United States Department of Agriculture	**Natural Resources Conservation Service**	**100 Campus Boulevard Suite 200 Newtown Square, PA 19087-4585**

Subject: Archaeology -- Geophysical Assistance **Date:** 12 August 2003

To: Richard Sims
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Purpose:
To assist Idaho's cultural resource specialist and archaeologists with the Bureau of Land Management (BLM) investigate two archaeological sites: the Pilgrim Stage Station and the Challis Bison Jump.

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
Marion McDaniel, Archaeologist, Challis, ID
Jeff Ross, Archaeologist, USDI-BLM, Twin Falls, ID

Activities:
All field activities were completed on 14 to 17 July 2003.

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 Trimble AG114 GPS receiver. With this acquisition system, the EM38DD meter is keypad operated and measurements can either be automatically or manually 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 two-dimensional simulations. Grids were created using kriging methods with an octant search.

Summary of Results:

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

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. At the Pilgrim Station Historic Site, an EMI survey revealed no evidence of the station. Spatial patterns of apparent conductivity conformed to differences in soils. A large number of buried and surface point reflectors were identified or observed on the terrace. However, many of these reflectors post date the station and represent modern cultural debris associated with sheepherder encampments. If remnants of the station exist at this site, the EMI survey revealed no evidence supporting major structural features or significant amounts of cultural debris relating to this distinct period of land use.

3. At the Challis Bison Kill Site, based on comparatively sparse sampling, no direct evidence or spatial patterns (abrupt, contrasting linear patterns) documenting the 1970 excavations were apparent. However, a prominent zone of higher apparent conductivity corresponds with the most likely location of the bison kill and the former excavations. This zone is adjacent to the foot of the talus slope and presumably contains deeper soils with higher clay and calcium carbonate contents than the more gravelly and coarser textured soils on adjoining portions of the alluvial fan.

4. The prevalence of 2:1 expanding lattice clays with high cation exchange capacities, and the high clay and calcium carbonate contents of soils at the two sites precluded the effective use of ground-penetrating radar. These conditions caused the rapid attenuation of the radar signal, limited the depth of penetration, and produced low signal to noise ratios.

It was my pleasure to work again in Idaho and assist the BLM in these projects.

With kind regards,

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EMI:
Electromagnetic induction is a noninvasive geophysical tool that can be used for detailed site 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 is a weighted, average measurement for a column of earthen materials to a specific penetration depth (Greenhouse and Slaine, 1983). Values of apparent conductivity are expressed in milliSiemens per meter (mS/m). Variations in apparent conductivity 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 apparent conductivity of soils increases with increases in soluble salts, water, and/or clay contents (Kachanoski et al., 1988; Rhoades et al., 1976).

Values of apparent conductivity 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 buried artifacts. Interpretations are based on the identification of spatial patterns within data sets. To assist interpretations, computer simulations are normally used.

Electromagnetic induction (EMI) has been used to locate and define archaeological features (Bevan, 1983; Frohlich and Lancaster, 1986; and Dalan, 1991). Studies have demonstrated the utility of EMI for locating, identifying, and determine the boundaries of various types of cultural features such as buried structures, tombs, filled fortification ditches, and earthen mounds. The detection of buried cultural features is affected by the electromagnetic gradient existing between the buried cultural feature and the soil. The greater or more abrupt 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 and all measurements were georeferenced with the Trimble AG114 GPS. 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 walking with the EM38DD meter at a fairly brisk and uniform pace, in a back and forth pattern across each site.

Survey procedures were simplified to expedite fieldwork. At each site, parallel sets of lines were laid out. These lines helped to define the perimeter of the site. Along each line, survey flags were inserted in the ground at intervals of 2 m. These flags served as grid line end points and provided ground control. At the Challis Bison Kill site, steep talus slopes and dense vegetation restricted the number, alignment, and lengths of traverses.

Results:
Pilgrim Stage Station Historic Site – Elmore County
The Pilgrim Stage Station Historic Site is located along Big Pilgrim Gulch in southeastern Elmore County. Pilgrim Stage Station was established in the mid-1860's and served as a stopover on the Oregon Trail and later as a stage stop on the Kelton Road. A notable historic event was the robbery of this station in 1879 by highwaymen. In 1883, the completion of railroad lines altered the mode of shipping freight through the region and eliminated the need for the station. Today, little is known about the former station. An EMI survey was conducted to assess subsurface conditions and possibly locate buried structural remnants of the former station.

