Applications Of Geophysical Tools Within NRCS

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National Soil Survey Center

- Soil Survey Research and Laboratory Staff (Larry West, National Leader)

- Jim Doolittle – Research Soil Scientist
- Wes Tuttle – Soil Scientist (Geophysical)

- Provide Geophysical Technical Assistance to the States (Ground-Penetrating Radar (GPR) and Electromagnetic Induction (EMI)

ELECTROMAGNETIC INDUCTION (EMI)

How EMI Tools Work

- A primary electromagnetic current is induced into the soil.
- The soil responds with a secondary current which is measured by the EMI instruments.
- Spatial conductivity patterns (ECa measurements) are compared across a given area.

Factors Influencing ECa

- Salt Content
- Clay Content & Clay Mineralogy
- Moisture Content
- Temperature

- The apparent conductivity of soils increases with an increase in soluble salts, clay, and water contents.

Salinity Survey

Randy Lewis
(Soil Scientist)
Great Salt Lake Basin, UT

EM-38 meter, Allegro Data Recorder, Trimble AG-114 GPR Receiver


Salinity is not always this easy to observe.
Ute Mountain Ute Indian Reservation
Cortez, CO

Salinity Survey

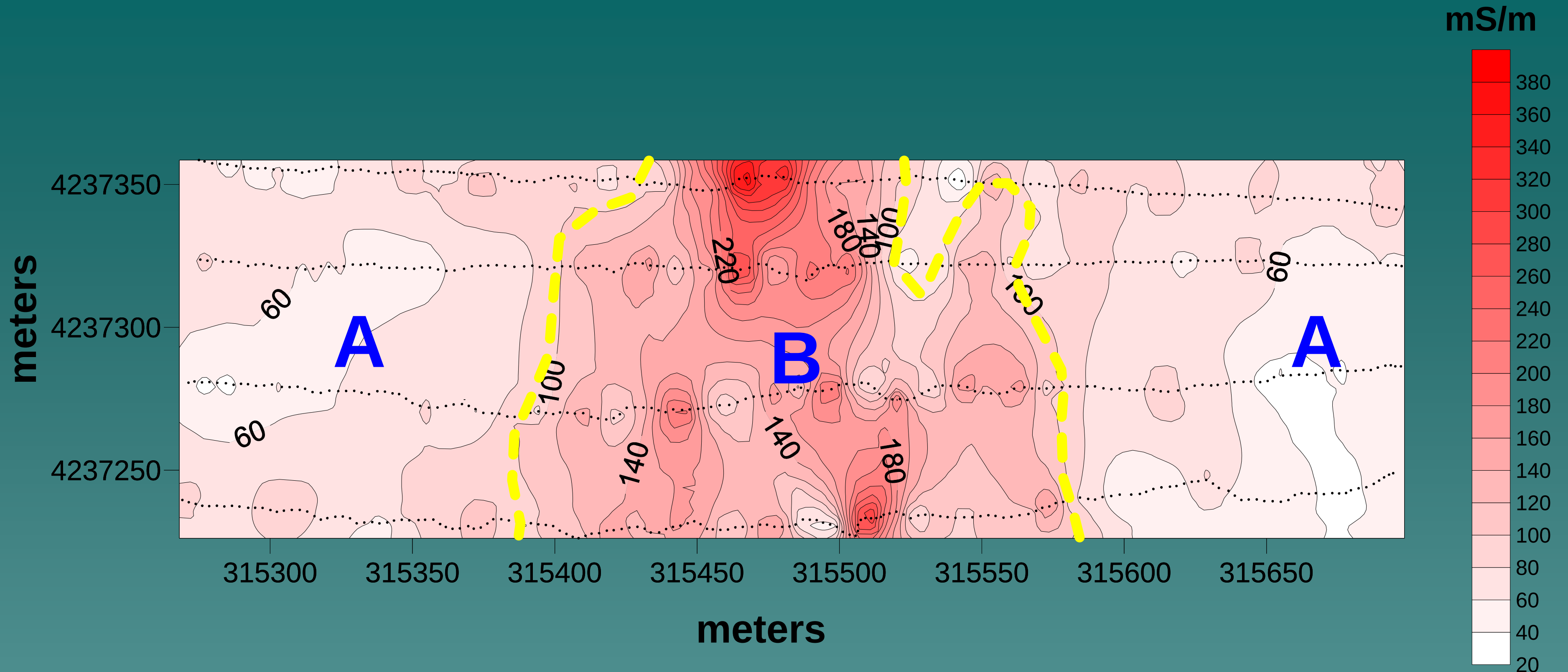

Chuck Natsuhara
(Soil Scientist), Puyallup, WA
Puget Sound Region
Washington
GEM-300 sensor


Mojave Desert
California
Dualem-4 meter
Greater intercoil spacing (longer instrument)
allows for greater observation depths

