United States
Department of
Agriculture

Soil
Conservation
Service

Northeast NTC
160 East 7th Street
Chester, PA 19013-6092
215-499-3960

Subject: GPR Technical Assistance; North Carolina - 12 to 16 November 1990

Date: 12 January 1990

To: Bobbye Jack Jones
State Conservationist
SCS, Raleigh, NC

Purpose:

To conduct ground-penetrating radar (GPR) field studies in preparation for the North Carolina Mountain Soil Tour and Seminar scheduled for 16 - 20 July 1990.

Participants:

Jacob Crandall, Area Conservationist, SCS, Waynesville, NC
James Doolittle, Soil Specialist (GPR), SCS, Chester, PA
Andy Goodwin, Soil Specialist, SCS, Shelby, NC
Brooks Hale, Soil Scientist, SCS, Cullowhee, NC
Mike Sherrill, Soil Party Leader, SCS, Cullowhee, NC
Horace Smith, State Soil Scientist, SCS, Raleigh, NC
Arthur Wade, Soil Conservation Tech., SCS, Swain County, NC
Brian Wood, Soil Scientist, SCS, Cullowhee, NC

Activities:

The GPR unit and specialist arrived in Sylva on the morning of 13 November 1989. Preliminary field work and calibration trials were conducted during the afternoon of 13 November. Multiple transects were completed in areas of Cullowhee fine sandy loam 0 to 2 percent slopes and Dellwood cobbly fine sandy loam, 0 to 3 percent slopes, occasionally flooded, along Cullowhee Creek and Allen Creek on 14 November. An area of Cullowhee fine sandy loam, 0 to 2 percent slopes was gridded and a detailed GPR investigation was conducted on 15 November. The GPR unit returned to Chester, PA, on the 15 and 16 November 1989.

Results and Discussion:

The GPR system used in this study was the Subsurface Interface Radar (SIR) System-8 [1]. Components used included the Model 4800 control unit, SR 8004H graphic recorder, DT 6000 tape recorder, power distribution unit, and 120 MHz antenna. Transects were completed by towing the antenna behind a 4WD vehicle at speeds of 2 to 3 km/h.

Figure 1 is a representative profile from an area of Cullowhee fine sandy loam 0 to 2 percent slopes along Cullowhee Creek. The distance between observation points (dashed, vertical lines) was 10 feet (3.05 m). The scanning time was set at 150 ns which provided a profiling depth of about 4.0 m. This estimation is based upon the depth to a metallic reflector (delineated in box in Fig 1) buried at 50 cm. The dielectric constant of the coarse-loamy surficial deposits was calculated as 7.8.

In Figure 1, the contact between the coarse-loamy (sandy loam) surficial deposits and the underlying sandy (very gravelly sand) deposits appears to be abrupt, strongly contrasting (inferred from darkness of the images), and clearly defined across the radar profile. However, in places, a thin gradational layer of an intermediate texture (loamy sands) can be discerned (less intense shade of grey rather than black). Also apparent in Figure 1, is an underlying, unidentified, and more strongly contrasting layer at a depth of 1.7 (62 ns) to 2.3 (87 ns) meters. This layer will be probed and identified by soil scientists prior to the Forest Soil Tour. What is significant is that this layer underlies not only the study site along Cullowhee Creek but also the study site along Allen Creek and at a similar depth.

A small study area adjacent to the transect appearing in Figure 1 was selected for systematic sampling with the GPR. A 30 by 30 meter grid with observations at 3.0 m intervals was established with the help of a transit. Elevations were not tied to a benchmark and therefore the lowest recorded surface point within the plot was taken as the 0.0 m datum. A GPR survey was completed with runs along parallel grid lines. A computer software program (SURFER) was used to plot the GPR data and to provide two- and three-dimensional plots of the topographies of the ground surface and the subsurface interface which separates the coarse-loamy and sandy sediments.

Figure 2 is a contour map of the ground surface within the study site. The contour interval is 5 cm. Cullowhee Creek runs parallel and to the left of this figure. The study area was located on a higher-lying surface within the flood plain and may not be representative of the map unit. Within the study area the ground surface is highest in the upper left-hand corner (southeast) and slopes to the west and northwest.