The site is located along Big Pilgrim Gulch, a dry wash, in the northeast quarter of Section 27, T. 6 S., R. 11 E.

The assumed site of the station is located on a terrace in an area of Buko fine sandy loam, 4 to 12 percent slopes (Noe, 1991). The moderately deep, well drained Buko soil formed in material weathered from calcareous mixed alluvium on alluvial terraces. Buko soil is a member of the coarse-loamy over sandy or sandy-skeletal, mixed, mesic Durinodic Xeric Haplocalcids family.

Figure 1 shows the spatial distribution of apparent conductivity measured with the EM38DD meter in the shallower sensing horizontal (left-hand plot) and the deeper sensing vertical (right-hand plot) dipole orientations. Each plot was constructed from 4299 EMI measurements. In each plot, colors have been used to show the distribution of apparent conductivity. In each plot the isoline interval is 1 mS/m. In each plot the locations of several trails and a dry wash have been identified. Also, the location of a narrow, very shallow ditch has been shown. Tom Burnham suggested that the trampling of soil adjacent to an enclosure's fence by horses or livestock could have formed the ditch. In each plot, the location of the scarp that separates the terrace from the dry wash channel has been identified with a dark brown line.

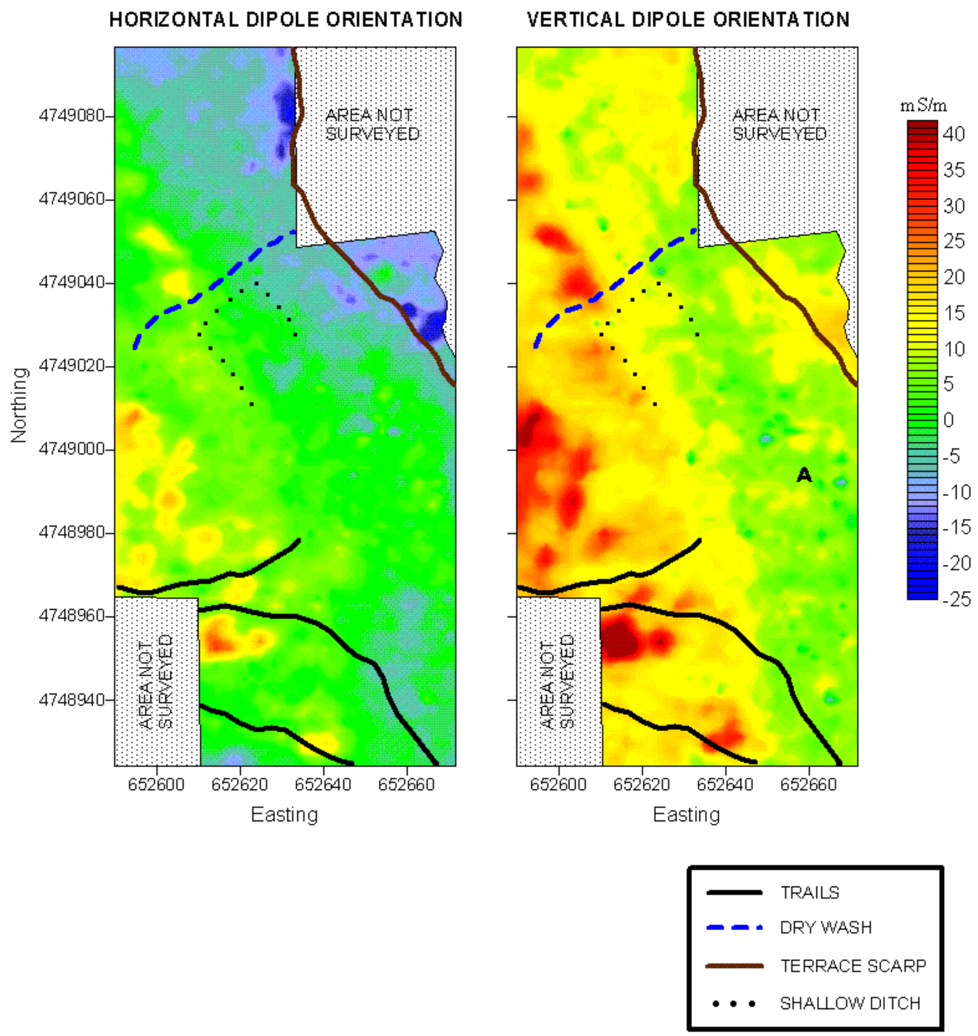

Figure 1. Apparent conductivity plots of Pilgrim Station Site.

