APPENDIX C: GROUND PENETRATING RADAR SURVEY REPORT

Contents

Summary

1. Field 1: Radar suggests that there could be an irregularly shaped boundary between soil and bedrock across the survey. This apparent contact is wavy in nature, and resembles the dissolution features that are manifested in cutter and pinnacle karst. Depth to bedrock and karst features appear to be more shallow near the top of the hill surveyed, which would conform to standard soil landscape models for the area.
2. Field 5a: Radar shows a contrasting layer at a depth near 50 to 60-cm across much of the field. Field observations found that clay content increased near this depth consistently, changing from silt loam or fine sandy loam to clay, clay loam, or silty clay loam at greater depths for field soils adjacent to Big Creek.
3. Field 12: Radar suggests that an argillic layer around 25-cm and a wavy gravel layer (about 35 to 45%) around a depth of 80 to 120 cm, which is typical of the other fields surveyed adjacent to Big Creek. However, the gravel layer appears to be overlain with fine sandy loam (0 to 25 cm depth) and sandy clay loam material (25 to 80 cm depth) that is of valley and alluvial origin.

4. Overall, soils varied in depth across and among fields. Field 1 had an overlying layer of soil that varied from zero (rock outcrops) to 50 cm (20 inches). Fields 5a and 12 adjacent to Big Creek had soils varying in depth from 80 to 150 cm deep (30 to 60 inches). The deeper soil profiles for Fields 5a and 12 were adjacent to Big Creek, with the thinner soils on the side of the field further from the Creek. This is typical of periodic flooding of Big Creek depositing alluvial material adjacent to the stream bank over the last century following land settlement.

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Purpose and Overview

A series of ground penetrating radar surveys were conducted on two fields permitted to receive slurry applications (Fields 1 and 12) and one planned for possible future applications (Field 5a), to investigate subsurface soil properties. Participating were Wes Tuttle, Geophysical Soil Scientist, NRCS; Richard Vaught, Soils Scientist and GPR operator, NRCS; Dr. Kris Brye and Lawrence Berry, University of AR Crop, Soil and Environmental Science Department; Dr. Mike Daniels, Professor, Extension Water Quality, University of AR Division of Agriculture; and Cory Hallmark and Josh Hesselbein, University of AR Extension, University of AR Extension.

Field 1

1. A SIR-3000 Ground-Penetrating Radar (GPR) system (Geophysical Survey Systems Inc) with 200-Mhz antenna was used at this site (Figures 1 and 2).
2. A metal plate was buried at the site at a depth of 50-cm to calibrate the instrument and to ground-truth soil conditions. A second hole was hand dug to 50-cm to further ground-truth soil conditions.
3. Conditions were too rocky at the site to successfully use a Giddings soil probe to a depth of deeper than 20-cm.
4. Two 90-m transects were laid out. The transects were flagged at 10-m intervals.
5. Transect/GPR survey #18 proceeded in a generally northeasterly direction, up hill, where slopes ranged from 3 to 15 % or greater (Figure 2).


Figure 1. Preparing a transect for the Ground Penetrating Radar assessment at C&H Farm.

6. Transect/GPR survey #20 ran at a right angle to transect #18, and traveled in a northwesterly direction, where slopes ranged from 3-5% (Figure 2).

Figure 2. Conducting the Ground Penetrating Radar assessment at C&H Farm.

