Jill Betts
Coles and Betts Environmental Consulting

UST Survey - Vacant Lot
N Williams Avenue and NE Russell Street Block
Portland, Oregon

A geophysical survey was conducted across the city block bordered by N. Williams Avenue, NE Russell Street, NE Knott Street and N. Vancouver Avenue in Portland, Oregon for Coles and Betts. The site is presently a grass-covered, flat, vacant lot. In the past, the property contained several residences and buildings including a paint store and warehouse, two cleaners, a printing shop, and an insect-powder manufacturer. The scope of this survey was to detect possible underground storage tanks (USTs) and/or excavations from which tanks had been removed, and remnants of the old structures. The adjacent sidewalks and the southern part of N. Knott Street from the curb to the parking lines to the north were included. No surface evidence of USTs, including fill ports and vent pipes, was seen in the survey areas.

A Geometrics G858 cesium-vapor magnetometer was used to collect magnetic data across the sidewalk. Data were collected along parallel survey lines established using a measuring wheel and tapes. Each data point was located to an accuracy of about 1 foot using a Geode 2 sub-meter-accuracy GPS system. Figure 1 shows the site location as well as magnetic data points.

Figure 2 shows the result of the magnetic survey. Data are contoured using a contour interval of 500 nT (nanoTesla). In the figure, magnetic anomalies higher in amplitude than the normal local magnetic background are shown in red and are usually found over areas where ferrous objects are located below the sensor, carried at a height of about 3 feet. USTs usually produce red-colored anomalies. Magnetic anomalies at or below the amplitude of the local magnetic field are shown in blue and are generally caused by ferrous objects located above the sensor. Telephone poles, metallic street signs and bollards located along the sidewalks created magnetic interference. A small UST located near these objects could have been missed.

This site was relatively clear of large buried metallic objects. A Schonstedt magnetic gradiometer and an Aqua-Tronics Tracer metal detector were used to locate and investigate the anomalies shown in the figure. The Tracer is excellent at determining if a buried object is linear (a possible pipe) or 3D (a possible UST). The anomalies were also examined using a GSSI SIR2000 ground-penetrating radar (GPR) system connected to a 400-MHz antenna during the subsequent ground penetrating radar (GPR) survey. None of the objects appeared to be three-dimensional; most appeared to be caused by pipes or surface features. They did not appear to be USTs.

Magnetometer Anomalies:
A- possible pipe
B- underground pipes
C- surface object
D- not a 3D object
E- surface feature – bollard and sign
F- not a 3D object
G- not a 3D object
H- underground pipes
I- underground pipe, bollard
J- surface features
K- reinforced concrete
L- decorative wall

The entire site was scanned using the GSSI GPR system. Traverses were made along survey lines set approximately 5 feet apart. The quality of the data was adequate to detect features within the top 2 to 3 feet.

Several large, "flat" zones were detected just below the ground surface (Figure 3). One, near the B anomalies, could be related to a former building (Insect Powder Manufacturer). These flat zones could be remnants of slab building floors. One disturbed soil zone (DSZ) was detected. It could be a former excavation. Several other GPR anomalies were detected; however, their identity could not be determined. They did not appear to contain metal and were only seen in one or two adjacent profiles.

No USTs were detected with this survey across the accessible areas of the site.

Jeff Mann and Nikos Tzetos of Pacific Geophysics conducted the survey for Ms. Jill Betts of Coles and Betts Environmental Consulting on August 20 and 21, 2020. This letter report was written by Jeff Mann, reviewed by Nikos Tzetos, and emailed to Ms. Betts on September 1, 2020.

Limitations

The conclusions presented in this report were based upon widely accepted geophysical principles, methods and equipment. This survey was conducted with limited knowledge of the site, the site history and the subsurface conditions.

The goal of near-surface geophysics is to provide a rapid means of characterizing the subsurface using non-intrusive methods. Conclusions based upon these methods are generally reliable; however, due to the inherent ambiguity of the methods, no single interpretation of the data can be made. As an example, rocks and roots produce radar reflections that may appear the same as pipes and tanks.