Figure 3 is a two-dimensional contour map which plots the areas which are less and greater than 1.0 meter to sands and gravel. The

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1.Manufactured by Geophysical Survey Systems, Inc., 15 Flagstone Drive, Hudson, NH 03051.

hachured areas have depths to sand and gravel greater than 1.0 meter. Within the study area depths to sand and gravel ranged from 41 to 133 cm. In addition, based on soil depth criteria, the soils at this site are: 1 % shallow (0 to 50 cm), 69 % moderately deep (50 to 100 cm), and 30 % deep (100 to 150 cm) to sand and gravel. Dellwood soils are shallow and Cullowhee soils are moderately deep to sands and gravel. These soils represent 70 % of the study site. Thirty percent of the study site consist of deep soils which are similar to Cullowhee soil.

In Figure 4, computer-generated three-dimensional surface net maps of the ground surface and the surface of the sand and gravel deposits are shown. The ground surface displays a smoother and less variable topography than the surface of the sand and gravel deposits. Also, several irregularly shaped "highs" and pothole like "lows" are apparent in this figure.

Near the Cullowhee Creek study site, a transect was conducted across adjoining footslope and flood plain areas (Figure 5). In Figure 5, the distance between the observation sites is 15.2 meters. The footslope area includes the five observation sites in the left-hand portion of this figure. The flood plain includes the five other observation sites. The image of the flood plain portion of this profile is similar to the radar images appearing in Figure 1. However, in Figure 5, the soil profile appears to be more stratified in the upper part (see C).

In Figure 5, the underlying, unidentified, and more strongly contrasting layer beneath the sand and gravel layer (referenced above) is again apparent. This layer appears to continue and to trend to deeper depths beneath the footslope area (from A3 to A1). Also, at the base of the footslope a deep trough of loamy sediments is apparent (B).

Two profiles are displayed in Figure 6. The upper figure is an un-annotated copy of Figure 5. In the lower figure, the radar imagery has been corrected for variations in the topography of the ground surface. This is the first opportunity I have had to use the RADAN software program to accomplish terrain correction of the radar data. *Terrain correction has been defined by Bates and James (1980)* as the "correction applied to observed values obtained in geophysical surveys in order to remove the effects of variations due to topography." The results of terrain correction are stunning and affords a more realistic and interpretable radar image.

The terrain corrected radar profile has been reprinted and annotated in Figure 7. The numbers appearing in this figure are surface elevations of the observation sites.

The data presented in this report will be prepared for field presentation during the North Carolina Forest Soil Tour scheduled for July 1990. I welcome all comments to the enclosed imagery and interpretations.