Major spatial patterns shown in Figure 1 conform to recognizable soil patterns. Spatial patterns evident if Figure 1 reflect difference principally in clay content and soil depth or depth to bedrock. Higher-lying, more sloping areas are located in the left-hand portion of each plot. These areas have higher values of apparent conductivity associated with deeper depths to basalt bedrock and higher clay content soils. In the right-hand portion of each plot, the lower-lying terrace has lower values of apparent conductivity. Soils on the terrace are shallower to basalt and generally coarser textured.

In each plot, conspicuous point anomalies are apparent on the terrace. A large amount of small metallic debris is visibly scattered across the terrace and is responsible for many of these isolated, negative conductivity values. In the right hand plot these point anomalies are most apparent near "A." In the horizontal dipole orientation (left-hand plot of Figure 1), negative values of apparent conductivity were recorded over areas with exposed basalt bedrock that adjoined the scoured dry wash. These negative values are attributed to calibration errors, as the EM38DD meter was not zero adjusted.

Subsurface reflectors from the former station, if present, are too small, faintly expressed, and indistinguishable in the soils to be identified. EMI provides some indication of the spatial distribution of soil features and some subsurface anomalies, but no unambiguous indications of the Pilgrim Stage Station.

Challis Bison Kill Site – Custer County

The Challis Bison Kill Site is located south of Challis in Custer County. In 1970, John Ivie of Challis, Idaho, reported the occurrence of bison bones and artifacts at the base of an escarpment and talus slope in the upper Salmon River Valley. Later that year, Dr Robert Butler of Idaho State University excavated the site (Butler, 1971). Butler laid out an irregularly shaped, 24 by 10 m grid consisting of 40, two-meter squares across a portion of the site. This area included a 10 m long stratigraphic trench, which was excavated perpendicular to the foot of the talus slope. Bison remains and artifact were recovered from an upper soil layer suggesting that at least 20 to 30 bison were killed in one event. The BLM wishes to use geophysical methods to add additional knowledge of the site's history (Cannon and Hearne, 2002). Electromagnetic induction was used to help reassess the locations of the excavation units made in 1970 and to expand our understanding of the site.

The Challis Bison Kill site is located in the northeast quarter of Section 9, T. 13 W., R. 19 E. The kill site is located on an alluvial fan terrace at the base of a cliff. The relatively high cliff escarpment forms a portion of the north wall to the Salmon River floodplain. Two prominent canyons extend away from the floodplain on either side of the site. An alluvial fan that issues from the downstream canyon extends across this site and has been partially excavated for gravel. The area had been mapped as Zer gravelly loam, warm, 2 to 15 percent slopes. The very deep, well drained Zer soil formed in loess and slope alluvium mixed with colluvium on outwash fans and terraces. Zer is a member of the loamy-skeletal, mixed, superactive, frigid Xeric Haplocalcids family. The particle-size control section of Zer soil averages (weighted) 10 to 18 percent clay and contains 35 to 80 percent rock fragments. The depth to carbonates range from 0 to 7 inches.

Figure 2 shows the spatial distribution of apparent conductivity across the Challis Bison Kill site. The plot consists of measurements recorded with the EM38DD meter in the vertical dipole orientation. This plot was constructed from 1522 EMI measurements. In Figure 2, colors have been used to show the distribution of apparent conductivity. The isoline interval is 3 mS/m. The location of a conspicuous cairn believed to overly Butler's refilled stratigraphic trench has been identified. In addition, the locations of two conspicuous rock outcrops, a cave (Quill cave), and a point along the escarpment have been shown. The locations of the widely scattered EMI observation points have also been shown.