Under reasonable conditions, geophysical surveys are good at detecting changes in the subsurface caused by man-made objects or changes in subsurface conditions, but they are poor at actually identifying those objects or subsurface conditions.

Objects of interest are not always detectable due to surface and subsurface conditions. The deeper an object is buried, the more difficult it is to detect, and the less accurately it can be located.

The only way to see an object is to physically expose it.

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August 24, 2020

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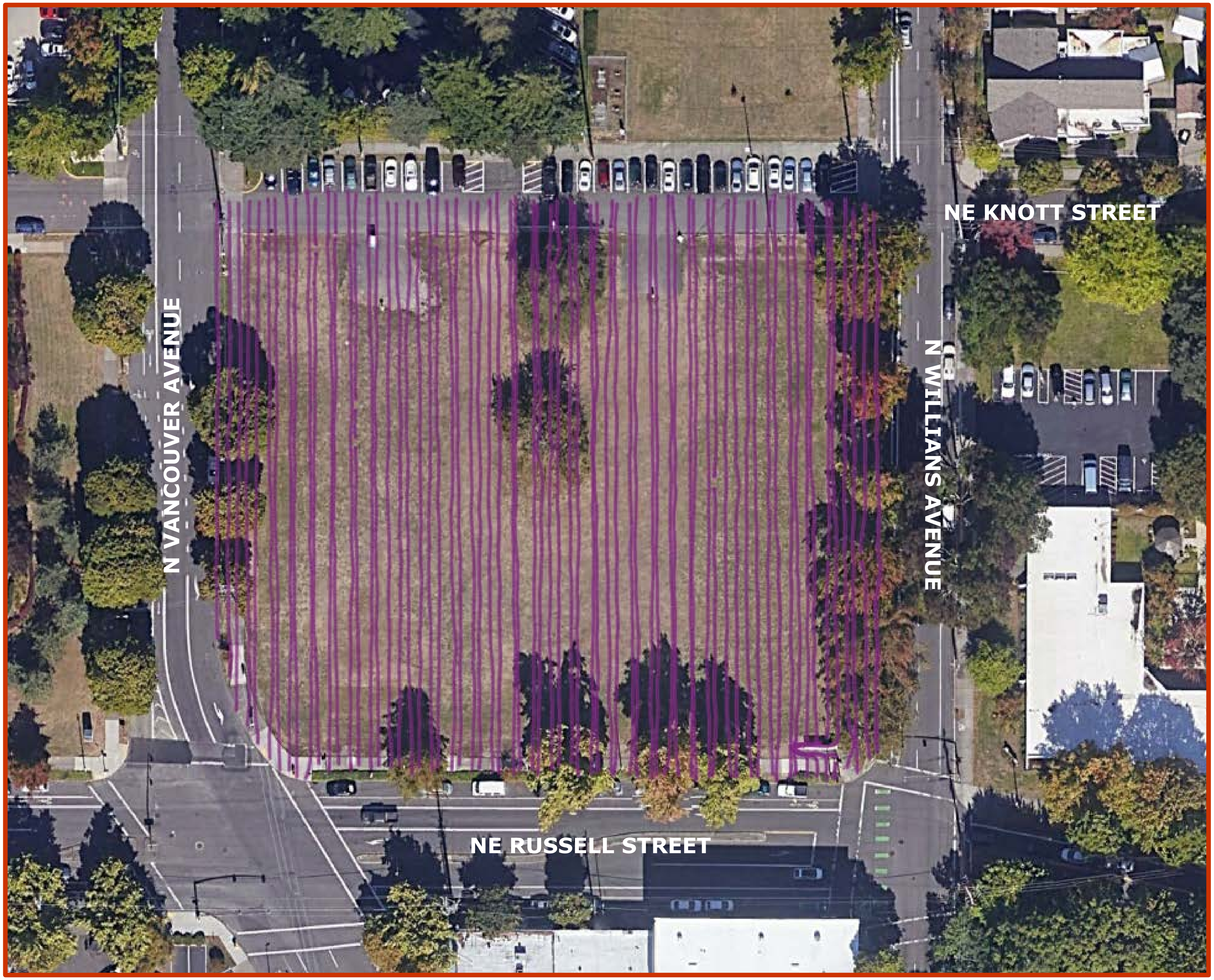