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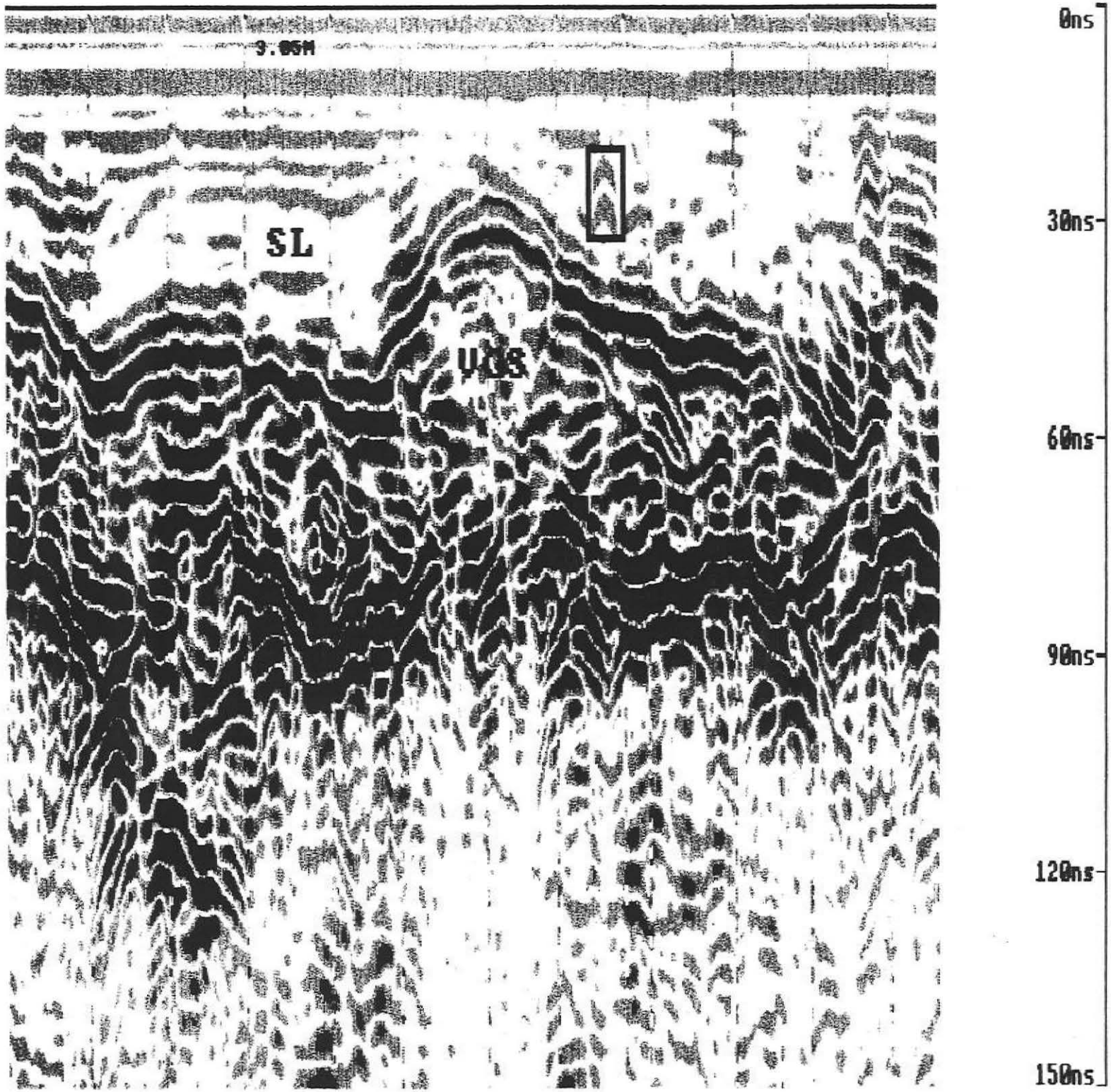
*R. L. Bates and J. A. Jackson. 1980. Glossary of Geology. American Geological Institute, Falls Church, VA. pp. 749.

As always, I enjoy the opportunity to work in your state and with members of your fine staff. With kind regards.