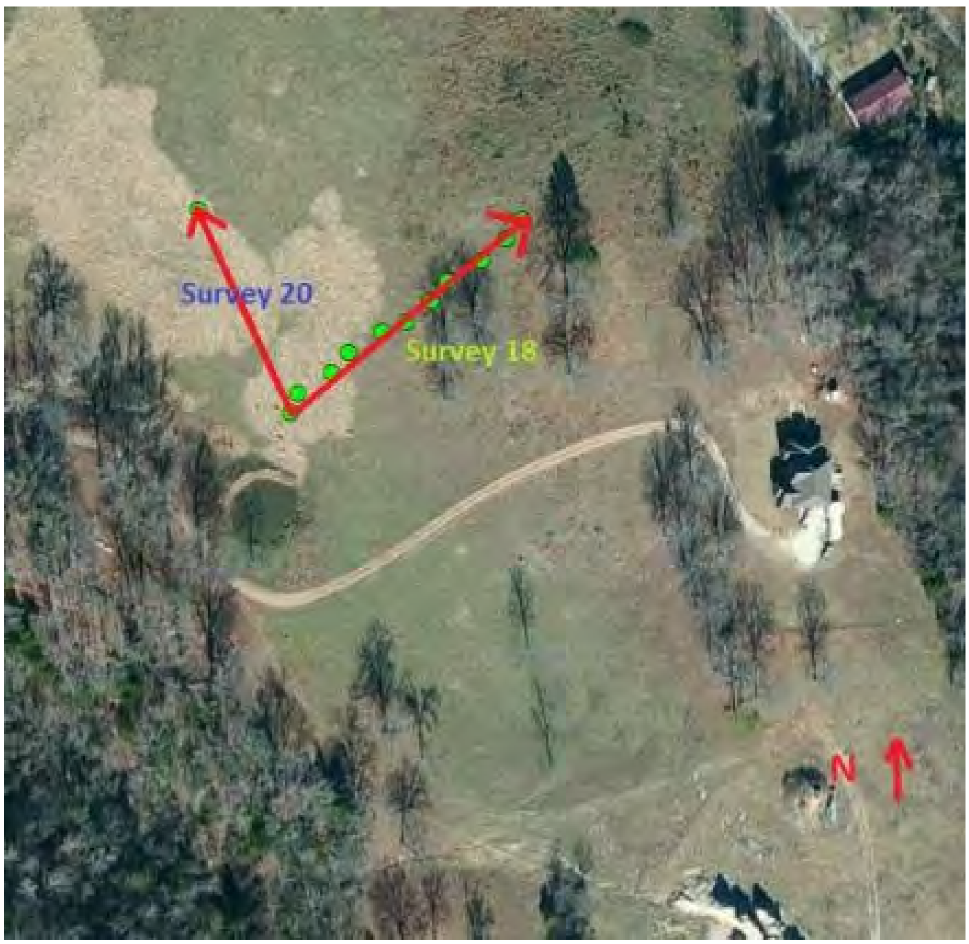

Figure 3. Location of ground penetrating radar surveys at field 1 near Mount Judea, AR. Surveys were 90-m in length.

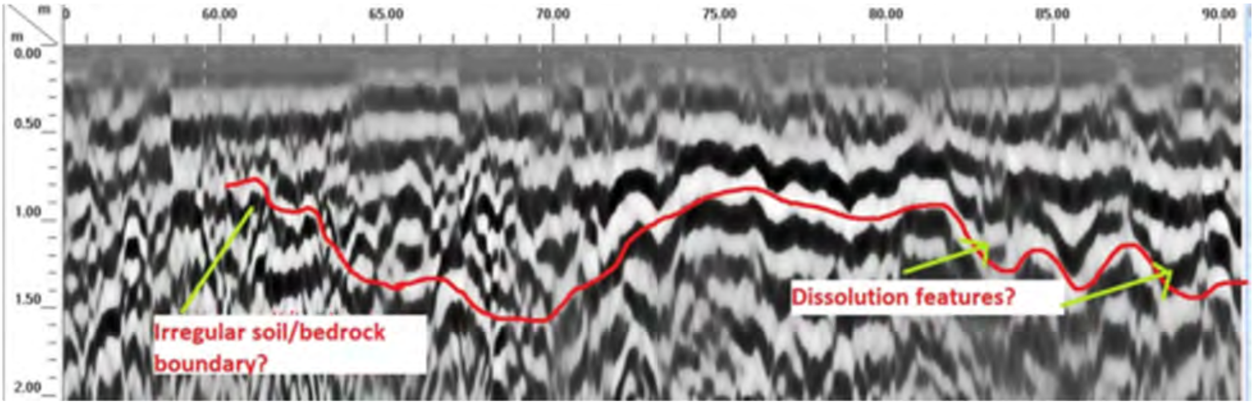

Figure 4. Possible solution features on the end sections of survey 18.

Summary: Transect 18

1. Soils observed at the site seemed to agree with the Newton county soil survey, and resembled the Noark series, which is formed in residuum and colluvium of clayey limestone.
2. The radar records from this site are of good interpretative quality. Several features that were not readily evident in the field became more noticeable after processing the data.
3. Excavation to identify many of the subsurface features was not feasible due to rocky conditions. Thus, it should be noted that most features "observed" in the radar record have not been verified in the field.
4. The radar record indicates that soil features across survey 18 are not homogenous, which is not surprising, since the landform changed across the survey.
5. The data suggests that there could be an irregularly shaped boundary between soil and bedrock across the survey (Figures 4 and 5). This apparent contact is wavy in nature, and resembles the dissolution features that are manifested in cutter and pinnacle karst.
6. Depth to bedrock and karst features appear to be more shallow near the top of the hill surveyed, which would conform to standard soil landscape models for the area.

