United States Department of Agriculture

Natural Resources Conservation Service

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Subject: Archaeology -- Geophysical Assistance

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Purpose:
To provide geophysical field assistance to the Bureau of Land Management (BLM) in an archaeological investigation of an undeveloped recreational site known as *Deadman's Hole* near Challis, Idaho.

Participants:
Tom Burnham, District Conservationist, USDA-NRCS, Jerome, ID
Jim Doolittle, Research Soil Scientist, USDA-NRCS, Newtown Square, PA
Carol Hearne, Archaeologist, USDI-BLM, Challis, ID

Activities:
All field activities were completed during the period of 4 to 6 October 2004.

Summary of Results:

1. Interpretations contained in this report are considered preliminary estimates of site conditions. These interpretations do not substitute for direct observations, but rather reduce their number, direct their placement, and supplement their interpretations. Interpretations should be verified by ground-truth observations.

2. Electromagnetic induction provided some information concerning the cultural integrity of *Deadman's Hole*. Isolated, anomalous areas of relatively high apparent conductivity (EC_a) were attributed to a reinforced concrete boat ramp and several road culverts. Within the exception of these features, spatial patterns of EC_a suggest natural soil conditions. Large, conspicuous areas of relatively high EC_a occurring along the bases of slopes were attributed to the discharge and evaporation of seepage and the accumulation of soluble salts in soil profiles. The western two-thirds of the site were characterized by relatively low and invariable EC_a. In these portions of the site, fill materials used for the construction of the roadbed for Highway 75 were indistinguishable from the presumably undisturbed soils.

3. With the exception of responses from several large and conspicuous modern cultural features (boat ramp and culverts), no pattern of EC_a that could be attributed to cultural features were apparent in plots of EMI data. If present, other artifacts were either missed or lacked sufficient contrast and/or size to be detected with EMI.

It was my pleasure to work again in Idaho and with Tom Burnham, and to assist the BLM in this project.

With kind regards,

James A. Doolittle
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cc:
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Background:
Deadman's Hole is an undeveloped recreational site that is managed by the Bureau of Land Management (BLM). Although undeveloped, the site contains a boat launch, toilet facility, and has been used by campers. Prehistoric cultural materials (flakes) have been found at this site. Archaeologist wants to confirm the cultural integrity and characteristics of the site. In addition, the BLM wants to insure that the site is not eligible for the National Register and can be developed. Portions of site have been disturbed for the construction of a ditch, boat ramp, well, and former and present toilet facilities. The use of electromagnetic induction (EMI) was proposed as a noninvasive method that could supply additional information on the location and extend of disturbed and undisturbed soils within the site.

Deadman's Hole:
Deadman's Hole is located along the Salmon River about 14 miles south-southwest of Challis, Idaho, along Highway 75. The site is located on a terrace that is sandwiched between the Salmon River and Highway 75 (see Figure 1). The site is located in an area that has been mapped as Mogg-Dawtonia association, 20 to 40 percent slopes. The shallow, well drained Mogg soil and the very deep, well drained Dawtonia soil formed in colluvium and slope alluvium on uplands. Included in this site are areas of rock outcrop and fill materials (embankment to Highway 75). Though not mapped, the area is believed to contain areas of Zer soil. The very deep, well drained Zer soil formed in colluvium on fan terraces. The taxonomic classifications of these soils are listed in Table 1. The site contains several primitive roads and is in rangeland.

Table 1
Taxonomic Classification of soils recognized in the *Deadman's Hole* Site.