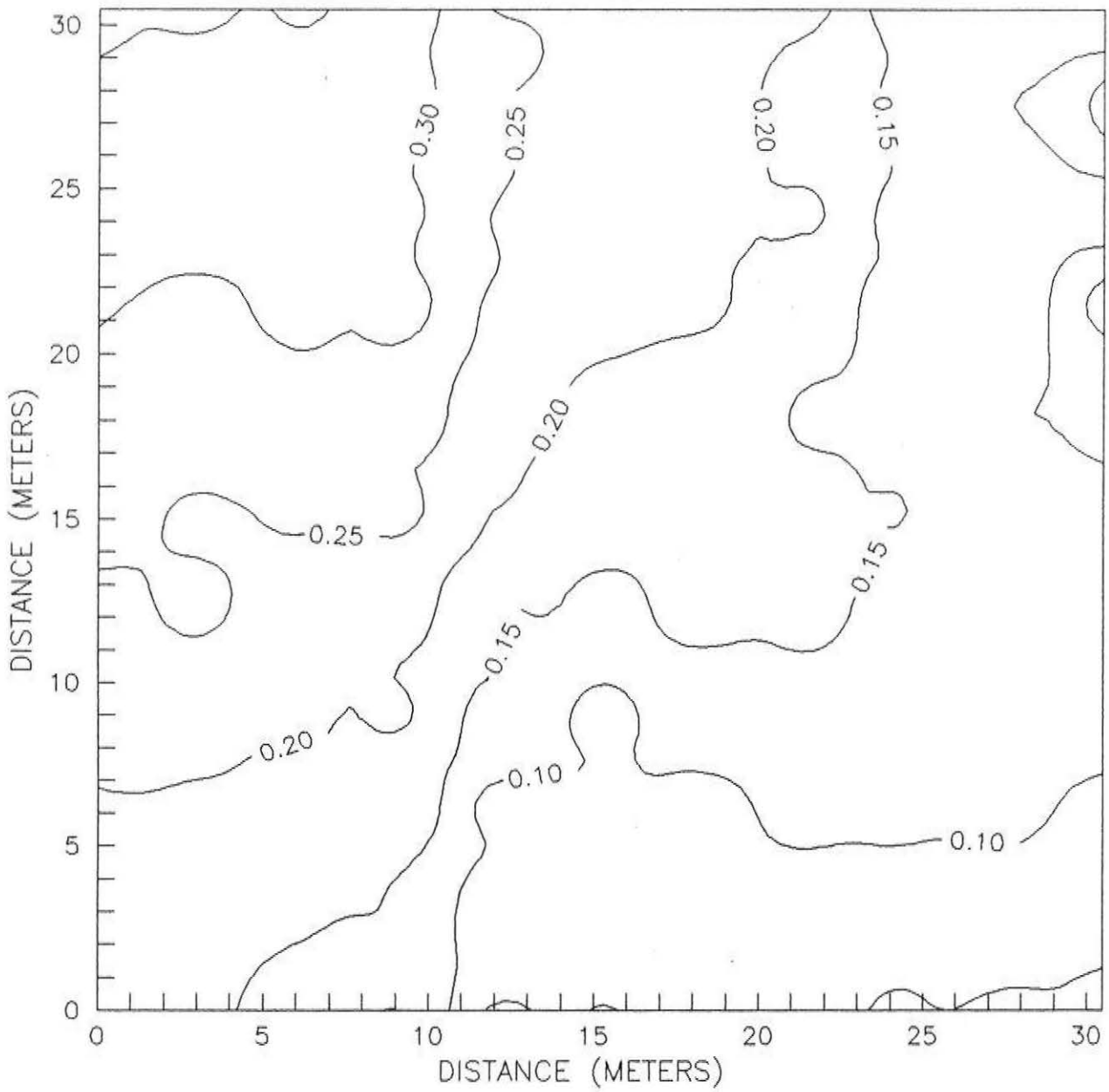
James A. Doolittle

James A. Doolittle
Research Soil Scientist (GPR)

