United States Department of Agriculture

Natural Resources Conservation Service

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Subject: Archaeology -- Geophysical Assistance

Date: 23 August 2001

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Purpose:
Ground-penetrating radar (GPR) and electromagnetic induction (EMI) were used in an attempt to locate gravesites and buried historic structures or features at Old Fort Boise, the Old State Penitentiary in Boise, and at a site near New Plymouth, Idaho. In addition NRCS provided GPR assistance to the Sheriff's Department in Oneida County in an attempt to locate a body.

Participants:
Tom Burnham, District Conservationist, USDA-NRCS, Jerome, ID
Jim Doolittle, Research Soil Scientist, USDA-NRCS, Newtown Square, PA
Suzi Neitzel, Deputy State Historic Preservation Officer, Boise, ID
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Neil Peterson, State Soil Specialist, USDA-NRCS, Boise, ID
Jeff Simrad, Sheriff, Oneida County Sheriff Department, Malad City, ID
Steve Stocks, Sgt. Oneida County Sheriff Department, Malad City, ID

Activities:
All field activities were completed during the period of 13 to 15 August 2001.

Equipment:
The radar unit is the Subsurface Interface Radar (SIR) System-2000, manufactured by Geophysical Survey Systems, Inc.[1] The SIR System-2000 consists of a digital control unit with keypad, VGA video screen, and connector panel. A 12-volt battery powered the system. This unit is backpack portable and, with an antenna, requires two people to operate. 400 and 200 MHz antennas were used in this study. Hard copies of the radar data were printed in the field on a model T-104 printer.

Geophysical Survey Systems, Inc. manufactures the GEM300 multifrequency sensor.[1] This EMI sensor is portable and requires only one person to operate. No ground contact is required with the GEM300 sensor. This sensor is configured to simultaneously measure up to 16 frequencies between 330 and 19,950 Hz with a fixed coil separation (1.3 m). The GEM300 sensor is keypad operated. Measurements can be either automatically or manually triggered. With the GEM300 sensor, the depth of penetration is considered *skin depth limited*. The *skin-depth* represents the maximum depth of penetration and is frequency and soil dependent: low frequency signals travel farther through conductive mediums than high frequency signal. The theoretical penetration depth of the GEM300 sensor is dependent upon the bulk conductivity of the profiled earthen material(s) and the operating frequency. Multifrequency sounding with the GEM300 allows multiple depths to be profiled with one pass of the sensor.

EMI
Electromagnetic induction measures vertical and lateral variations in magnetic and/or electrical fields associated with induced subsurface currents. Traditionally, EMI data are expressed as apparent conductivity in milliSiemens per meter (mS/m). The GEM300 sensor automatically converts data recorded in the quadrature phase into apparent conductivity. Values of apparent

[1] Manufacturer's names are provided for specific information; use does not constitute endorsement.

conductivity are expressed in milliSiemens per meter (mS/m). Apparent conductivity is a weighted, average conductivity measurement for a column of earthen materials to a specific depth (Greenhouse and Slaine, 1983). Variations in apparent conductivity are produced by changes in the electrical conductivity of earthen materials. The electrical conductivity of soils is influenced by the volumetric water content, type and concentration of ions in solution, amount and type of clays in the soil matrix, temperature, and phase of the soil water (McNeill, 1980). The apparent conductivity of soils increases with increased soluble salts, water, and clay contents (Kachanoski et al., 1988; Rhoades et al., 1976).

Electromagnetic induction measures vertical and lateral variations in apparent electrical conductivity. Values of apparent conductivity are seldom diagnostic in themselves, but lateral and vertical variations in these measurements can be used to infer changes in earthen materials. Interpretations are based on the identification of spatial patterns within data sets.

