Estimating Depth to Bedrock using Ground Penetrating Radar in the Carolina Slate Belt.

R. S. Butalia[1], J.W. Tuttle[2], J. G. White[3]

(North Carolina State University , Raleigh, NC - [1] Department of Forestry, [3] Department of Soil Science,; [2] USDA-NRCS National Soil Survey Center; Lincoln, Nebraska)

INTRODUCTION

Ground Penetrating Radar (GPR) studies on soils in the Carolina Slate Belt (Ultisols and Inceptisols at our site) are limited. GPR was used to develop an understanding of the variability in depth to bedrock at two forested watersheds in the North Carolina Piedmont. . Preliminary investigations using GPR indicated high variability in depth to bedrock within the study area. Further analyses will examine the significance of the correlation between geomorphologic variability and depth to soft saprolite / bedrock. This investigation demonstrates the applicability of GPR as a soil survey assessment tool.

Site Description

The site is located in the Duke Forest in Orange County, North Carolina off NC 86, approximately 3 miles south of Hillsboro. Surface runoff and precipitation were measured continuously for a 14 year period from 1991-2004 at two small upland drainages (Figure 1) with a predominantly mesic oak-hickory hardwood forest.. Soils at the site are mapped as Georgeville – Goldston in the NRCS soil survey (Figure 1), but a Georgeville-Herndon series group is more likely based on field investigations.

METHODS

Three GPR transects were marked at 10 meter intervals (Figure 1) The transects were selected to capture geomorphologic variability, i.e. landscape position, topographic curvature and slope, in order to test for correlation of these with depth to bedrock. Points marking 10 meter intervals were geolocated using Trimble GeoExplorer CE units and processed to create GIS data. Elevations for the points were determined by overlaying them on a LiDAR derived Digital Elevation Model (DEM), and extracting the elevations from it.

Transects were surveyed using Ground Penetrating Radar (GPR) to develop an understanding of the variation in depth to saprolite,/soft bedrock. GPR data were collected using GSSI 200 Mhz sensor on January 21 2009. During the survey, GPR data were 'calibrated' by using metal buried at 50 cms and were validated by borings of 50 cm, 65 cm and 1.5 m correlated well with depths interpreted from GPR. auger holes at a few locations. Based on the calibration and validation we estimate that GPR samples are reaching a depth of 2.2 meters below the ground surface.
A LiDAR derived DEM was used to create maps of geomorphologic characteristics. LAS (USGS-CLICK) data were used to create the DEM, after removal of non-ground points. ArcGIS software was used to process the data.