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FIGURE 1

Survey Location and Coverage

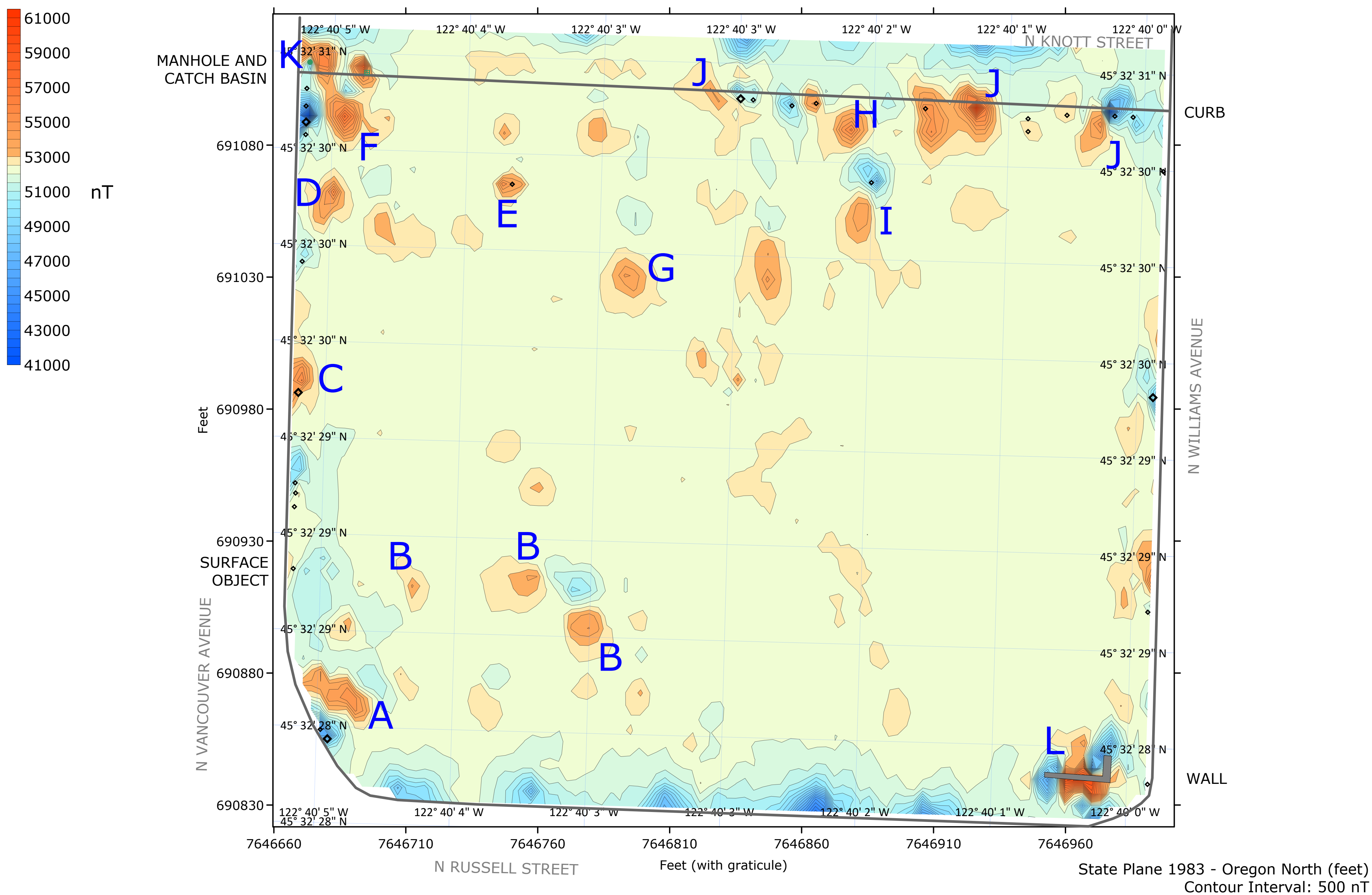
Project: 200705

Vacant Lot
N Russell Str. at N Vancouver Ave.
Portland, Oregon

Drawn by : NT

Prepared for: Coles & Betts

Base Photo from Google Earth