Summary: Transect 20

1. The radar record suggests (as was verified at both test holes) that there is a horizon boundary that is mostly located in the vicinity of 50-cm. This horizon was observed to be a BC horizon, heavy silt loam or silty clay loam, with approximately 60% coarse fragments.
2. The radar record suggests an irregularly shaped boundary between soil and bedrock across the survey (Figure 6). This apparent contact is wavy in nature, and resembles the dissolution features that are manifested in cutter and pinnacle karst.

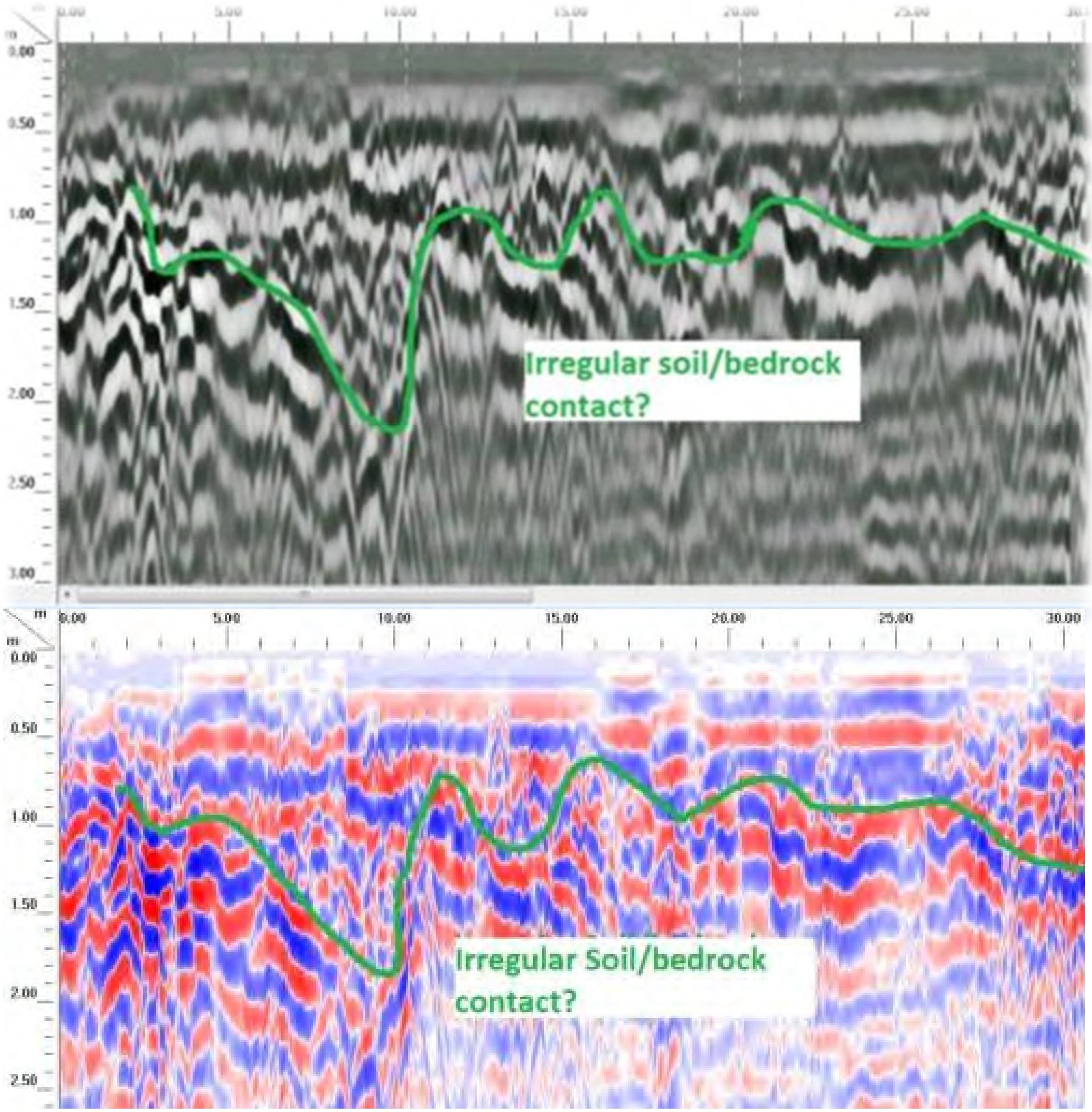

Figure 5. Two different representations of possible soil/bedrock interface at the beginning of survey 18.