A noticeable area of relatively high (9 to 18 mS/m) extends in a southwest to northeast direction along the foot of the talus slope. This zone is located in the general area believed to have contained the remnants of the bison kill and the site of the excavations by Dr Robert Butler of Idaho State University. The higher apparent conductivity values recorded near A in Figure 2 are presumably caused by thinner talus and deeper soil profiles that contain greater amounts of silts, clays and calcium carbonates.

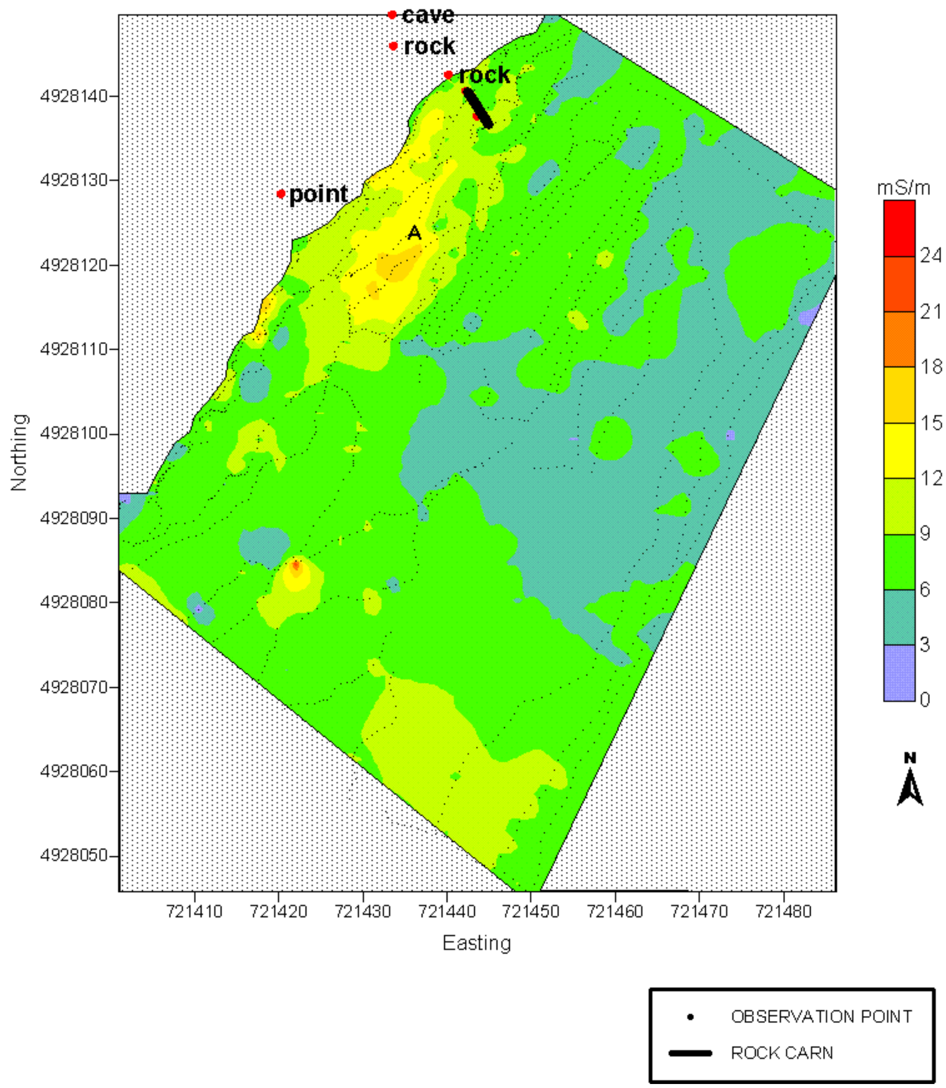

Figure 2. Apparent conductivity plots of Challis Bison Jump site.

No direct evidence or spatial patterns suggesting the 1970 excavations are apparent in Figure 2. However, a conspicuous zone of higher apparent conductivity corresponds with the most probably location of the bison kill and the former excavation. This may be coincidental or may be related to the kill itself. The zone is adjacent to the foot of the talus slope. Owing to its higher apparent conductivity, this zone presumably contains deeper soils with higher silt, clay, and calcium carbonate contents than the more gravelly and coarse textured soils on lower lying portions of the alluvial fan. These factors would produce higher apparent conductivity values. At this time, the effects of a large concentration of bison bones or fly puparial cases on EMI response are unknown.

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