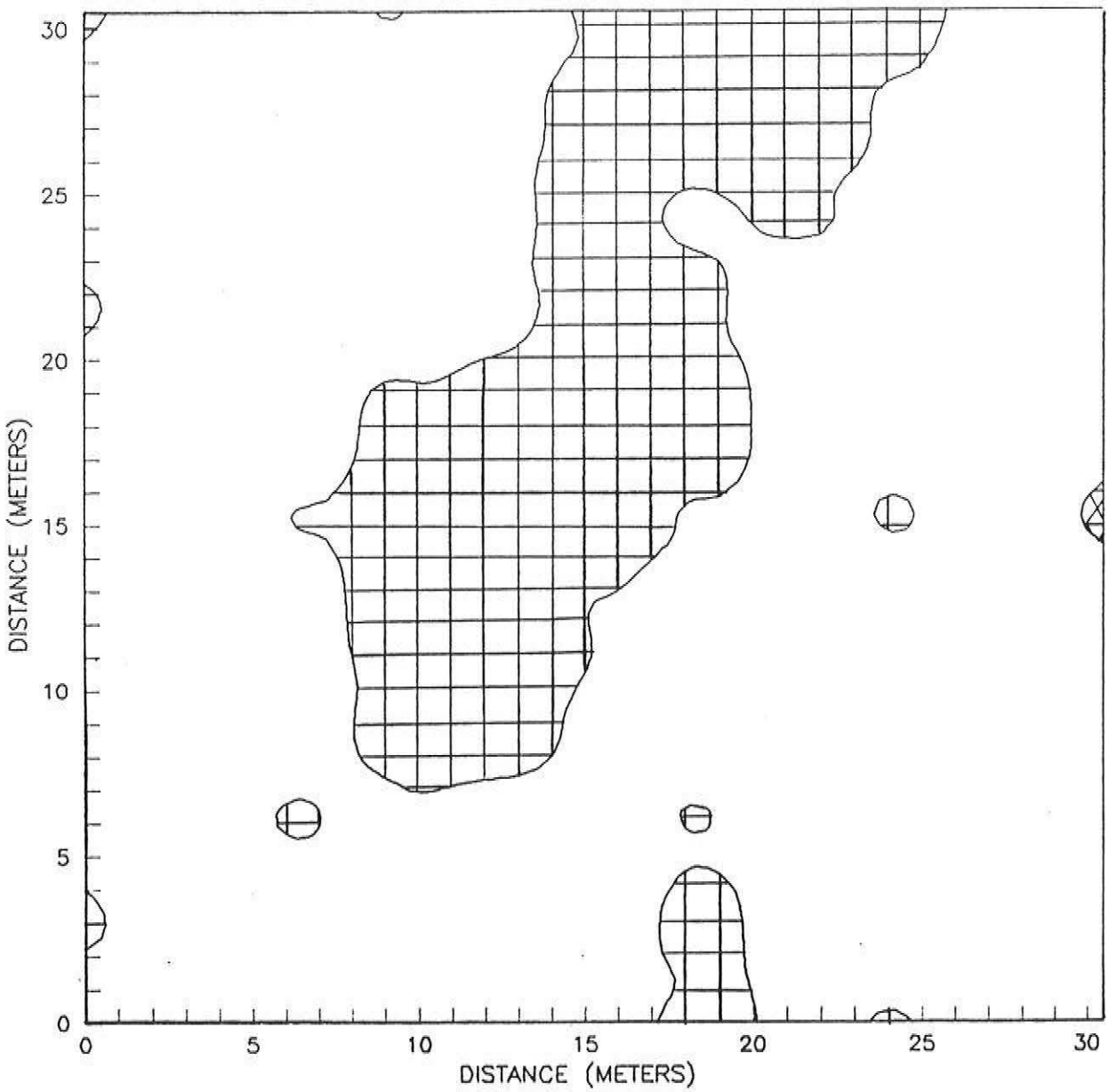
cc:
A.J. Dornbusch, Jr., Director, SCS, MWNTC, Lincoln, NE
C.S. Holzhey, Ass't. Director, Soil Survey Division, NSSC, SCS, Lincoln, NE
E.G. Knox, Head, NSSL, NSSC, SCS, Lincoln, NE
W.C. Lynn, Research Soil Scientist, NSSL, NSSC, SCS, Lincoln, NE
C.G. Olson, Staff Leader, FIS, NSSL, NSSC, SCS, Lincoln, NE
M.L. Sherrill, Soil Party Leader, SCS, Cullowhee, NC
H. Smith, State Soil Scientist, SCS, Raleigh, NC

