United States Department of Agriculture

Natural Resources Conservation Service

5 Radnor Corporate Center, Suite 200 Radnor, PA 19087-4585

Subject: Archaeology—Geophysical Assistance

Date: 24 November 1997

To: William J. Hartman
State Conservationist
USDA - NRCS
75 High Street, Room 301
Morgantown, West Virginia 26505

Purpose:

To provide ground-penetrating radar (GPR) cultural resources field assistance to West Virginia.

Participating Agencies:

Horizons Research Consultants
USDA-Natural Resources Conservation Service
West Virginia Division of Culture and History
West Virginia University

Participants:

Jeff Bartley, Volunteer, WVU Field School, Morgantown, WV
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Anna Cicala, Crew Chief, WVU Field School, Morgantown, WV
Carlos Cole, Team Soil Scientist, USDA-NRCS, Parkersburg, WV
Jim Doolittle, Research Soil Scientist, USDA-NRCS, Radnor, PA
Ben Horter, Archaeologist, USDA-NRCS, Morgantown, WV
Rex Rexrode, District Conservationist, USDA-NRCS, Hurricane, WV
Jesse Rouse Staff Archaeologist, Horizon Research Consultants, Morgantown, WV
Pat Trader, Senior Archaeologist, West Virginia Div. Culture and History, Charleston, WV
John Vandevender, Plant Material Center Manager, USDA-NRCS, Beaver, WV

Activities:

All field activities were completed during the period of 19 to 21 November 1997.

Equipment:

The radar unit used in this study was the Subsurface Interface Radar (SIR) System-2, manufactured by Geophysical Survey Systems, Inc. The SIR System-2 consists of a digital control unit (DC-2) with keypad, VGA video screen, and connector panel. The system was powered by a 12-volt battery. This unit is backpack portable and requires two people to operate. The use and operation of GPR have

been discussed by Morey (1974), Doolittle (1987), and Daniels and others (1988). Antennas used in this investigation include the 500, 120, and 200 mHz.

The GPR is a time scaled system. This system measures the time that it takes electromagnetic energy to travel from the antenna to an interface (e.g., artifact, soil horizon, stratigraphic layer, bedrock surface) and back. To convert the travel time into a depth scale, either the velocity of pulse propagation or the depth to a reflector must be known. The relationships among depth (d), two-way, pulse travel time (t), and velocity of propagation (v) are described in the following equation (Morey, 1974):

$$v = 2d/t$$

The velocity of propagation is principally affected by the dielectric permittivity (e) of the profiled material(s) according to the equation:

$$e = (c/v)^2$$

where c is the velocity of propagation in a vacuum (0.3 m/nanosecond). The velocity is expressed in meters per nanosecond (ns). The amount and physical state of water (temperature dependent) have the greatest effect on the dielectric permittivity of a material. Tabled values are available that approximate the dielectric permittivity of some materials (Morey, 1974; Petroy, 1994). As limited "ground truth" verifications were conducted during this study, tabled values were used to approximate the depth of radar observation. A value of 19 was selected from the tables of Petroy (1994) for the dielectric permittivity. This is a value for wet, loamy soils. Based on this value, the velocity of propagation is 0.0688 m/ns. A velocity of propagation of 0.0688 m/ns and a scanning time of 50 ns provided an observation depth of about 1.72 m at the Plant Material Center. A scanning time of 40 ns provided an observation depth of about 1.37 m at the Holly Grove and the Blennerhassett sites.

Results:

Plant Material Center, Alderson, West Virginia: 19 November 1997

Three, 30 by 30 meter grids were established at the Plant Material Center. The grid interval was 3 m. Survey flags were inserted in the ground at each grid intersection. This provided 121 observation points for each grid. At each of the three test areas, the radar survey was completed by pulling the 200 mHz antenna along eleven, parallel, east-west trending, grid lines. Radar surveys began in the northwest corner and ended in the southeast corner of each test area. This procedure provided about 990 m of continuous radar imagery. Based on a scanning time of 50 ns and a velocity of propagation of 0.0688 m/ns, the anticipated observation depth was about 1.72 meters.

Ground-penetrating radar provided continuous, highly resolved images of the subsurface. No major structural feature or anomaly was detected within the test areas. One strongly and several weakly expressed point reflectors were identified on the radar profiles. Some of these reflectors should be uncovered to confirm their identify and to verify the types of features being detected with GPR.

The radar profiles are arranged by file numbers. The following tables list the radar profiles in the order that they were collected within each test area. The first file listed in each test area began in the northwest corner. The last file listed in each test area ended in the southeast corner.