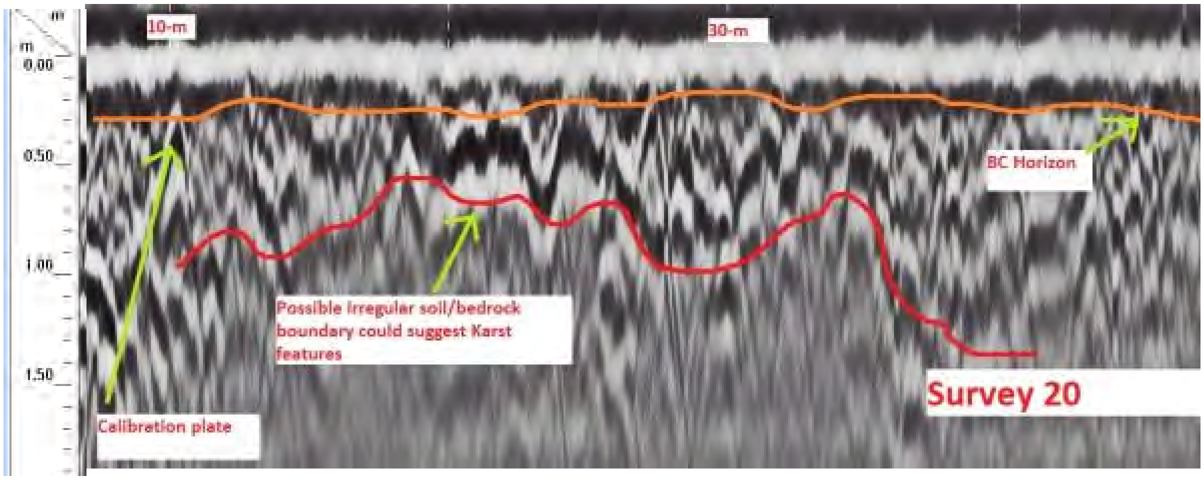

Figure 6. The apparent soil/bedrock contact was wavy in nature across survey 20.

Field 5a

Activities: Surveys 27, 28 and 29

1. A SIR-3000 Ground-Penetrating Radar (GPR) system (Geophysical Survey Systems Inc.) with 400-mhz antenna was used at this site.
2. A metal plate was buried at the site at a depth of 50-cm to calibrate the instrument and to ground-truth soil conditions.
3. A series of three transects were laid out and flagged at 10-m increments perpendicular to Big Creek, progressing from a portion of a toe slope , over a terrace to the flood plain. The bulk of the transects were located on the terrace (Figure 7).
4. Three holes were hand dug on survey 27 to observe soil conditions.
5. Three to four holes were bored with a Giddings soil probe to a depth of around 80-cm along each of the transects to collect samples and to ground-truth the radar survey.

Figure 7. Field 5.

Summary: Transect 27

1. The radar record and field observations indicated an argillic layer beginning in the vicinity of 25-cm over much of the transect. Field textures for this layer were mostly silt loam.
2. The radar record shows a contrasting layer at a depth near 50 to 60-cm over much of the transect. Field observations found that clay content increased near this depth consistently, changing from silt loam or fine sandy loam to clay, clay loam, or silty clay loam at greater depths.
3. Coarse fragment content observed in most of the borings was less than 10%. The Giddings probe worked well due to lack of fragments.
4. An anomaly was noted on the radar record near the end of survey 27, near the 160-m mark. Boring with the Giddings probe was not possible at this location, due to coarse fragment content. Further digging with a spade showed that coarse fragment content was 40-60% at a depth of 30-cm. Heavy coarse fragment content made further digging unfeasible due to time constraints.
5. Based on the radar records, field observation, and proximity to the creek, the area with an increase in coarse fragment content could be a gravel lens.