Series	Taxonomic Classification
Mogg	Loamy-skeletal, mixed, superactive, frigid Lithic Xeric Haplocalcids
Dawtonia	Loamy-skeletal, mixed, superactive, frigid Xeric Calciargids
Zer	Loamy-skeletal, mixed, superactive, frigid Xeric Haplocalcids

Equipment:
The electromagnetic induction meter used in this study was the EM38DD, manufactured by Geonics Limited.[1] Geonics Limited (2000) describes the operating procedures of this meter. The EM38DD meter is portable and requires only one person to operate. No ground contact is required with this meter. The EM38DD operates at a frequency of 14,600 Hz. It has effective penetration depths of about 0.75 and 1.5 m in the horizontal and vertical dipole orientations, respectively. The EM38DD meter consists of two EM38 meters bolted together and electronically coupled. One meter acts as a master unit (meter that is positioned in the vertical dipole orientation and having both transmitter and receiver activated) and one meter acts as a slave unit (meter that is positioned in the horizontal dipole orientation with only the receiver switched on).

The Geonics DAS70 Data Acquisition System was used to record and store both EMI and GPS data.[1] The acquisition system consists of the EM38DD meter, an Allegro field computer, and a Garmin Global Positioning System Map 76 receiver (with a CSI Radio Beacon receiver, antenna, and accessories that are fitted into a backpack). With the acquisition system, the EM38DD meter is keypad operated and measurements were automatically triggered.

To help summarize the results of this study, the SURFER for Windows (version 8) program, developed by Golden Software, Inc., [1] was used to construct the two-dimensional plots shown in this report. Grids were created using kriging methods with an octant search.

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

EMI:
Electromagnetic induction (EMI) is a noninvasive geophysical tool that can be used for archaeological investigations. Advantages of EMI are its portability, speed of operation, flexible observation depths, and moderate resolution of subsurface features. Results from EMI surveys are interpretable in the field. This geophysical method can, in a relatively short time, provide the large number of observations that are needed to comprehensively cover archaeological sites. Computer simulated plots prepared from properly interpreted EMI data provide the basis for assessing site conditions, planning further investigations, and locating exploratory test pits.

Electromagnetic induction use electromagnetic energy to measure the apparent conductivity of earthen materials. Apparent conductivity (EC_a) is a weighted, average measurement for a column of earthen materials to a specific depth (Greenhouse and Slaine, 1983). Values of EC_a are expressed in milliSiemens per meter (mS/m). Variations in EC_a are caused 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, temperature and phase of the soil water, and amount and type of clays in the soil matrix (McNeill, 1980). The EC_a of soils increases with increases in soluble salts, water, and/or clay contents (Kachanoski et al., 1988; Rhoades et al., 1976).

Values of EC_a are seldom diagnostic in themselves, but lateral and vertical variations in these measurements can be used to infer changes in soils and soil properties and the locations of large, contrasting artifacts. Interpretations are based on the identification of spatial patterns within data sets. To assist interpretations, computer simulations are normally used.

Electromagnetic induction has been used to locate and define archaeological sites and features (Bevan, 1983; Frohlich and Lancaster, 1986; and Dalan, 1991). These studies have demonstrated the utility of EMI for locating, identifying, and determining the boundaries of buried structures, tombs, filled fortification ditches, and earthen mounds. The detection of buried cultural features is affected by the dimensions of the artifact and the electromagnetic gradient existing between the buried cultural feature and the soil. The larger the cultural feature and/or the greater the difference in electrical properties between the buried cultural feature and the surrounding soil matrix, the more likely the artifact will be detected. Buried cultural features with electrical properties similar to the surrounding soil matrix are often difficult to discern.

Field Procedures:
The EM38DD meter was operated with the DAS70 data acquisition system. The meter was operated in the continuous mode with measurements recorded at a 1-sec interval. The meter was held 2 to 3 inches above the ground surface with its long axis parallel to the direction of traverse. Surveys were completed by randomly walking across the site with the EM38DD meter. Dense and impenetrable vegetation restricted the area that could be surveyed with EMI. Figure 1 shows the location of the 4572 geo-referenced EMI measurements that were recorded in the survey of *Deadman's Hole*. Also shown in Figure 1 are the locations of several access (dirt) roads that cross the site and the toilet facility.