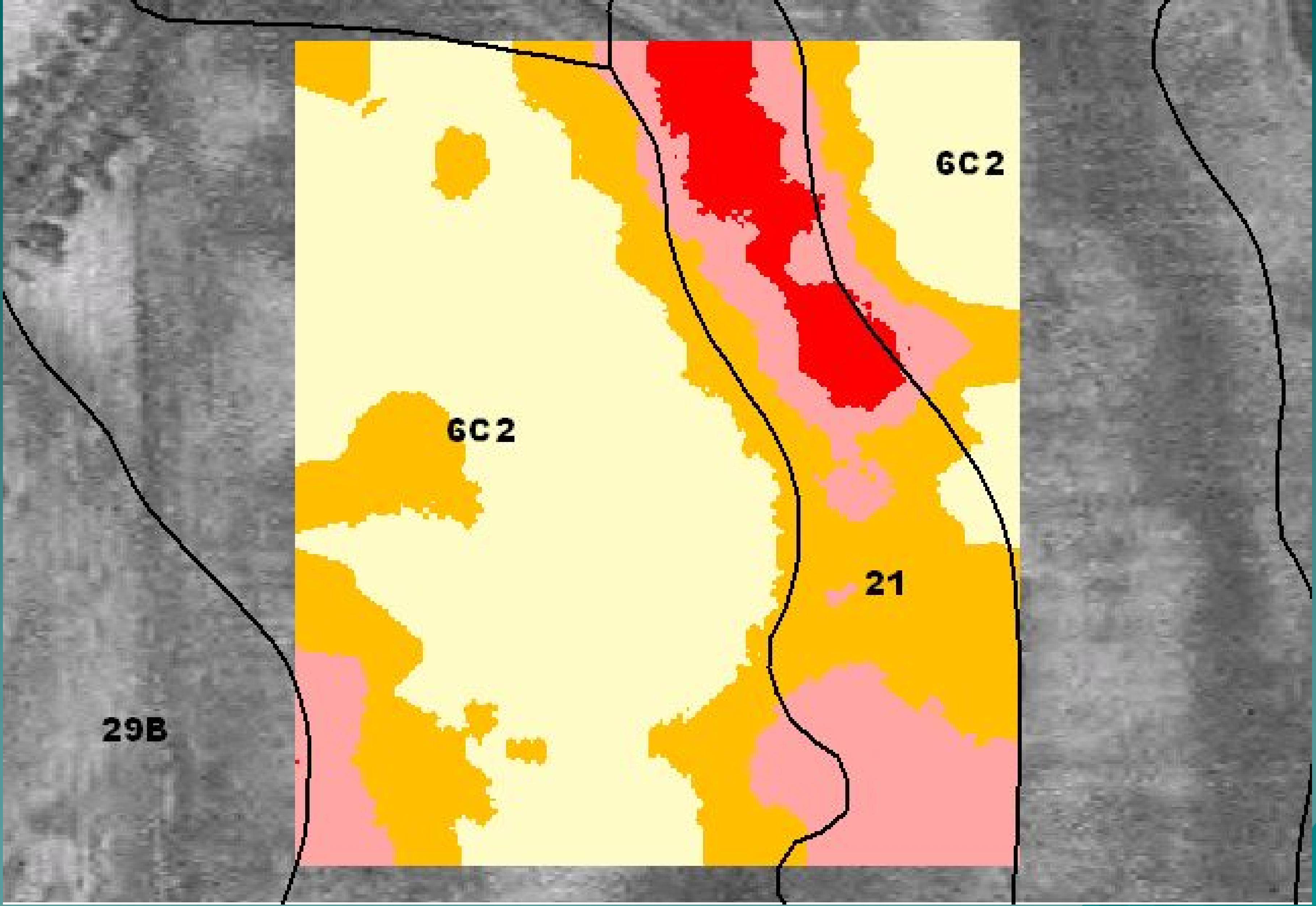
EMI

- Apparent conductivity is a weighted, average conductivity measurement for a column of earthen materials to a specific depth.
- Changes in spatial ECa patterns are associated with changes in soil characteristics.

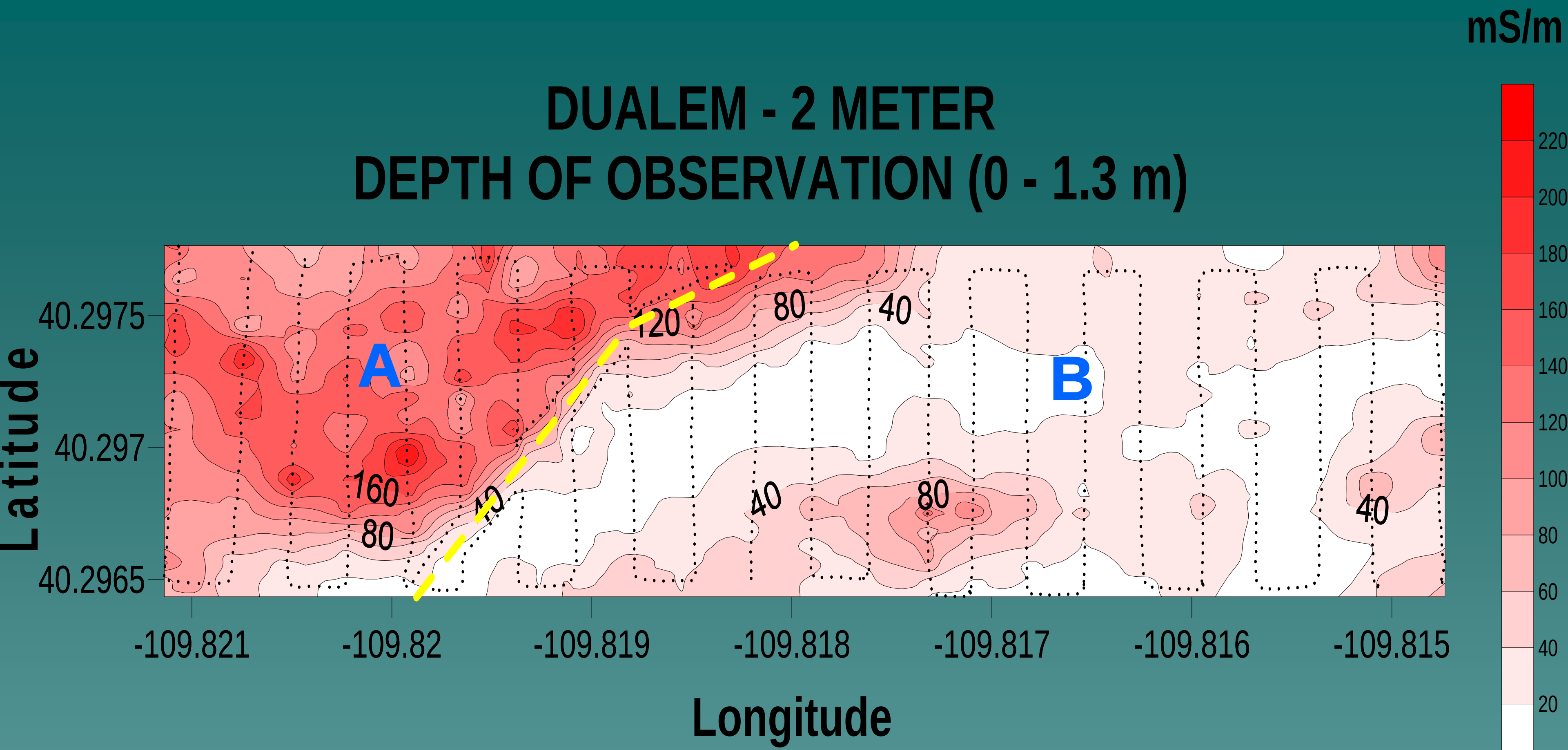
Kent Sutcliffe, Soil Scientist, Utah (USDA / NRCS) conducts an EMI survey with the Geonics EM38 meter, the Garmin GPS backpack and receiver, and the Allegro field data recorder. The survey is conducted in an area of Uvada silty clay loam, 0 to 2 percent slopes.