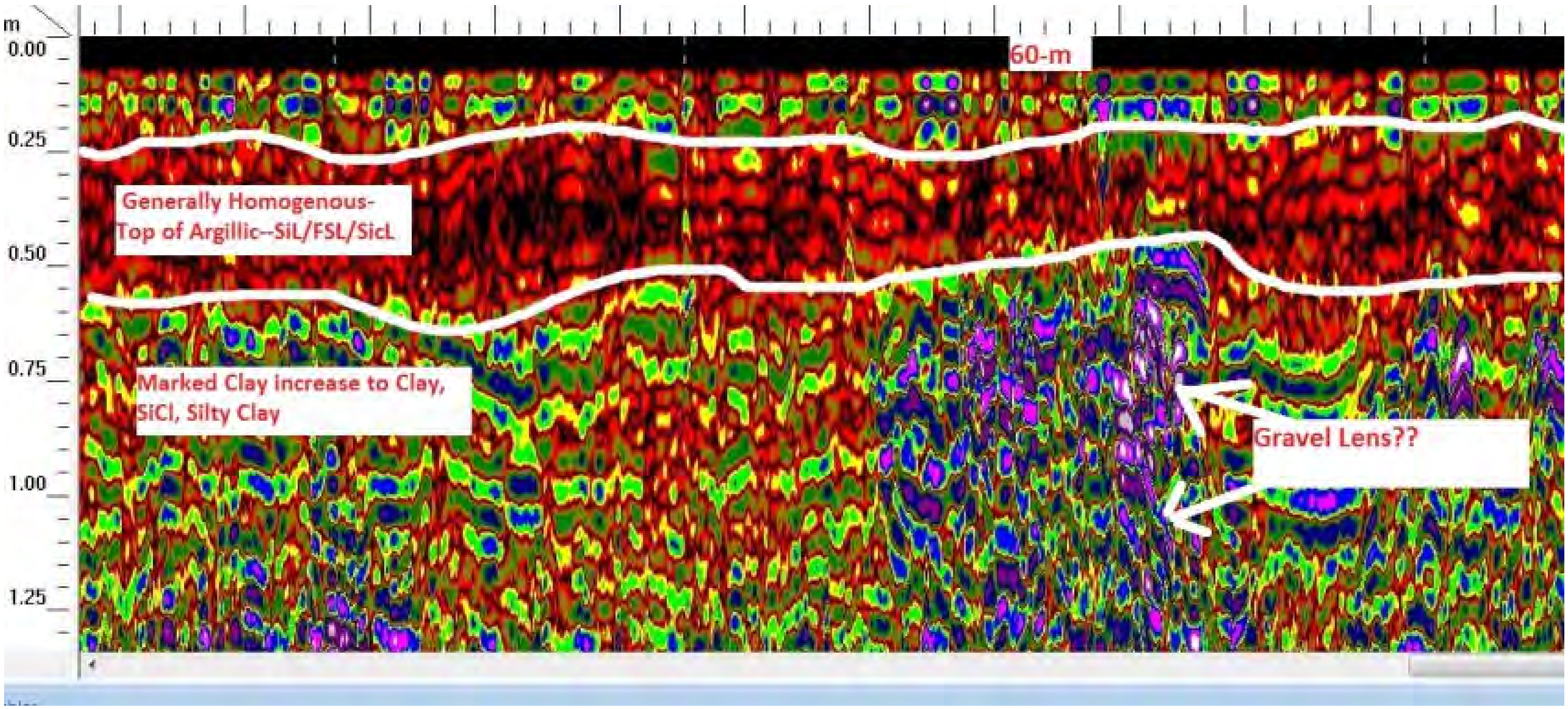

Figure 8. A marked increase in coarse fragments was observed in the field at the 60-m mark of survey 27.

Summary: Transect 28

1. Much like survey 27, the radar record and field observations indicated an argillic layer beginning at around 25-cm over much of the transect. Field textures for this layer were mostly silt loam.
2. The beginning portion of the transect occurred on a toe-slope. The radar record suggests that the soil-bedrock interface could be wavy in nature, which may suggest cutter and pinnacle karst (Figure 8).
3. The radar record shows a contrasting layer at a depth of around 50 to 60-cm over much of the transect. Field observations found that clay content increased near this depth consistently, changing from silt loam or fine sandy loam to clay, clay loam, or silty clay loam at greater depths (Figure 9).
4. Signatures from portions of this radar record resembled the area from transect 27 where coarse fragment content greatly increased. These areas could contain gravel lenses in the subsurface (Figure 10).
5. Based on field observations, soils near the end of the survey (closer to the creek) were younger and less developed.