PACIFIC GEOPHYSICS

FIGURE 2

Magnetic Contour Map

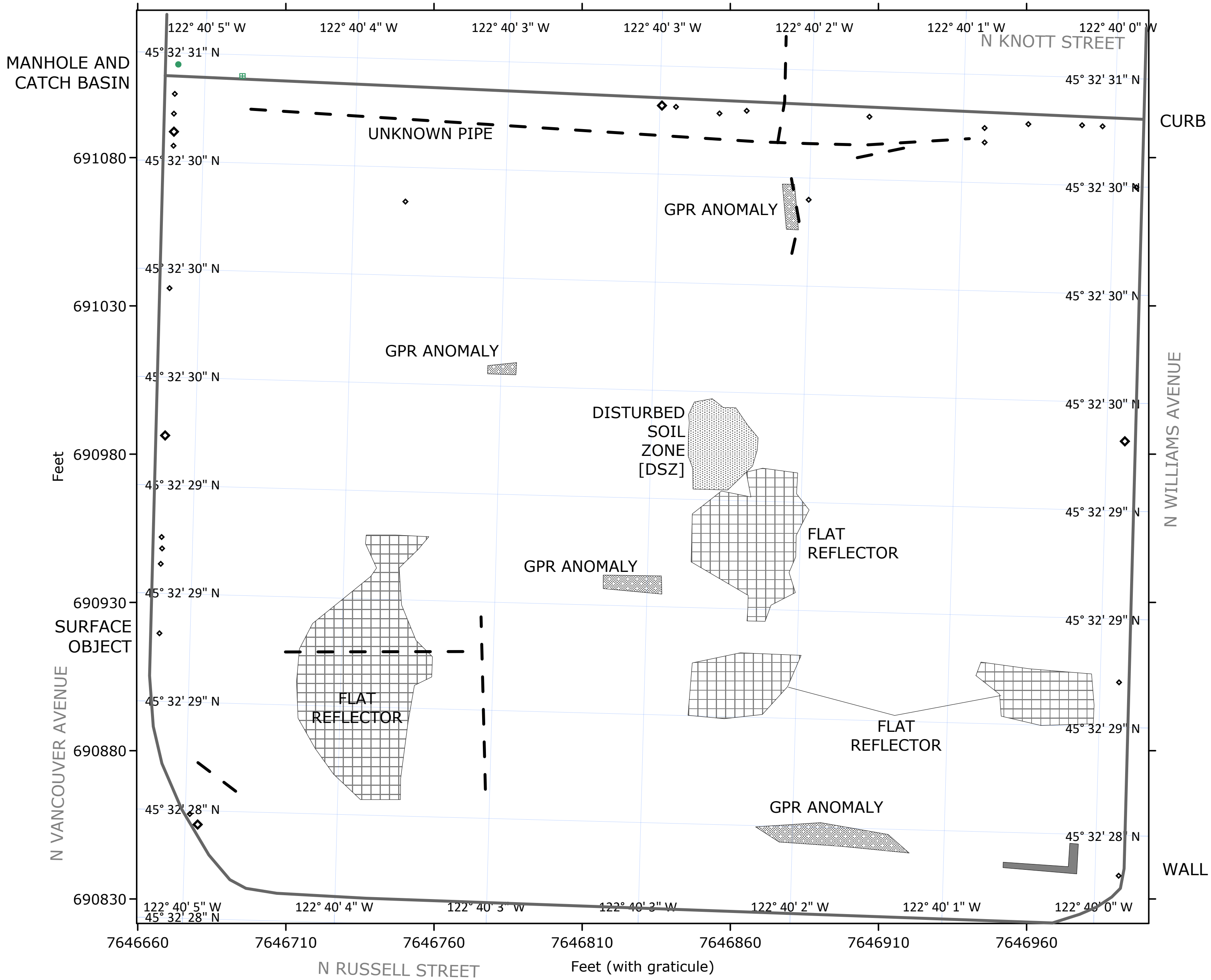
Project: 200705

Vacant Lot
N Russell Str. at N Vancouver Ave.
Portland, Oregon

Drawn by : NT

Prepared for: Coles & Betts

Survey Date: 8/20-21/2020



State Plane 1983 - Oregon North (feet)