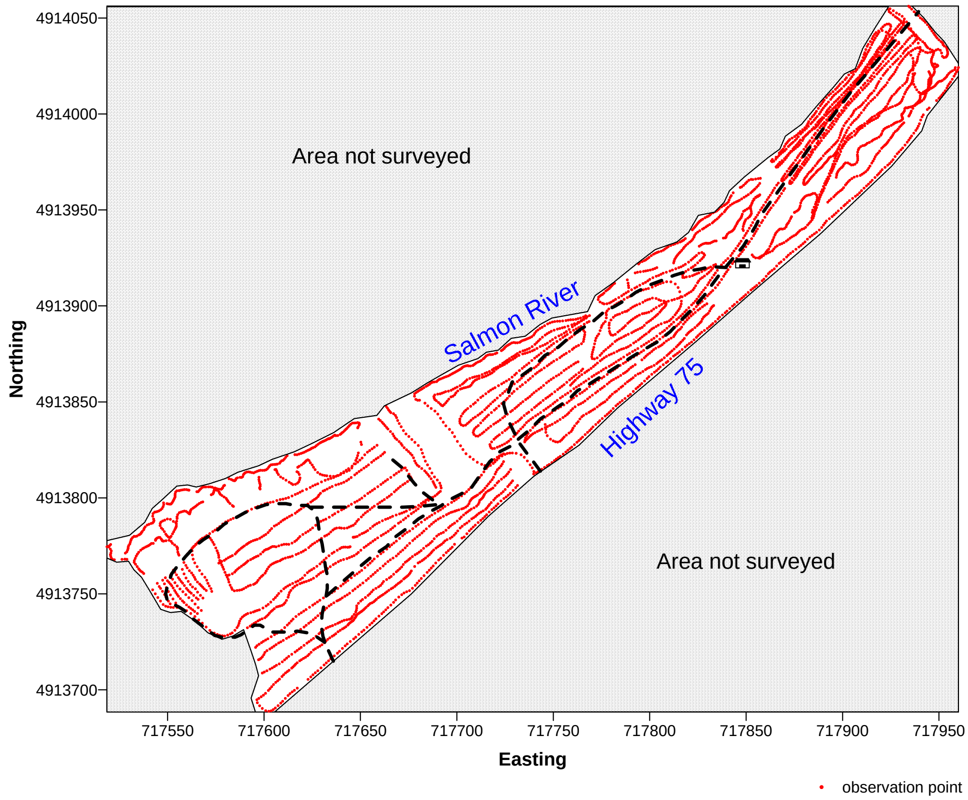

Figure 1. Locations of measurements made with the EM38DD meter within Deadman's Hole.

Results:
A total of 4572 geo-referenced measurements were recorded. In general, apparent conductivity was comparatively low and invariable across most of the site suggesting fairly uniform soil properties. In the deeper-sensing, vertical dipole orientation, apparent conductivity averaged 19.0 mS/m with a range of -560.2 to 469.25 mS/m. Extreme values were attributed to the presence of metallic objects. However, half of the measurements had values of apparent conductivity between 8.1 and 22.0 mS/m. In the shallower-sensing, horizontal dipole orientation, apparent conductivity averaged 18.1 mS/m with a range of -42.33 to 579.13 mS/m. Half of these measurements had values of apparent conductivity between 8.1 and 17.6 mS/m. In both dipole orientations, anomalously high and negative readings were attributed to metallic artifacts and the presence of rebar in the concrete boat ramp.

Figure 2 is a choropleth map that shows the spatial distribution of EC_a measured with the EM38DD meter in the horizontal dipole orientation (0 to 75 cm depth). This plot was constructed from 4572 EMI measurements. In Figure 2, color variations have been used to help show the distribution of EC_a. The color interval is 2 mS/m. The locations of roads and a toilet facility have been shown in this plot.