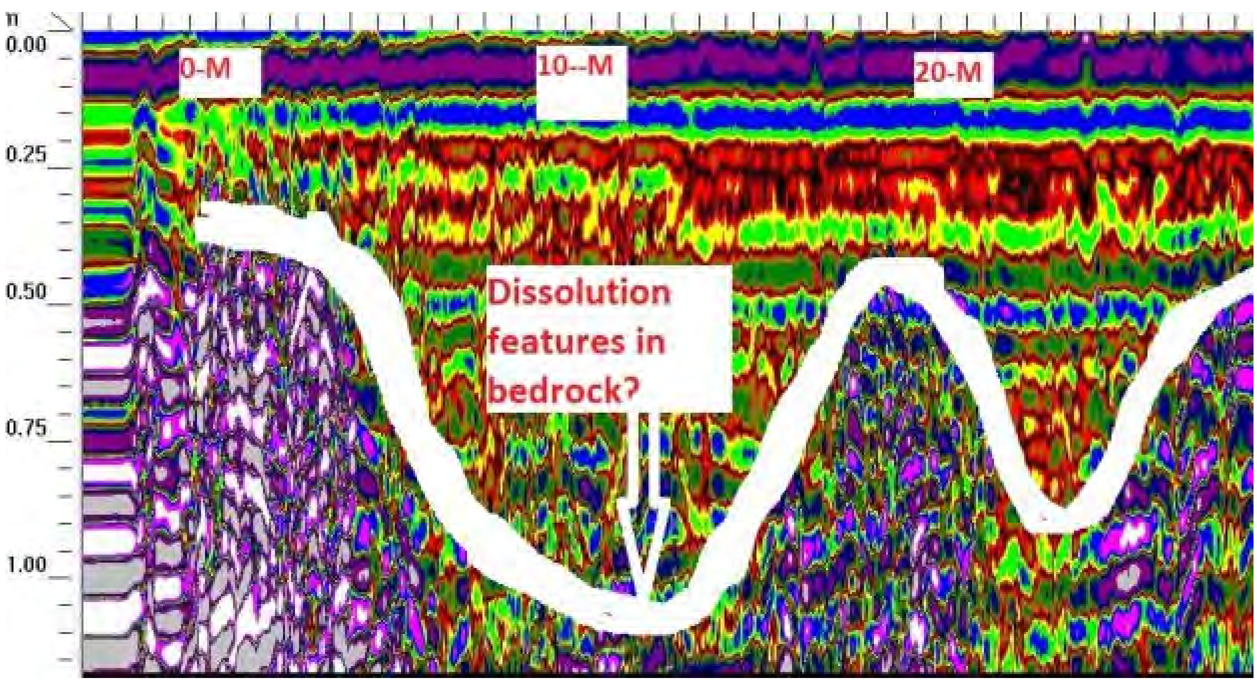

Figure 9. The first portion of transects 27-28 began on a toe-slope. The transect then dropped down onto a terrace. The toe-slope portion (above) may be underlain by dissolution features.