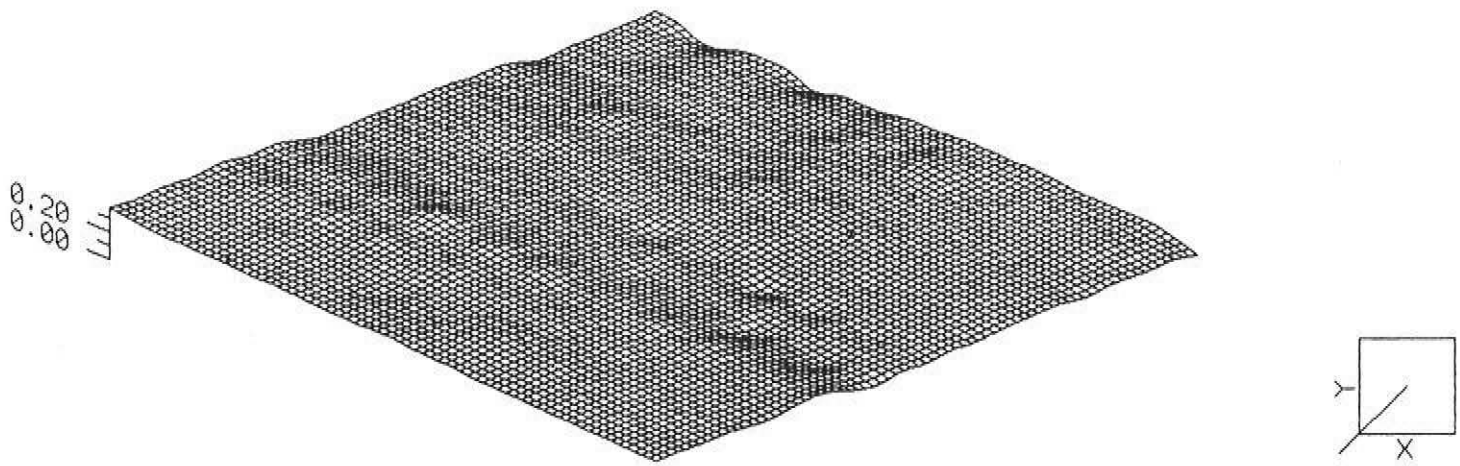

9.05M
SL
VLS
0ns
30ns
60ns
90ns
120ns
150ns

TOPOGRAPHY OF AN AREA OF CULLOWHEE FSL, 0 TO 2% SLOPES

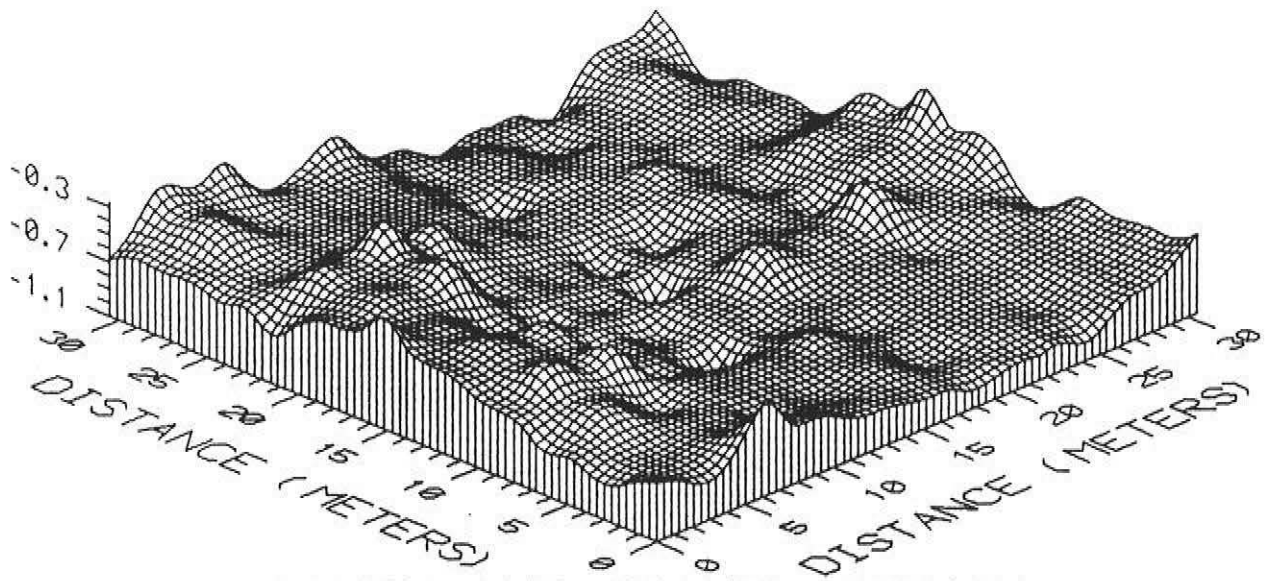