Spatial patterns of apparent conductivity measured with the EM38 meter in the vertical dipole orientation in an area of Uvada silty clay loam, 0 to 2 percent slopes. Apparent conductivity is measured in millisiemens per meter (mS/m). (B is an area with higher concentrations of salts)



ArcGIS presentation of soils and EMI data (Dexter, MO). Areas in red and pink were associated with soils containing more clay and moisture. EMI spatial patterns were consistent with soils mapping.



Spatial pattern of apparent conductivity measured with the Dualem-2 meter in the PRP (perpendicular) geometry (0 – 1.3 m) in an area of Ohtog-Parahtog complex, 0 to 2 percent slopes, and Parahtog loam, 0 to 2 percent slopes. Apparent conductivity is measured in mS/m (millisiemens/meter). The yellow dashed line is the location of a fence. Areas A and B were both in pasture but only area B was irrigated. Results from the EMI survey revealed significantly higher salt concentrations in area A (non irrigated portion). Irrigation appears to have helped reduce salinity in area B. The higher salt concentrations in area A will affect use and management at the site.

Area A

(Non-irrigated)

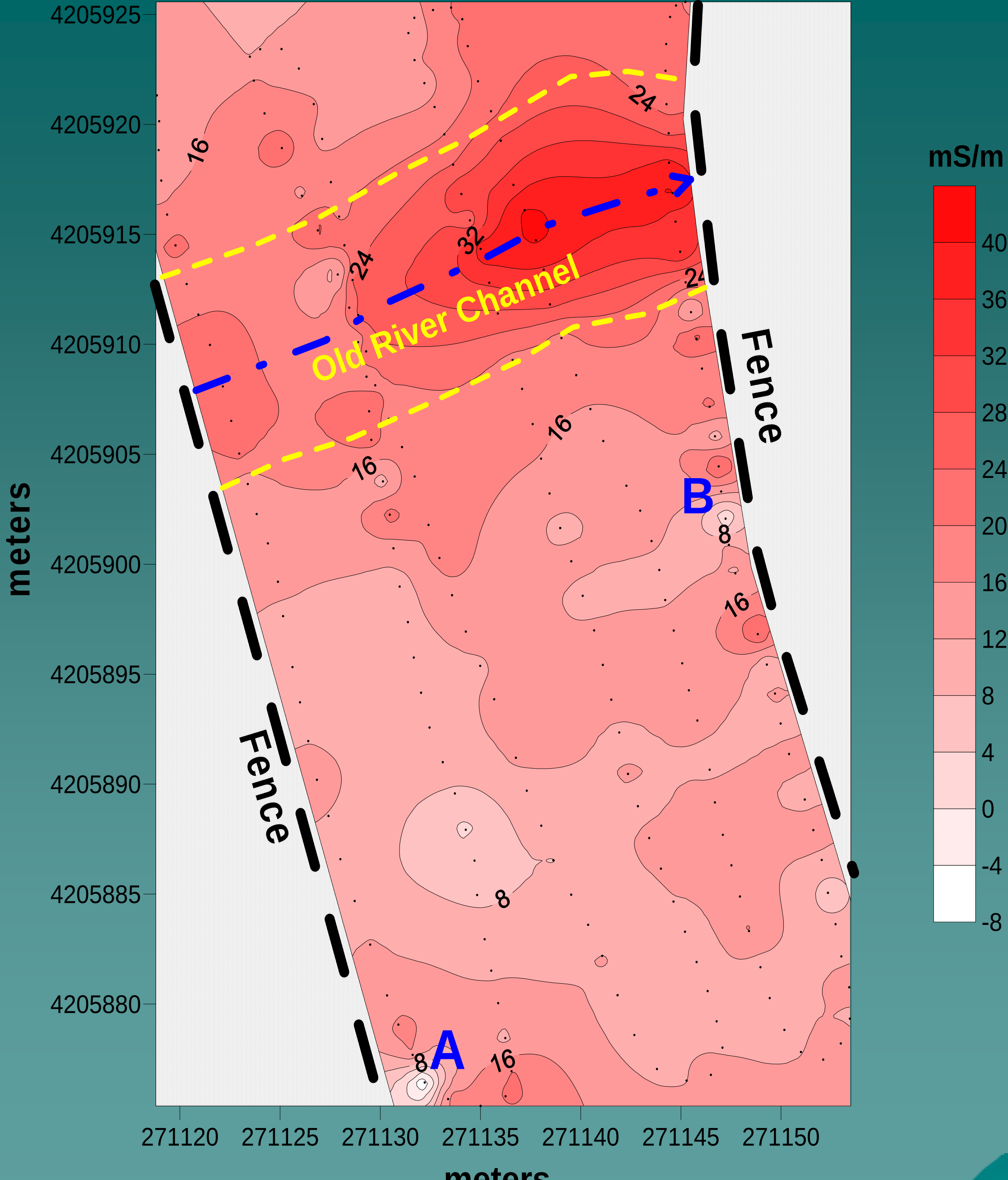
Area B

(Irrigated)