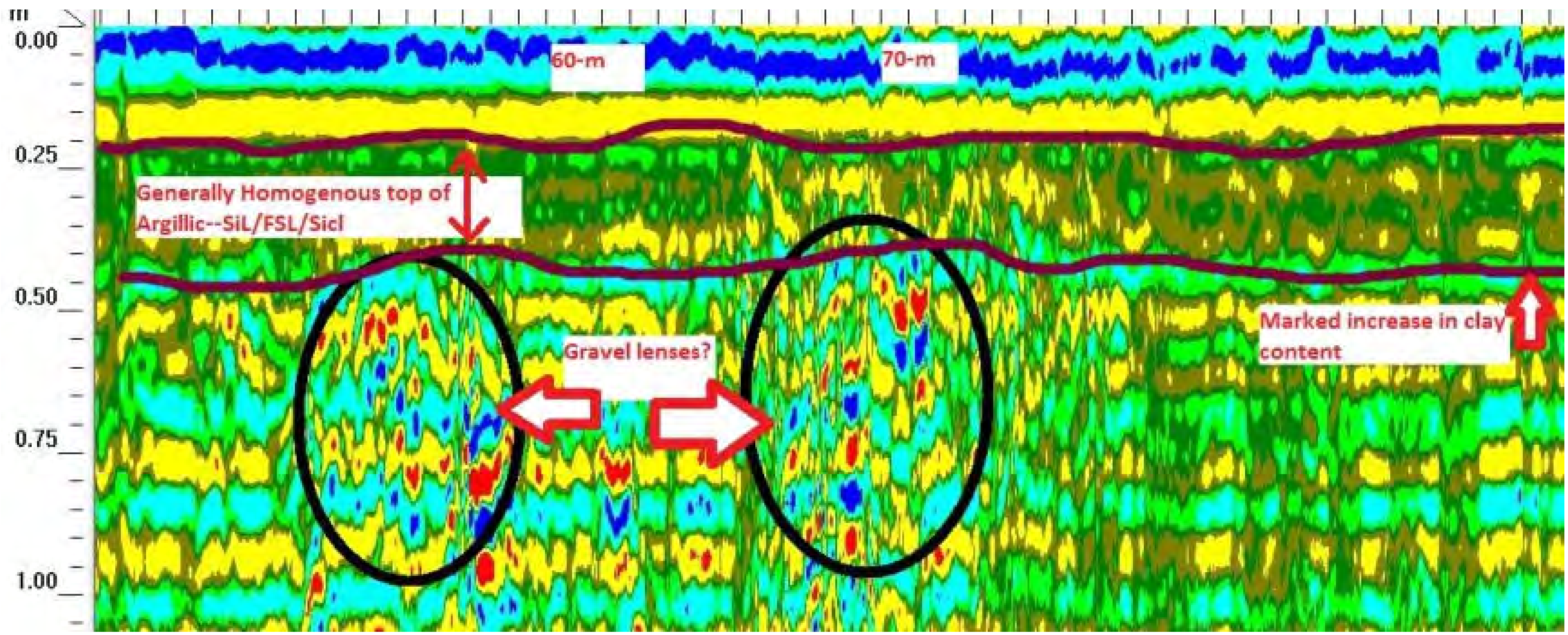

Figure 10. From survey 28. The right hand portion of the radar record seems to exemplify the overall nature of the field: a layer of silt loam or fine sandy loam, which transitions to clay or silty clay at around 50-cm. Possible gravel lenses were detected between 50-m and 70-m on the transect.

Summary: Transect 29

1. Much like surveys 27 and 28, the radar record and field observations indicated an argillic layer beginning at around 25-cm over much of the transect. Field textures for this layer were mostly silt loam.

2. The beginning portion of the transect occurred on a toe-slope. The radar record suggests that the soil-bedrock interface could be wavy in nature, which would be indicative of cutter and pinnacle karst.

3. The radar record shows a contrasting layer at a depth of around 50 to 60-cm over much of the transect. Field observations found that clay content increased near this depth consistently, changing from silt loam or fine sandy loam to clay, clay loam, or silty clay loam at greater depths (Figure 11).