GPR

The size, orientation, and depth to an anomaly affect detection. Large objects reflect more energy and are easier to detect than small objects. Small, shallowly buried features will be missed, unless located directly beneath the aperture of the radar antenna. With GPR surveys covering extensive areas, the detection of small cultural features is often considered fortuitous. Small, deeply buried cultural features are difficult to discern on radar profiles. In many of the soils profiled in southern Idaho with the GPR, signal attenuation limited observation depths and antenna selection.

Large, electrically contrasting features reflect more energy and are easier to detect than small, less contrasting features. Foundation walls of a large buried structure are more likely to be detected than a small, isolated artifact. The size, orientation, and depth to buried features affect their discernment with GPR. The size and shape of a subsurface anomaly may suggest its identity. Subsurface anomalies that are narrow and linear may, depending on their dimensions, can suggest a buried utility line, road, foundation wall, or burial. Multiple, randomly spaced, subsurface anomalies occurring at a common depth may suggest cultural features from a unique period of history. In instances where features are small, randomly distributed, non-aligned, and/or variable in depth, positive identification can not be assured from radar interpretations alone and a greater number of observation pits are required to verify interpretations.

Old Fort Boise

In 1834 the Hudson Bay Company established Fort Boise on the east bank of the Snake River immediately below its confluence with the Boise River. The fort was about 100 feet square and was enclosed by either a stockade of poles or adobe walls. The fort contained several adobe structures. Devastating floods destroyed Fort Boise in 1853 and 1862. These floods and the continual shifting of the river channel have erased all signs of the fort. As a consequence, the exact location of the fort is unknown. However, the site of the fort is suspected to be near a historic marker commemorating the fort in Deer Flat National Wildlife Refuge.

The study site is located in an area that has been mapped as Baldock loam, 1 to 3 percent slopes (Priest et al., 1972). The somewhat poorly drained, calcareous Baldock soil formed in alluvium on bottomlands and very low terraces. At the time of the soil survey, the Baldock soil was classified as a member of the fine-loamy, mixed, calcareous, mesic Typic Haplaquepts family. Based on revisions to Soil Taxonomy, the Baldock series is presently a member of the fine-loamy, mixed, superactive, mesic Typic Calciaquolls family.

<u>Field Procedures:</u>

A 75 by 100 foot grid was established from a base line. The northwest end of this base line was located 5 feet (northeast) from the pedestal of the fort’s commemorative marker. The grid consisted of a 75-ft base line and two additional parallel lines. The two parallel lines were also 75-ft long and spaced 50 and 100 ft from the base line. Along each of these lines, survey flags were inserted in the ground at intervals of 5 ft. Apparent conductivity was recorded at a frequency of 14790 Hz with the GEM300 sensor held at hip-height. Walking at a uniform pace between similarly numbered flags on the three parallel lines completed an EMI survey. The GEM300 sensor was operated in the continuous mode and recorded an observation every second. Measurements were made in the vertical dipole orientation. This resulted in 449 observations.

Later, a random, *wildcat* survey was conducted across the survey area with the GPR. The 400 MHz antenna was used with a scanning time of 50 nanoseconds. The presence of moderate amounts of 2:1 lattice clays and carbonates in Baldock soils severely limited the penetration depth and appropriateness of using GPR for archaeological or soil investigations.

<u>Results:</u>

Figure 1 shows the results of the EMI survey. Several prominent anomalies have been detected in the survey area. Because of their high negative apparent conductivity, these anomalies are presumed to represent buried metallic objects. These objects appear randomly distributed within the survey area. It is probable that these features represent modern trash and debris. If the remnants of adobe structures associated with Fort Boise are present in this area, they either lack sufficient contrast with the surrounding soil matrix to be identified with EMI or their identity has been masked by the strong response of these buried metallic features.