Salinity Survey (EMI)

Uintah County, UT

EM 38 Meter



The location of an old remnant river channel can be observed in the EMI survey. Higher apparent conductivity at this location was thought to be attributed to finer textured soil material (more clay / silt and moisture) that was deposited into an old remnant channel. The planar landform did not suggest the location of any remnant river channels at the site. The survey site was in a flood plain.

Frenchburg, KY

Ground-Penetrating Radar

(GPR)

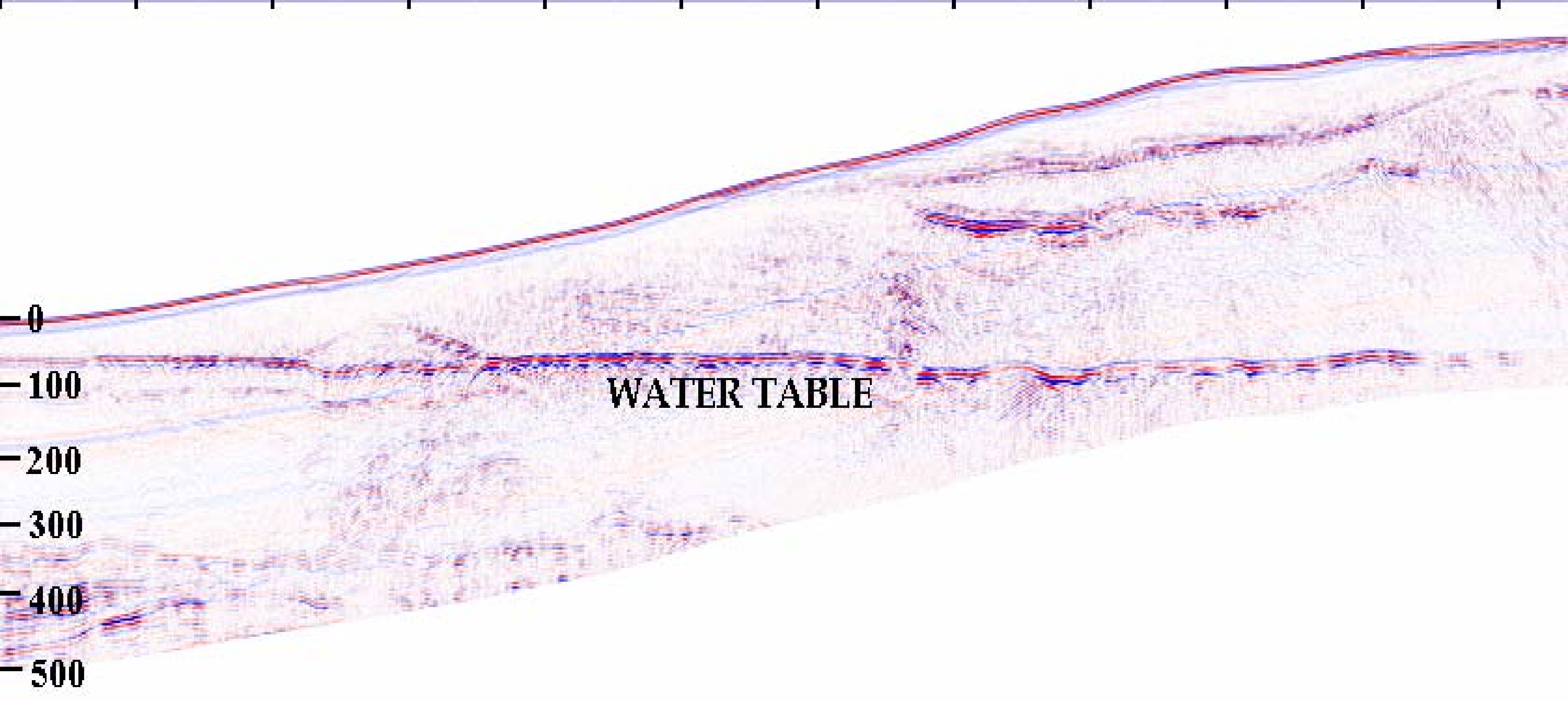
GPR does not perform well in soils with high amounts of:

Salts

Clay

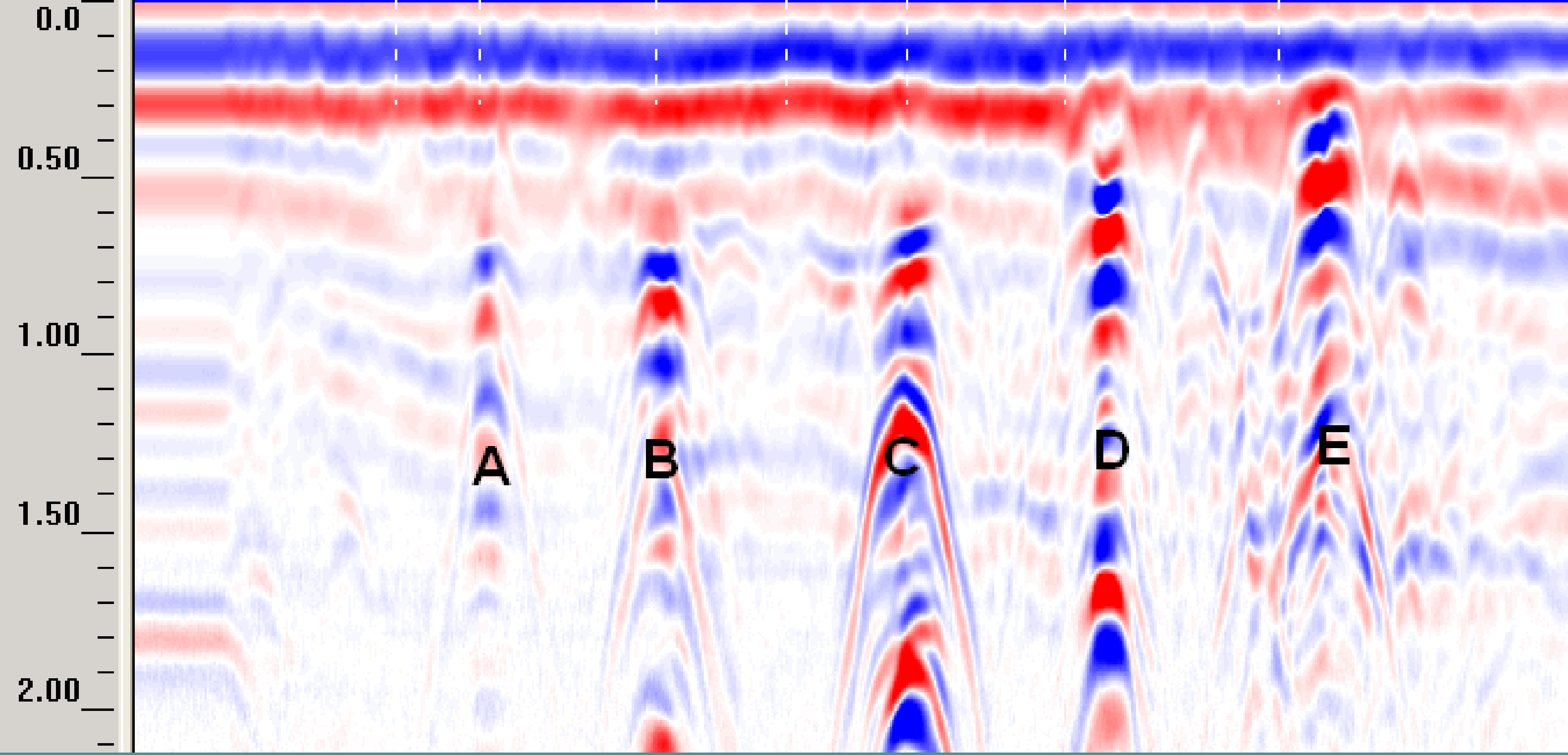
These soil factors increase GPR signal attenuation rates and decrease observation depths. Increases in soil moisture also have a tendency to increase GPR signal attenuation rates and reduce overall GPR effectiveness.

GPR performs best in coarse textured soils.



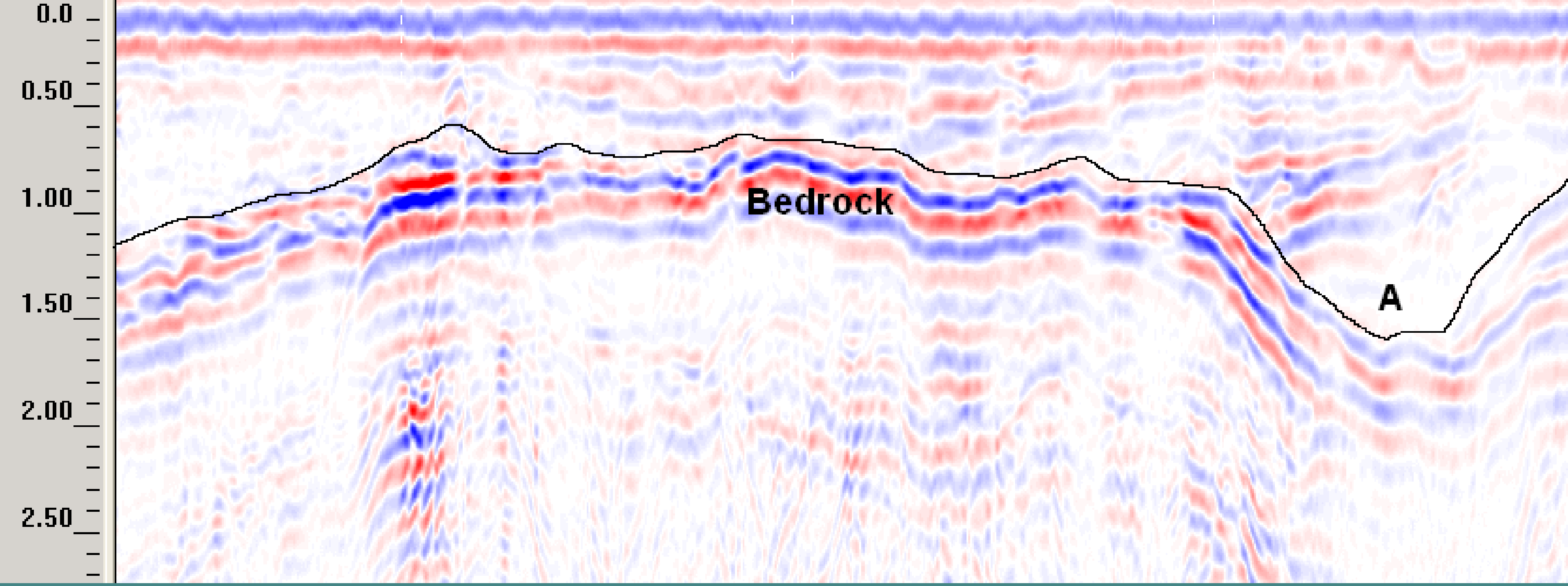
Nags Head, NC (Jockey’s Ridge State Park)
(sand dunes - 99% quartz) 2 to 40% slopes

A water table can be observed in the GPR record. Observation depths ranged to approximately 50 feet in this record. The scale is in nanoseconds. GPR observation depths are significantly less in soils containing more clay.