DEPTH TO SAND AND GRAVEL IN AN AREA OF CULLOWHEE FSL, 0 TO 2 % SLOPES



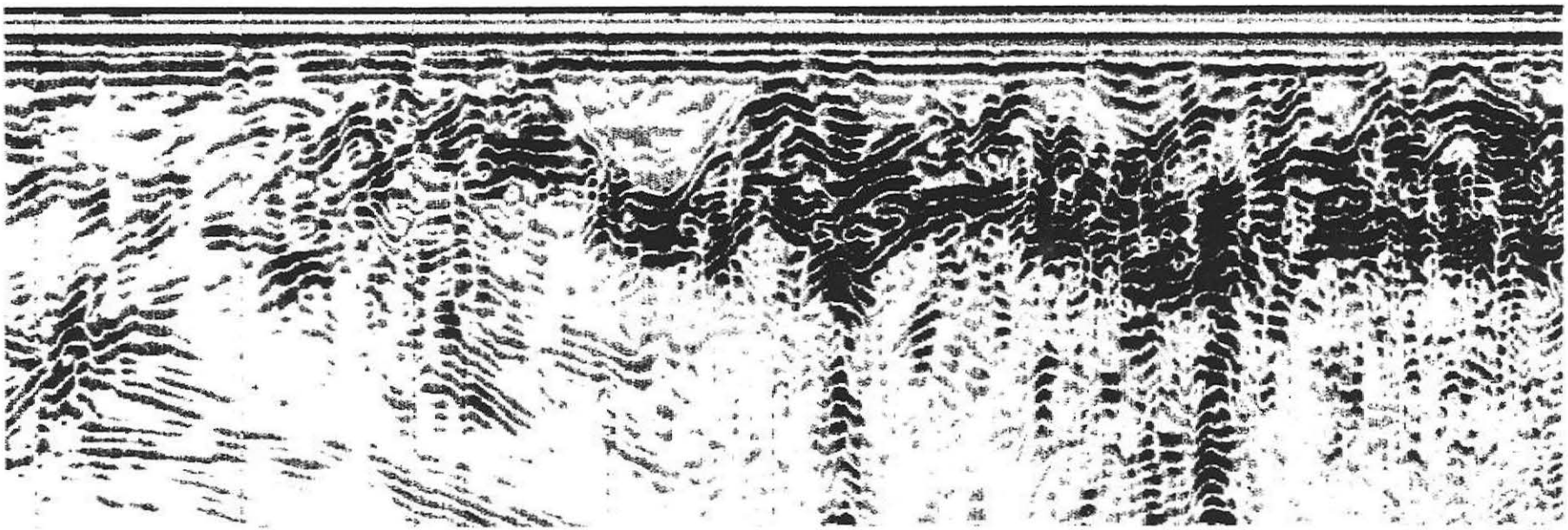


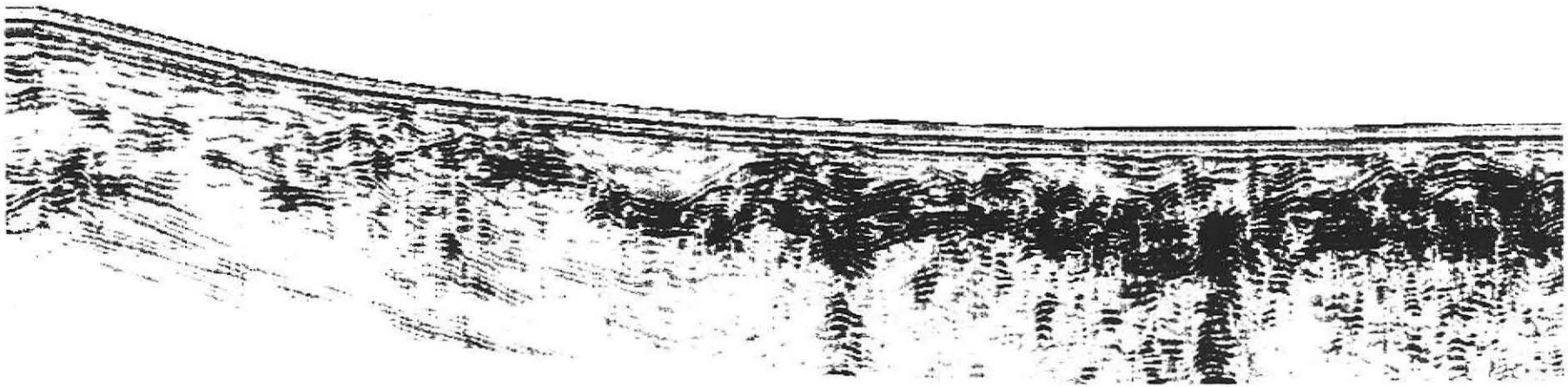
GROUND SURFACE