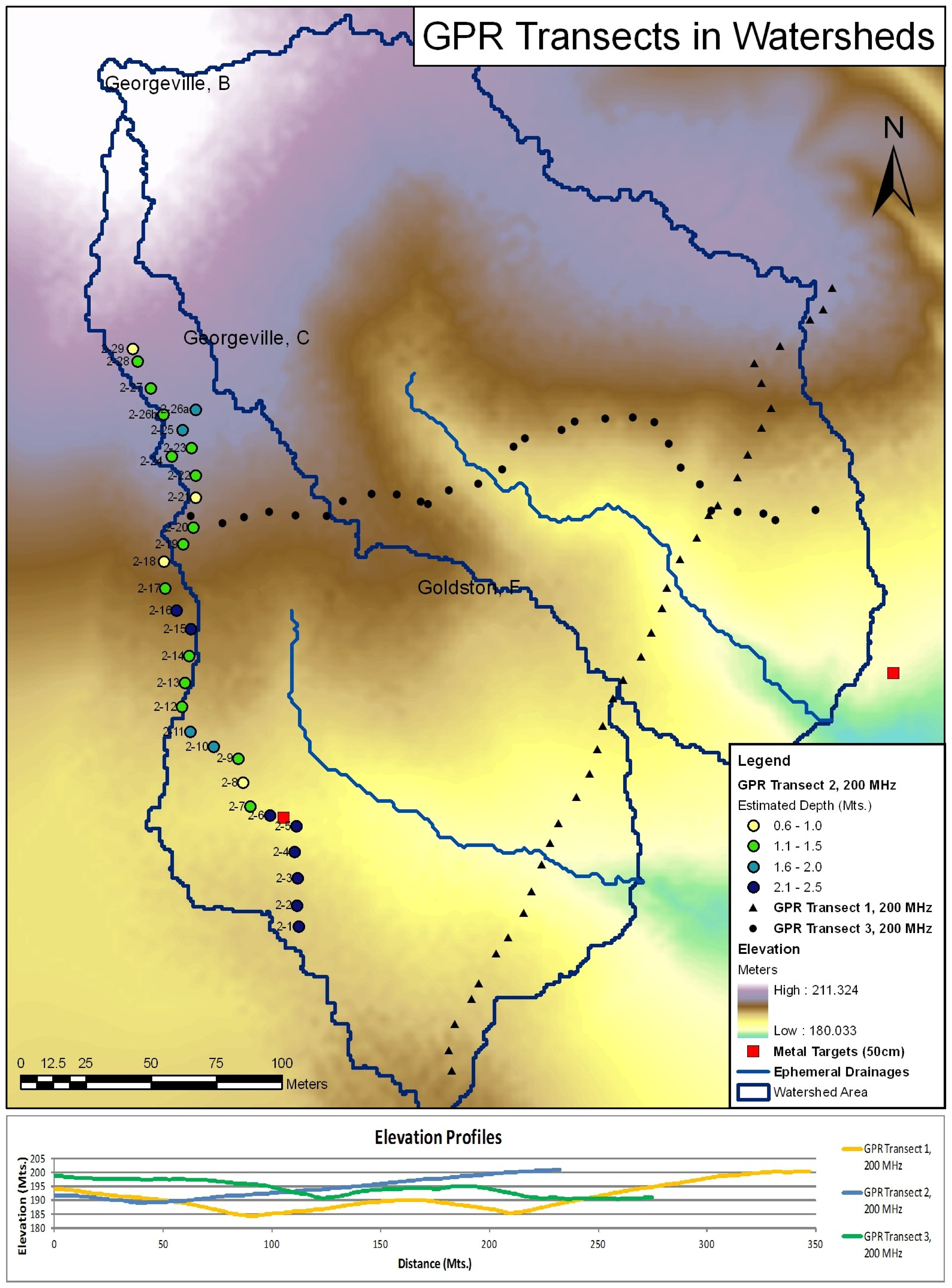

Figure 1. GPR transects, elevation, drainage features of study site and elevation profile of GPR transects