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FIGURE 3

Interpretation Map

Project: 200705	Vacant Lot N Russell Str. at N Vancouver Ave. Portland, Oregon
Drawn by : NT	Prepared for: Coles & Betts Survey Date: 8/20-21/2020

Appendix A. Geophysical Survey Methods

Magnetometer Surveys

Small disturbances in the Earth's local magnetic field are called "magnetic anomalies". These may be caused by naturally occurring features such as metallic mineral ore bodies, or from manmade features such as metal buildings, vehicles, fences, and underground storage tanks. The magnetometer only detects changes produced by ferrous objects. Aluminum and brass are non-ferrous metals and cannot be detected using a magnetometer.

A magnetometer is an electronic instrument designed to detect small changes in the Earth's local magnetic field. Over the years different technologies have been used in magnetometers. The Geometrics G-858 Portable Cesium Magnetometer used to collect magnetic data for Pacific Geophysics uses one of the most recent methods to detect magnetic anomalies. A detailed discussion describing the method this unit uses is available at Geometrics.com.

This magnetometer enables the operator to collect data rapidly and continuously rather than the older instruments that collected data at discreet points only. The G-858 is carried by hand across the site. The sensor is carried at waist level. Typically individual data points collected at normal walking speed are about 6" apart along survey lines usually 5 feet apart, depending on the dimensions of the target objects.

It is critical to know the exact location of each data point so that if an anomaly is detected it can be accurately plotted on a magnetic contour map. At most small sites, data are collected along straight, parallel survey lines set up on the site before the data collection stage begins. For very large, complex sites, the G-858 can be connected to a Global Positioning System (GPS) antenna which allows the operator to collect accurately-located data without establishing a survey grid. With GPS, data are collected and positioned wherever the operator walks. A limitation using GPS is that the GPS antenna must have line of sight with the GPS satellites. Data can be mislocated if the GPS antenna is under trees or near tall buildings.

Data are stored in the unit's memory for later downloading and processing. A magnetic contour map of the data is plotted in the field. Geographical features are plotted on the map. Magnetic anomalies appearing to be caused by objects of interest are then investigated on the site using several small hand-held metal detectors. If an object appears to be a possible object of interest, it may be investigated with GPR.

Magnetic contour maps may be printed in color in order to highlight anomalies caused by ferrous objects located under the magnetic sensor. Usually, ferrous objects situated below the sensor produce magnetic "highs" and anomalies located above the sensor produce magnetic "lows". Magnetic highs are of interest to the operator since most objects of interest are located underground.

Depending on the orientation, shape and mass of a metallic object, a high/low pair of magnetic anomalies may be present. In the northern hemisphere the magnetic low is located north of the object and the magnetic high toward the south. The object producing the anomaly is located part way between the high and the low anomalies.

Magnetometer surveys have limitations. Magnetometers only detect objects made of ferrous (iron-containing) metal. Large ferrous objects (buildings, cars, fences, etc.) within several feet of the magnetometer create interference that may hide the anomaly produced by a nearby object of interest.

Ground Penetrating Radar

A Geophysical Survey Systems, Inc. (GSSI) SIR-2000 GPR system coupled to GSSI antennas of various central frequencies is used to obtain the radar data for our surveys.