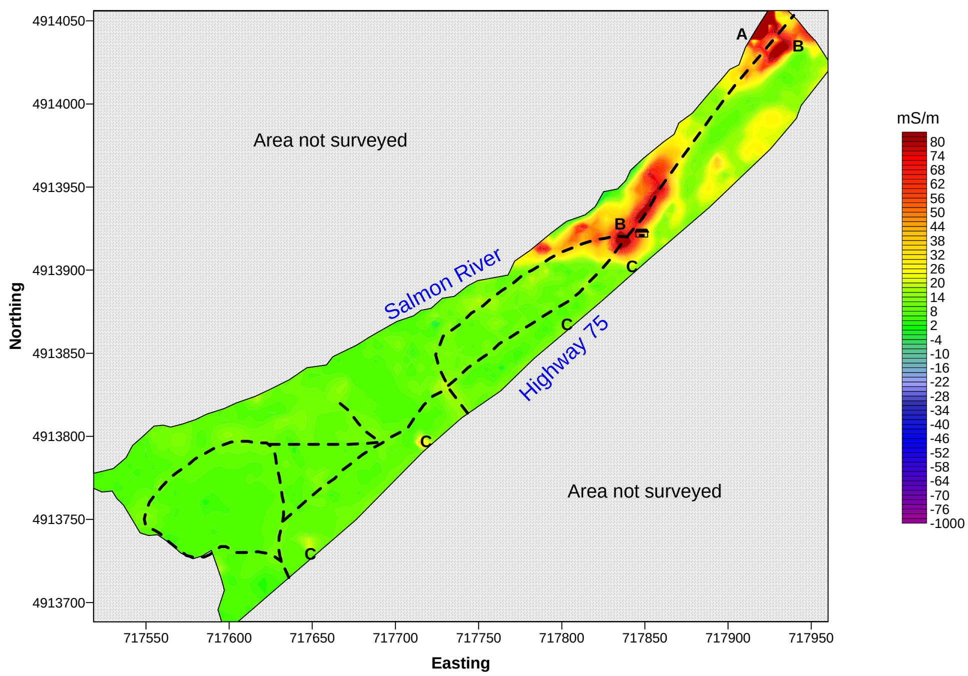

Figure 2. Spatial distribution of apparent conductivity measured with the EM38DD meter in the horizontal dipole orientation at the Deadman's Hole Site.

Figure 3 is a choropleth map that shows the spatial distribution of EC_a measured with the EM38DD meter in the vertical dipole orientation (0 to 150 cm depth). This plot was constructed from 4572 EMI measurements. In Figure 3, color variations have been used to show the distribution of EC_a. The color interval is 2 mS/m. The locations of roads and a toilet facility have been shown in this plot.

In figures 2 and 3, areas of relatively high EC_a are attributed to a rebar in the concrete boat ramp (A), natural seepage areas that contain high concentrations of soluble salts (B), and road culverts (C). In both plots, the western portion of the site is characterized by relatively low and invariable EC_a. In this portion of the site, fill materials used for the construction of the roadbed for Highway 75 are indistinguishable from the presumably undisturbed soils. Within the exception of the culverts and boat ramp, spatial patterns of EC_a provide little indication of soil disturbances or cultural features. The location of a former toilet was traverse with EMI, but it provided little contrast and was virtually indistinguishable from the surrounding, undisturbed soils. Because of the presence of metals (fence and pump), a well was not approached with the meter. A steel trash can holder and fence post were passed close by with the meter and sensed.

In both figures 2 and 3, large and noticeable patterns of higher EC_a are related to the discharge and evaporation of seepage and the accumulation of soluble salts in soil profiles (see "B" in both figures). With the exception of several large and conspicuous modern cultural features (boat ramp and culverts), no patterns of ECa that could be related to artificial features were apparent in either plot. If present, other artifacts were either missed or lacked sufficient contrast or size to be detected with EMI.