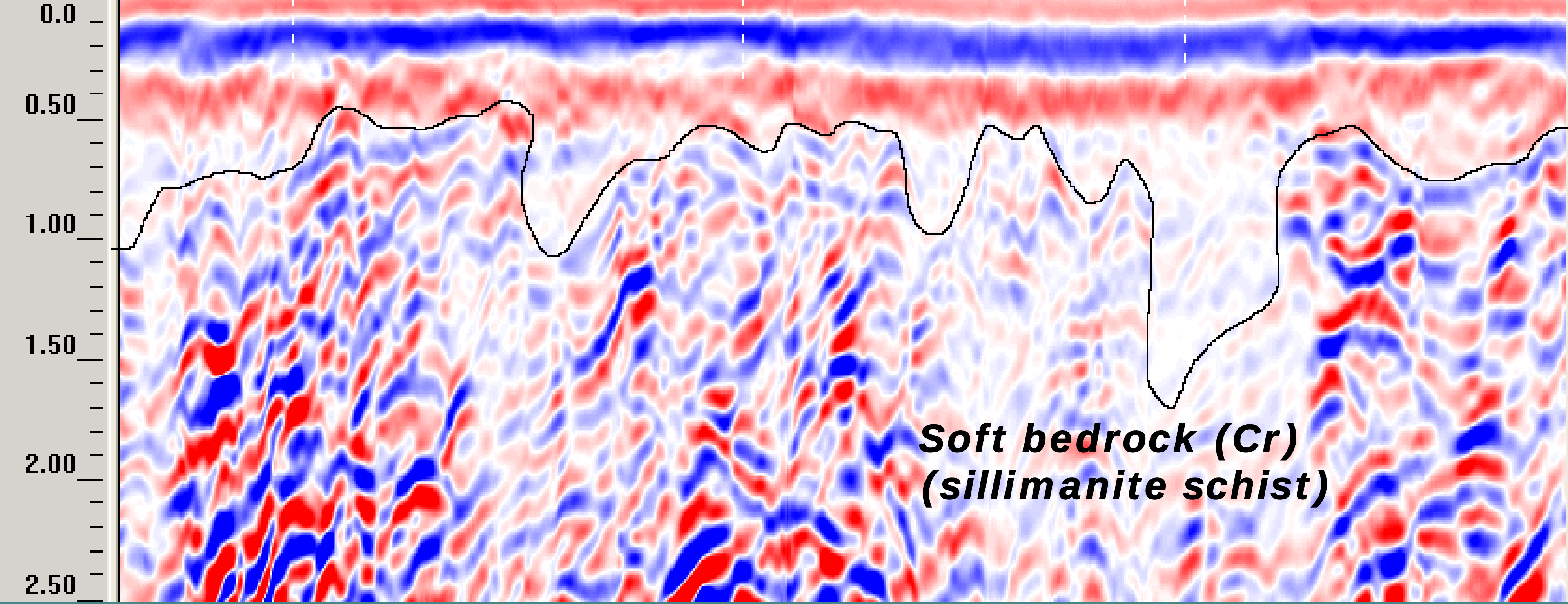
GPR Record - (septic drain lines)

Point objects appear as hyperbolic features in GPR records. In this portion of the radar record, drain lines range in depth from 20 cm to 70 cm from the soil surface. The depth scale is expressed in meters.



GPR Record - Wake County, NC (granite bedrock)

Interpreted depths to bedrock ranged from 60 cm to 1.5 meters (point A) along this portion of the radar record. Depths to bedrock were verified with soil borings. A black line highlights the approximate interface between soil material and bedrock. The use of GPR can reduce the number of soil borings needed to verify subsurface features and diagnostic horizons. The depth scale is expressed in meters.