GPR antennas both transmit and receive electromagnetic energy. EM energy is transmitted into the material the antenna passes over. A portion of that energy is reflected back to the antenna and amplified. Reflections are displayed in real-time in a continuous cross section. Reflections are produced where there is a sufficient electrical contrast between two materials. Changes in the electrical properties (namely the dielectric constant) that produce radar reflections are caused by changes in the moisture content, porosity, mineralogy, and texture of the material. Metallic objects of interest exhibit a strong electrical contrast with the surrounding material and thus produce relatively strong reflections. Non-metallic objects of interest (septic tanks, cesspools, dry wells, and PVC and clay tile pipes) are not always good reflectors.

Radar data are ambiguous. It can be difficult to distinguish the reflection produced by an object of interest from the reflection caused by some natural feature. Rocks or tree roots have reflections that appear similar to reflections from pipes. In concrete investigations reflections produced by metal rebar look exactly like those from electrical conduit or post-tension cables. Objects with too small an electrical contrast may produce no reflections at all and may be missed. Target objects buried below objects with contrasting properties that also produce reflections may be missed (e.g. USTs below roots, concrete pieces, pipes or rocks). If an object of interest like a UST is buried below the depth of penetration of the radar signal, it will be missed.

In addition to interpreting ambiguous data, radar has several limitations that cannot be controlled by the operator. The radar signal is severely attenuated by electrically conductive material, including wet, clay-rich soil and reinforced concrete. The quality of the data is affected by the surface conditions over which the antenna is pulled. Ideally the antenna should rest firmly on a smooth surface. Rough terrain and tall grass reduce the quality of radar data.

It is the job of an experienced interpreter to examine the GPR profiles and deduce if reflections are from objects of interest. A GPR interpreter cannot see underground, but can only interpret reflections based on experience.

The only way to truly identify an object is to excavate.

Hand-held Metal detectors

Two small, non-recording metal detectors are used to locate suspect magnetic anomalies detected using the G-858 Magnetometer in order to determine the likely cause of the anomaly. First, the magnetic contour map and a Schonstedt Magnetic Gradiometer are used to locate the center of the magnetic anomalies.

Once the anomaly is located an Aqua-Tronics Tracer is used to determine if the object producing the anomaly is a possible object of interest. Most anomalies are at least in part produced by features observed on the ground surface.

Schonstedt Magnetic Gradiometer: This magnetometer has two magnetic sensors separated vertically by 10". The magnetic field surrounding a ferrous object is strongest near the object and decreases rapidly as the distance increases. If the magnitude measured by the sensor located in the tip of the Schonstedt is very high, and the magnetic field measured by the sensor located farther up the shaft of the Schonstedt is low, there is a large vertical magnetic gradient and the instrument responds with a loud whistle indicating the object is near the surface. If there is a small difference in the magnitudes measured by the two sensors, the object is deeper. The instrument responds with a softer tone. A discussion of this instrument is available at Schonstedt.com.

Aqua-Tronics A-6 Tracer: The Aqua-Tronics A-6 Tracer uses a different method of detecting metallic objects. This instrument measures the electrical conductivity of a metal object. It is capable of detecting any electrically conductive metal, including non-ferrous aluminum and brass. The Tracer is capable of detecting three-dimensional objects as well as pipes.

The Tracer consists of a transmitter coil and a receiver coil. In the absence of any electrically conductive material in the vicinity of the Tracer, the electromagnetic field around each coil is balanced.

Basically the electromagnetic field produced by the transmitter induces an electric current into the area surrounding the instrument. Nearby conductive objects distort the EM field. The balance between the two coils is disturbed and the instrument produces an audible tone and meter indication.

Radio Detection RD8000 PDL pipe and cable detector: This instrument may be used to detect buried, conductive pipes and utilities. It consists of a transmitter and a receiver and can be used in two configurations.

The transmitter may be used to directly apply a small electrical current to exposed, electrically conductive pipes and utilities. The RD receiver is then able to "trace" the underground portion of the pipe or utility, under some conditions for several hundred feet. The transmitter can also induce an electrical current into buried pipes and utilities where direct contact is not available.

The receiver can also be used alone. It has the capability to locate pipes and utilities by detecting the very small electrical currents induced into the features by nearby AM/FM radio stations.

The receiver also has an AC power function that may be used to detect underground power lines.