Table 1
Test Area 2B

File #	Direction
1	west to east
2	east to west
3	west to east
4	east to west
5	west to east
6	east to west
7	west to east
8	east to west
9	west to east
10	east to west
11	west to east

Table 2
Test Area 2A

File #	Direction
13	west to east
14	east to west
15	west to east
16	east to west
17	west to east
18	east to west
19	west to east
20	east to west
21	west to east
22	east to west
23	west to east

Table 3
Test Area 1

File #	Direction
24	west to east
25	east to west
26	west to east
27	east to west
28	west to east
29	east to west
30	west to east
31	east to west
32	west to east
33	east to west
34	west to east

It was my pleasure to work with and to be of assistance to members of your fine staff.

With kind regards,

James A. Doolittle
Research Soil Scientist

cc:
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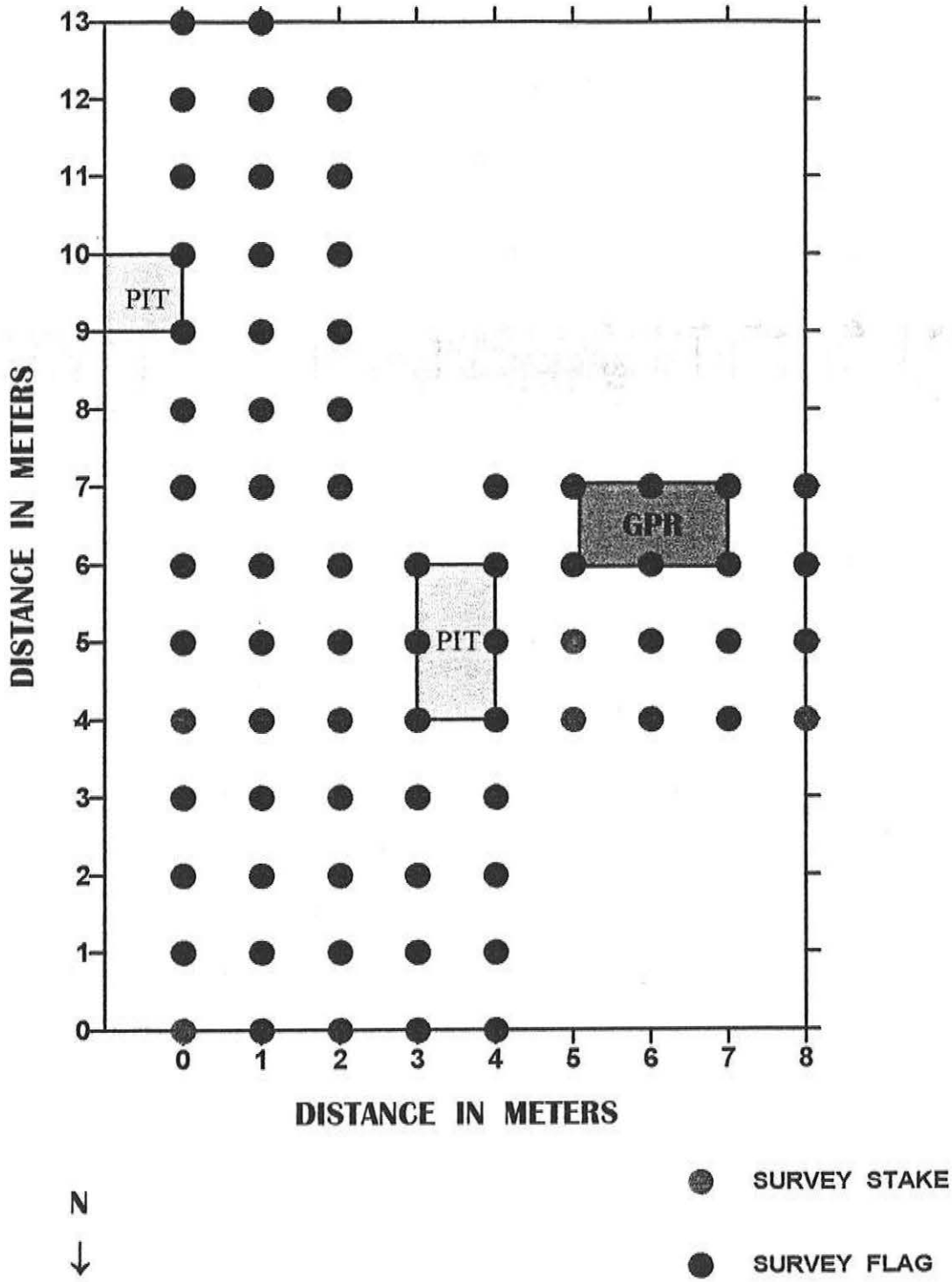
HOLLY GROVE SITE
CHARLESTON, WEST VIRGINIA