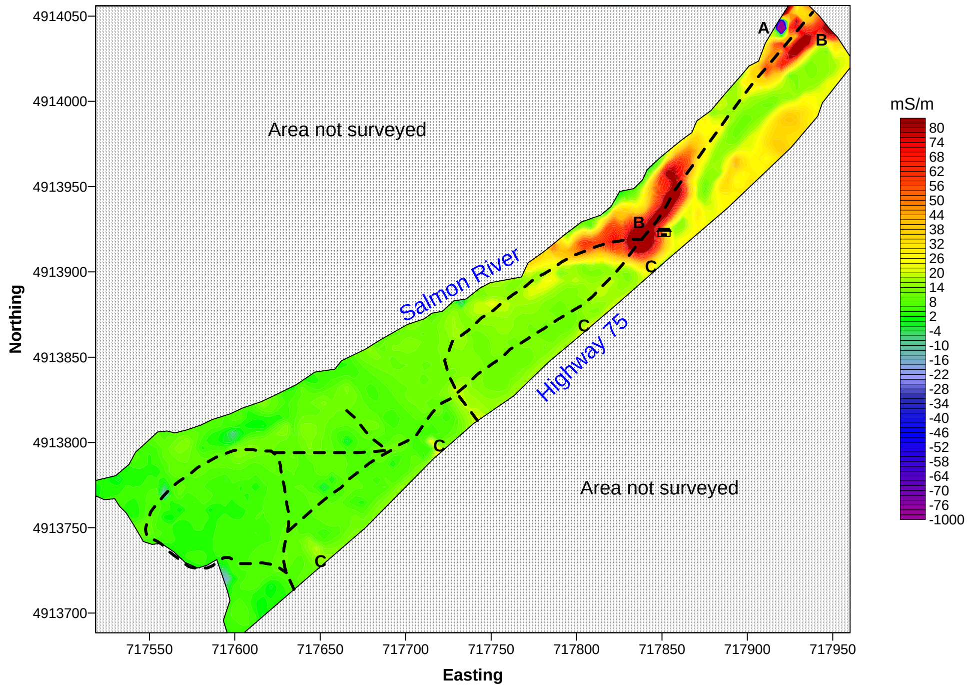

Figure 3. Spatial distribution of apparent conductivity measured with the EM38DD meter in the vertical dipole orientation at the Deadman's Hole Site.

References:

Bevan, B. W. 1983. Electromagnetics for mapping buried earth features. Journal of Field Archaeology 10:47-54.

Dalan, R. A. 1991. Defining archaeological features with electromagnetic surveys at the Cahokia Mounds State Historic Site. Geophysics 56:1280-1287.

Frohlich, B. and W. J. Lancaster. 1986. Electromagnetic surveying in current Middle Eastern archaeology: application and evaluation. Geophysics 51:1414-1425.

Geonics Limited 1998. EM38 ground conductivity meter operating manual. Geonics Ltd., Mississauga, Ontario.

Geonics Limited. 2000. EM38DD ground conductivity meter: Dual dipole version operating manual. Geonics Ltd., Mississauga, Ontario.

Greenhouse, J. P., and D. D. Slaine. 1983. The use of reconnaissance electromagnetic methods to map contaminant migration. Ground Water Monitoring Review 3(2): 47-59.

Kachanoski, R. G., E. G. Gregorich, and I. J. Van Wesenbeeck. 1988. Estimating spatial variations of soil water content using noncontacting electromagnetic inductive methods. Can. J. Soil Sci. 68:715-722.

McNeill, J. D. 1980. Electromagnetic terrain conductivity measurement at low induction numbers. Technical Note TN-6. Geonics Limited, Mississauga, Ontario.

Rhoades, J. D., P. A. Raats, and R. J. Prather. 1976. Effects of liquid-phase electrical conductivity, water content, and surface conductivity on bulk soil electrical conductivity. Soil Sci. Soc. Am. J. 40:651-655.