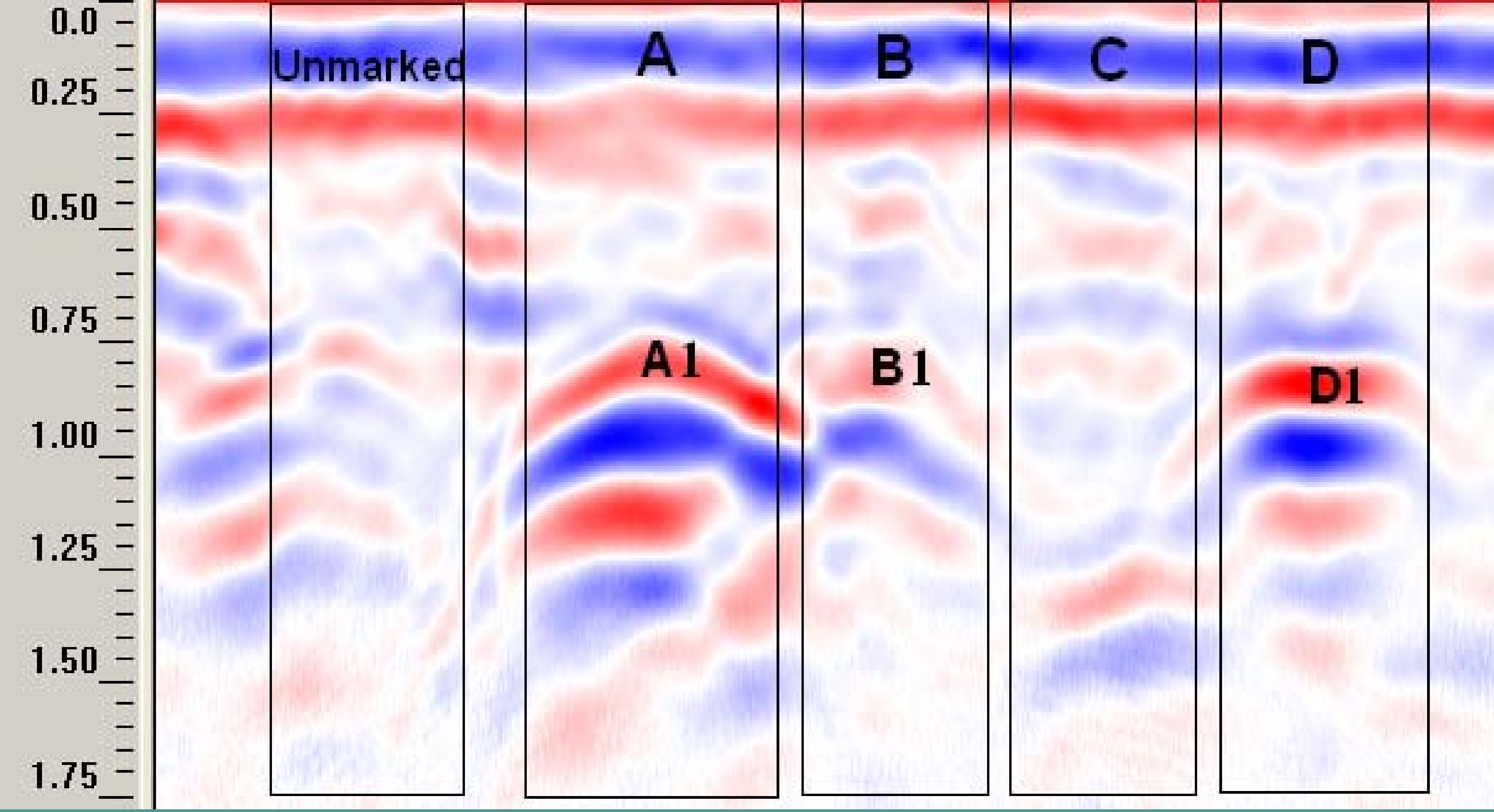
A portion of a representative radar record from an area previously mapped Madison gravelly fine sandy loam, 2 to 6 percent slopes, eroded. The map unit will be renamed to more accurately capture the varying depths to bedrock. The depth scale is expressed in meters.

Summary of transect data across the map unit
(GPR interpreted depths)

Depths to Soft Bedrock	Components Observed (21 total)	Component Percentage
0 to 20 in. (0 to 50 cm)	1	5%
20 to 40 in. (50 to 100 cm)	7	33%
40 to 60 in. (100 to 150 cm)	8	38%
> 60 in. (>150 cm)	5	24%

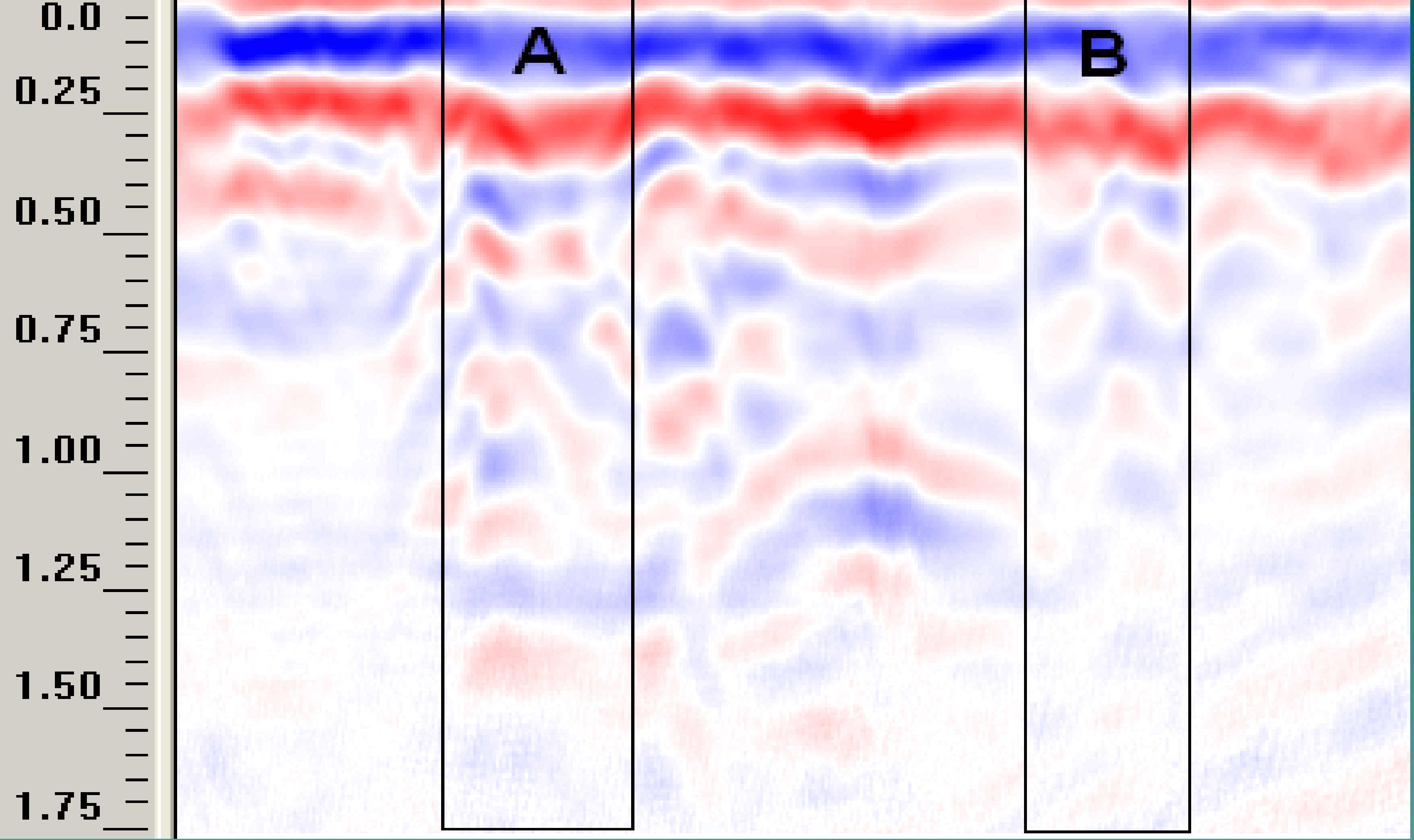
Iredell County, NC (piedmont)