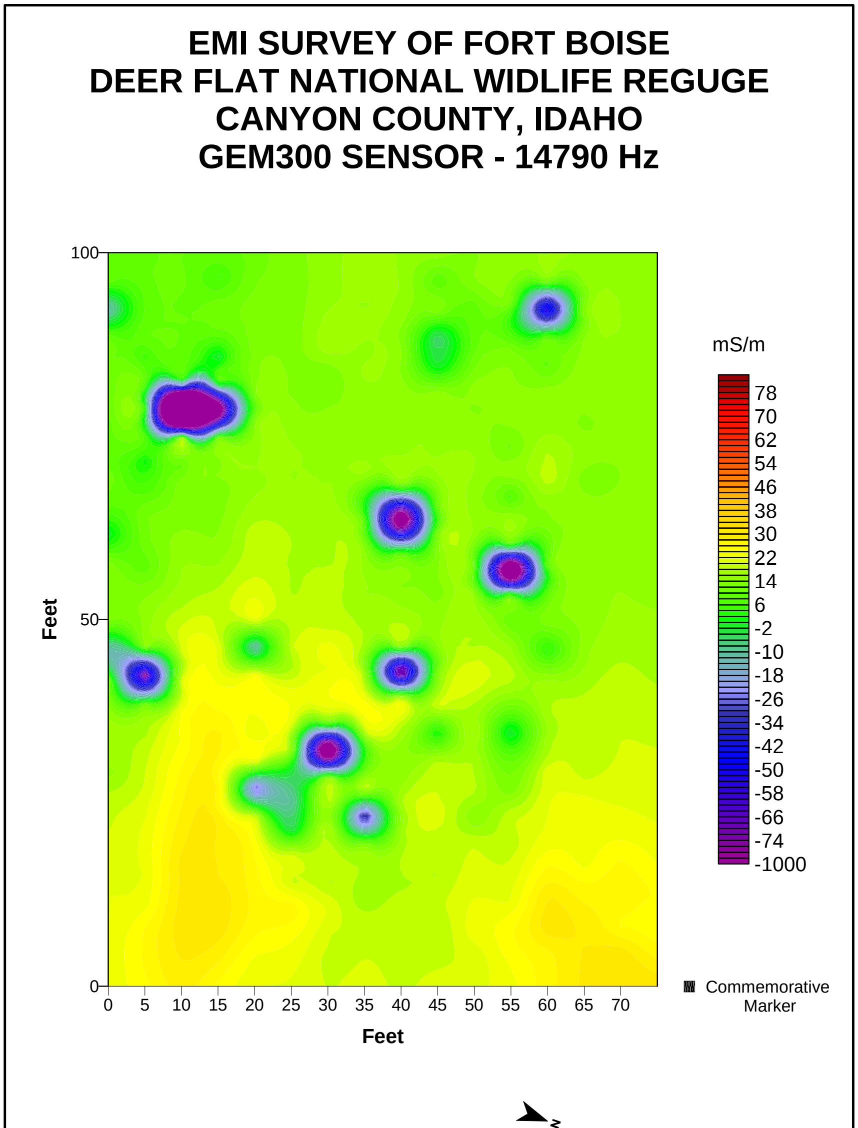

Figure 1

The GPR survey provided little information concerning the site. High rates of signal attenuation severely restricted the depth of penetration and the resolution of subsurface features. No anomalous subsurface features were detected with the GPR.

Old Penitentiary's Cemetery:

This penitentiary was established in 1870 and was used continuously until 1973. A cemetery is located on the grounds of the penitentiary. It is uncertain whether all of the gravesites are marked with headstones and if the existing headstones actually mark gravesites or have been moved over time.

The study site is located in an area that has been mapped as Brent loam, 8 to 12 percent slopes (Collett, 1980). The deep, well drained, Brent soil formed in unconsolidated or poorly consolidated fluviatile deposits of acid igneous origin on foothill and mountains. At the time of the soil survey, Brent soils were classified as members of the fine, montmorillonitic, mesic Xerollic Paleargids family. Based on revisions to Soil Taxonomy, the Brent series is presently a member of the fine, smectitic, mesic Xeric Paleargids family. The high content of active, 2:1 lattice clays and carbonates in Brent soil severely restricted the GPR's penetration depth. Because of the restricted depth of penetration, GPR is an inappropriate tool for soil and archaeological investigations in areas of Brent soil.