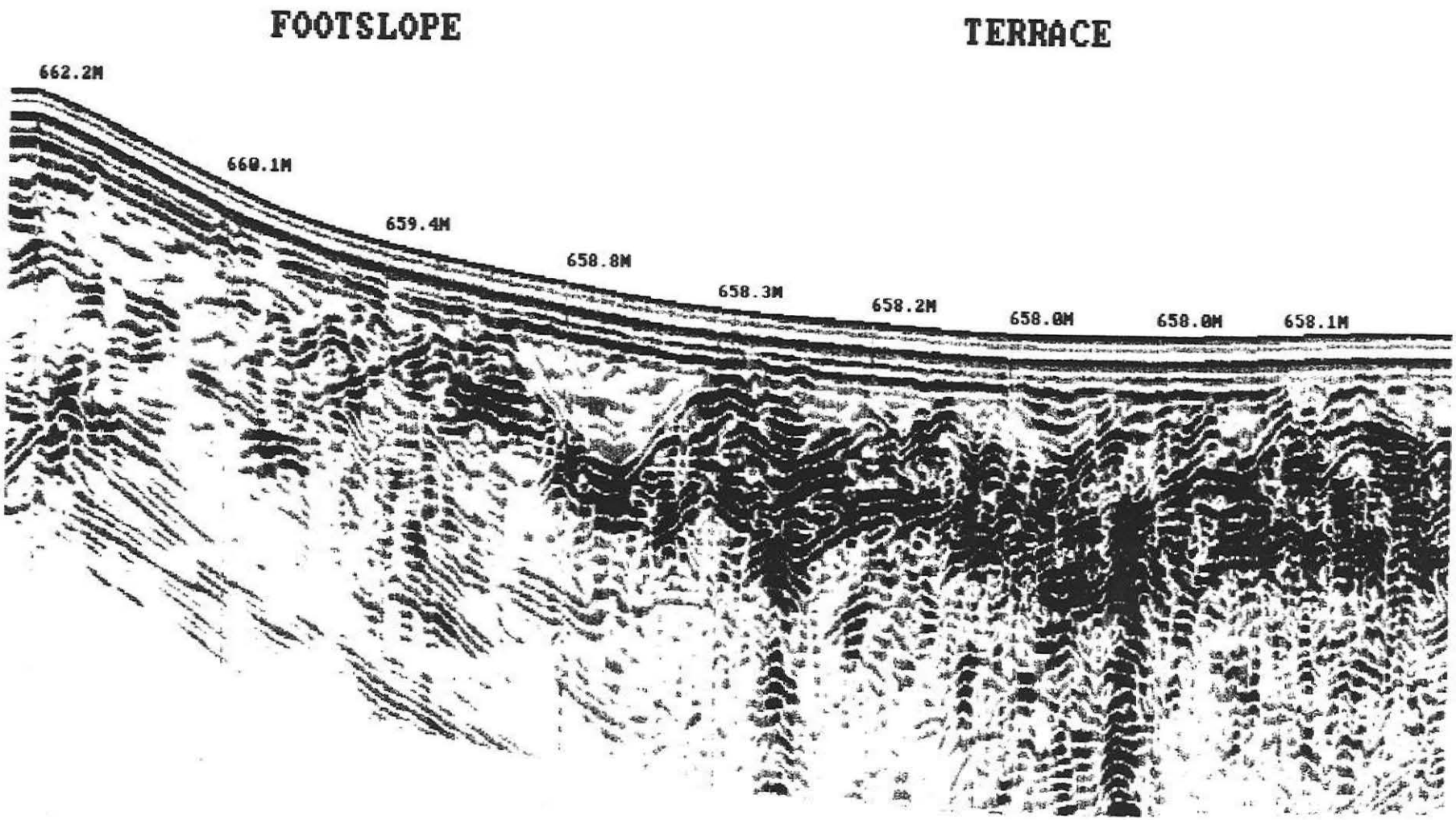


SANDY AND GRAVEL STRATA

A3
B
A2
A1
15.2M
0ns
30ns
60ns
90ns
120ns
150ns






FOOTSLOPE
TERRACE
662.2M
660.1M
659.4M
658.8M
658.3M
658.2M
658.0M
658.0M
658.1M