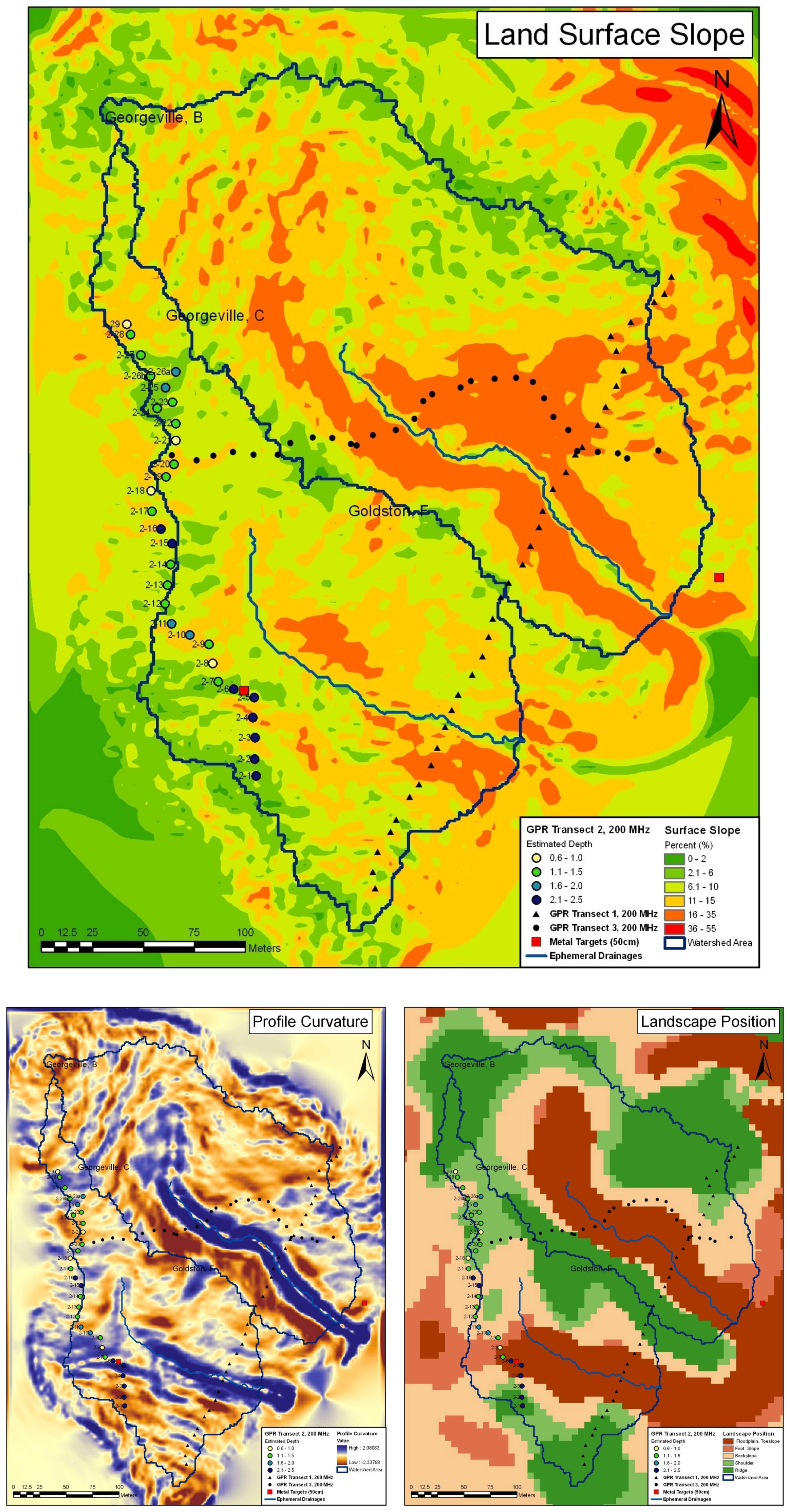

Figure 3. Selected terrain characteristics overlaid with GPR transects.

RESULTS

Elevation profiles for the three transects are shown in Figure 1, elevation does not vary by more than 20 meters for any transect. Figure 2 displays a portion of Transect 2, running N-S on the western edge of the study area. In this section the estimated depth varies from 0.6 meters to 2 meters. This amount of variability is typical of the site. Maps of three terrain characteristics are displayed in figure 3. Despite the relatively low elevation overall, the slope varies significantly within the site i.e. from 2 to 35 percent (Figure 3).

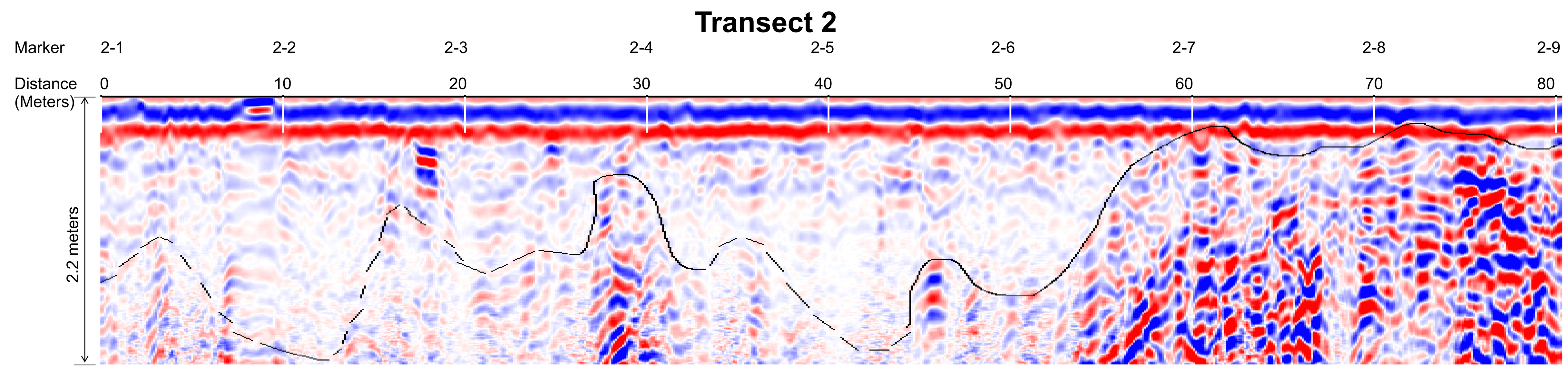

Figure 2. GPR data for 0 to 80 meters of Transect 2 . The black line represents estimated depth. The solid portions of the line represent portions where the estimates are more certain than the portions where the line is dashed. Marker numbers correspond to those on Figure 1.

DISCUSSION AND CONCLUSION

Estimating the depth to bedrock involves user judgment in detecting an appropriate pattern, this can be challenging if there is noise or a weak response. In Figure 2 there are sections where a clear signal is not evident (e.g. from 35 to 45 meters) and estimates were influenced by adjacent samples. In addition the depth of the investigation is limited by the 200 MHz frequency. Due to the nature of the terrain and its forested vegetation traversing it at a constant speed is not feasible, and this creates some uncertainty in the sampling between markers. From a visual perspective the depth to bedrock seems to vary with the terrain characteristics chosen (Figure 3). As an example, estimates of depth to bedrock along Transect 2 seem to be greater in flatter portions of the terrain.

FUTURE WORK

Future work planned includes comprehensive field validation of GPR data by boring and geolocation of validation points. Once this is accomplished a more rigorous approach to examining the correlations between terrain features and GPR based estimates of depth can be conducted.

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