Hillcrest Cemetery Winchester, KY



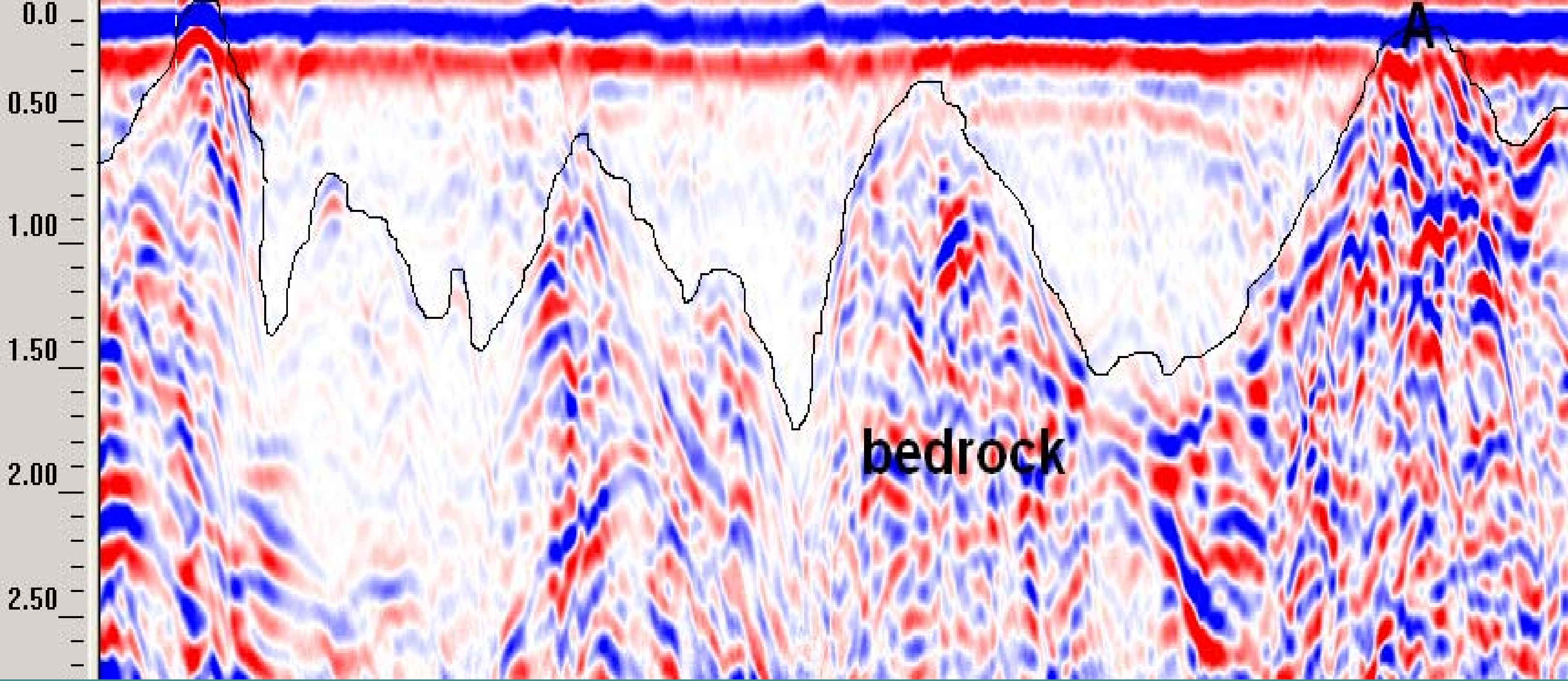
Potential Burial Sites

Burial markers were present at locations A, B, C, and D. Burial vaults/coffins were thought to be present in burial shafts A, B, and D. Burial vaults/coffins were identified within the burial shafts at points A1, B1, and D1 and often appear as hyperbolic features in radar records. The depth scale is expressed in meters.



Unmarked Graves / Older Burials

No burial markers were present at locations A or B. Truncated soil layers present in potential grave shafts A and B are an indicator of soil disturbance and potential burials. Older burials are often more difficult to detect than more recent burials utilizing metal coffins and vaults. Wooden coffins or linens which decay more rapidly, were often used in older burials. The depth scale is expressed in meters.



Depth to Bedrock Variability (50 m transect)

A representative portion of a radar record from an area of Pacolet-Saw complex, 6 to 10 percent slopes, bouldery. This portion of the radar record demonstrates the variability of depth to bedrock within the map unit. Interpreted depths to bedrock in this portion of the radar record ranged from 0 cm (rock outcrop) to greater than 1.5 meters. Soil borings at A revealed hard bedrock at approximately 30 cm. The depth scale is expressed in meters.

Fulton County, GA

Summary

Making Useful Interpretations Using Geophysical Tools

- EMI and GPR techniques are non-invasive tools, when used in combination with the knowledge of soils and soil properties, can result in more accurate interpretations.
- GROUND-TRUTHING is a NECESSITY!

- TEAM APPROACH.... Everyone involved contributes to interpretations.
- Rely on the knowledge and expertise of the local soil scientists and other persons familiar with the area.