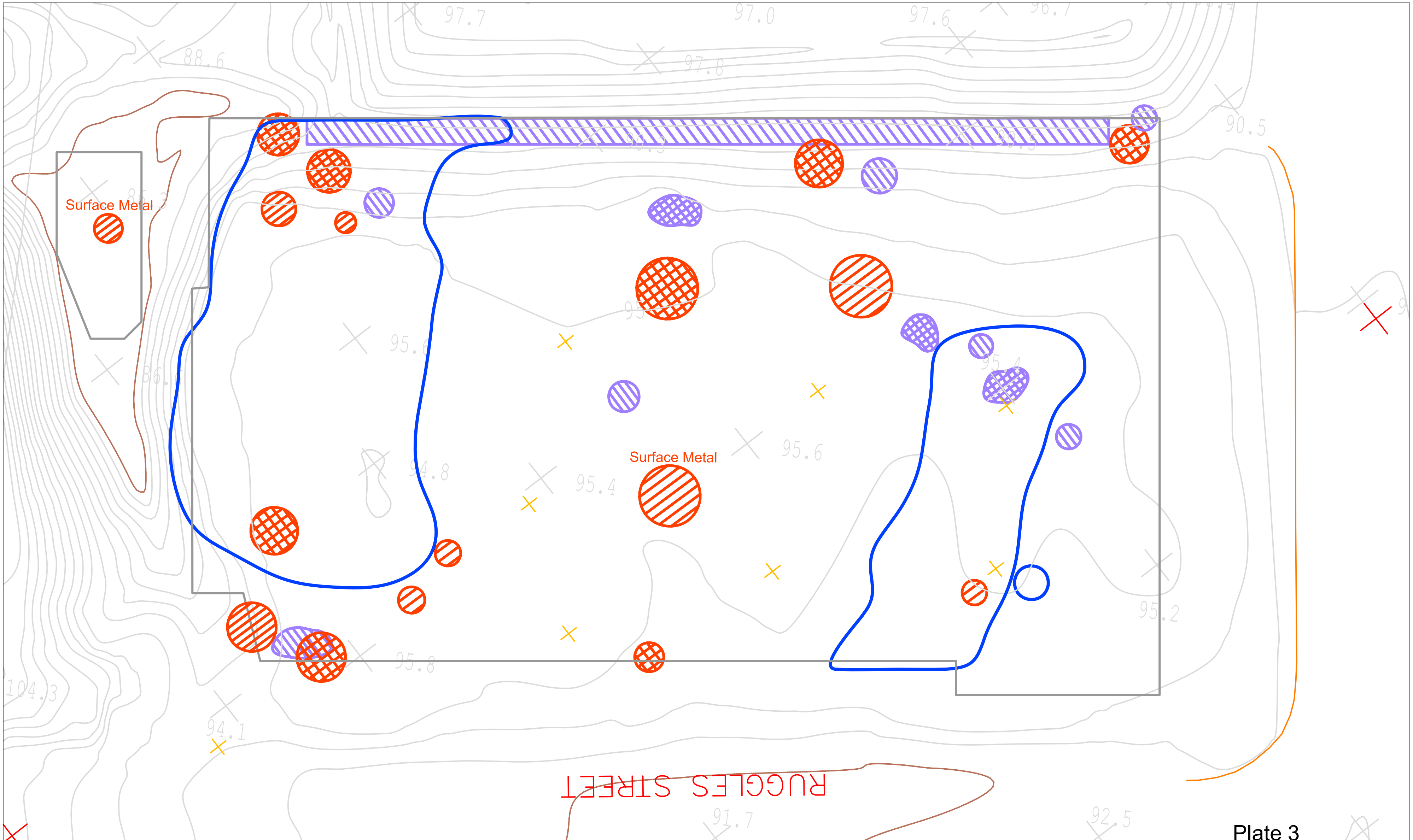

Plate 3

LEGEND

Survey Extent

EM Metal Anomaly

EM Metal Anomaly Marked in Field

EM Soil Conductivity Anomaly

GPR Anomaly

GPR Anomaly Marked in Field

Notes:
1) The GPR and EM results are overlaid as a best fit on a base map provided by TRC.
2) The "GPR Anomaly" category contains anomalies differentiated from the background due to their geometry and/or signal strength.
3) The "EM Anomaly" category contains anomalies differentiated from the background due to their electromagnetic properties.

HGI

Approximate

0 20 40 80

Scale in Feet

NOVEMBER 2010 | FILE NO. 2010081

Combined EM and GPR Results
Nemasket Street Lot
New Bedford, MA

Hager GeoScience, Inc.
596 Main Street, Woburn, MA 01801
(781)-935-8111 hgi@hagergeoscience.com

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