Reconnaissance GPR and EMI surveys of the site were completed. Both the 400 and 200 MHz antennas were severely restricted by high rates of signal attenuation. Passing over marked gravesites, no subsurface features were identified on the radar profiles. The EMI survey was equally disappointing. The apparent conductivity was remarkably uniform across the site (about 17 to 20 mS/m) and no contrasting features were detected with the GEM300 sensor.

New Plymouth Cache Site:

A landowner near New Plymouth, Idaho, while installing fence posts, uncovered a cache of points and other artifacts. The cache was over 6000 years old and predated soil formation. The cache was located in a livestock holding area. The GPR was used in a reconnaissance mode in an attempt to learn if more burial caches are located in this area.

The study site is located in an area that has been mapped as Nyssaton silt loam, 3 to 7 percent slopes (Rasmussen, 1976). The very deep, well drained, Nyssaton soil formed in laminated lacustrine sediments on intermediate terraces. At the time of the soil survey, Nyssaton soils were classified as members of the coarse-silty, mixed, mesic Xerollic Camborthids family. Based on revisions to Soil Taxonomy, the Nyssaton series is presently a member of the coarse-silty, mixed, superactive, mesic Xeric Haplocalcids family. Nyssaton soils have a calcic horizon that ranges in depth from 6 to 16 inches.

A reconnaissance GPR survey of the site was completed. The GPR provided adequate profiling depth (1 to 1.5 m) and clear images of the subsurface. Layers of indurated soil horizons, and laminated clays were detected. Numerous point objects were detected with the GPR in this area. Many of these objects displayed multiple reverberations or "ringing" indicative of metallic objects. These objects mostly represent discarded remnants from range operations. Two point reflectors, not suspected to be buried metallic objects, were unearthed to verify interpretation. These features were identified as a piece of wire and some buried stones. As soils evolved after the burial of cache objects, no truncation of soil horizons caused by the burial was observable. Such disruptions of soil horizons often serve as a diagnostic clue to burials. The GPR survey did not reveal the presence of any other buried caches in the area.

Twin Springs:

At the request of the Sheriff's Department, Oneida County, a GPR survey was completed at the Twin Springs Camp Site, western Oneida County, in an attempt to locate a body supposedly disposed of in the park. A bone had been unearthed at this site by archaeologists conducting a summer field session. The bone was about ten years old. It is uncertain whether the body was buried in the campsite, or the bone carried into the site by a scavenger.

A reconnaissance GPR investigation was conducted with the 400 MHz antenna across suspected areas with no positive results. The survey lasted about 2.5 hrs and provided comprehensive coverage of the suspected area. The GPR provided adequate profiling depth and fairly clear images of the subsurface. Several point anomalies were identified on the radar profiles. However, these features were identified to be rodent holes, rock fragments, and discarded debris.

Although no bones were discovered, the Sheriff's Department was satisfied that a comprehensive and professional GPR survey had been performed across the site and was thankful of the assistance rendered by USDA-NRCS.

Conclusions:

1. In a brief period, geophysical techniques were used in diverse soils to locate buried features. This study has shown that in similar soils of southern Idaho, the use of GPR to locate burials is inappropriate. The GPR is suitable for the detection of buried structural features or large caches. The use of EMI is less restricted by soil properties, and providing there is sufficient contrast between buried artifacts and the surrounding soil matrix, it is a more appropriate geophysical tool than GPR for archaeological investigations in southern Idaho.

2. Participants were appreciative of the USDA-NRCS's efforts and commitment to the preservation and restoration of cultural resources. While results were disappointing (nothing of significance was found), this study did strengthen the bonds between the participating agencies.

It was my pleasure to work in Idaho and with members of your fine staff.

With kind regards,

James A. Doolittle
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