4. There were no potential grave lenses observed on this radar record.

5. Based on field observations, soils near the end of the survey (closer to the creek) were younger and less developed.

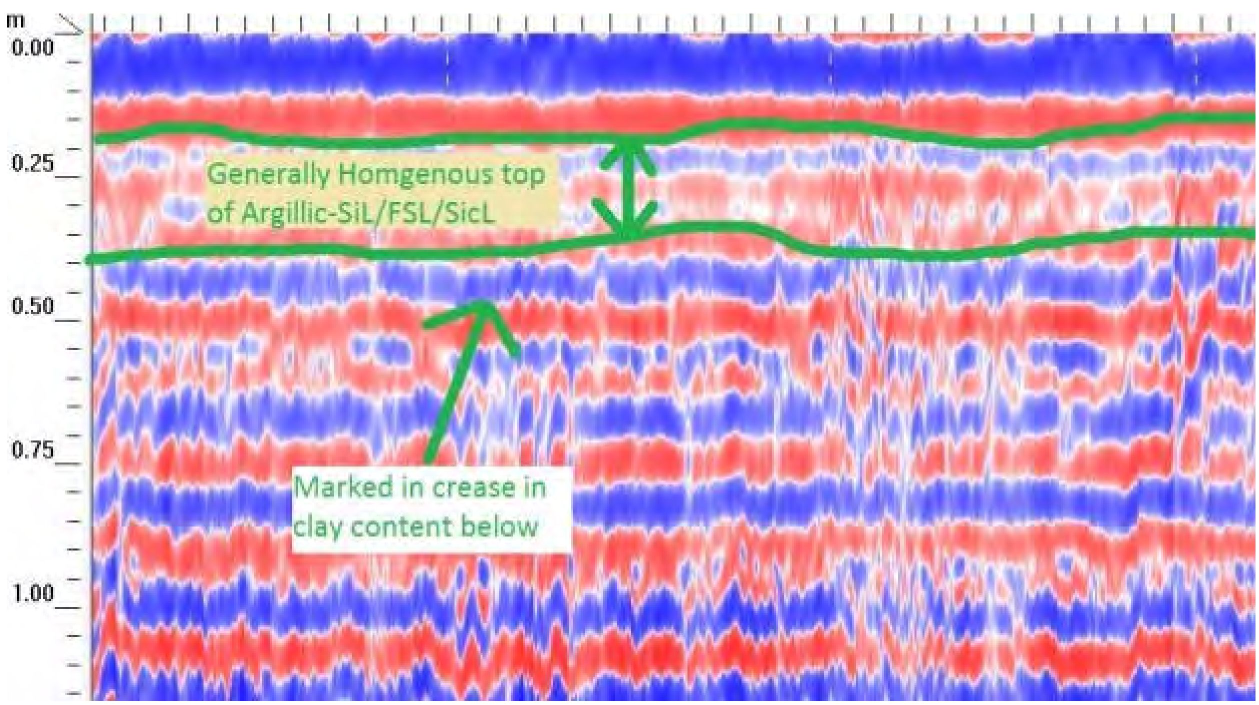

Figure 11. Typical portion of the radar record from survey 29, along the terrace/flood plain NRCS report and brief interpretation.

Field 12

Activities

1. Five transects were flagged on the field in an east-west direction, roughly perpendicular to Big Creek (Figure 12). The transects were spaced at 50 meters. Each transect was flagged at 10-m intervals, and the approximate location of each flag was recorded with a Garmin 76s GPS. All radar surveys proceeded from east to west.
2. A SIR-3000 Ground-Penetrating Radar (GPR) system (Geophysical Survey Systems Inc.) with 200-Mhz antenna was used.
3. A metal plate was buried at the site at a depth of 50-cm to calibrate the instrument and to ground-truth soil conditions. The plate was buried along transect #4.
4. Three holes were augured on both transect #3 and #4 to ground-truth soil conditions. Ground-truthing along transects #5, #6 and #7 was not possible.

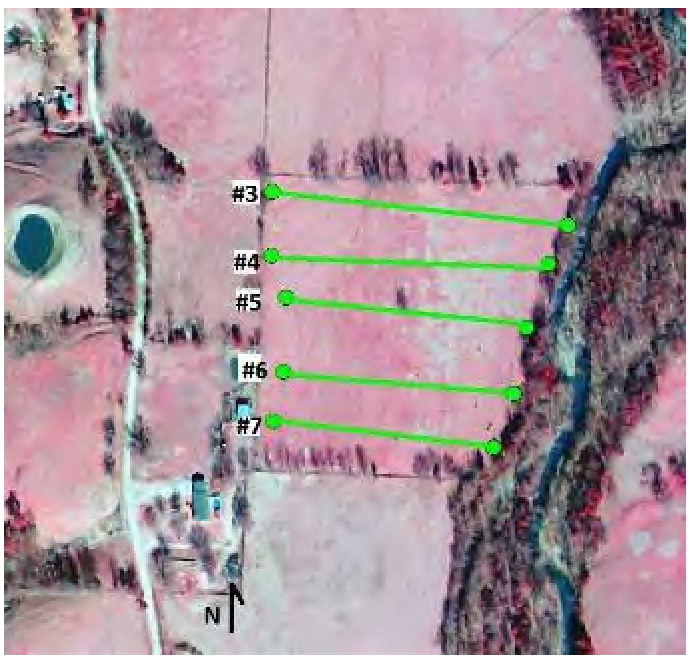

Figure 12. Location of ground penetrating radar surveys at field 12, south of Mount Judea, AR.

Summary: Transect 3

1. Soils observed at the site via test hole mostly agreed with the Newton County soil survey, and resembled the Spadra series, which is an Ultisol. From the county soil survey: "Spadra is a very deep, well-drained soil on stream terraces. This soil formed in loamy alluvial material derived from sandstone, siltstone, and shale. Permeability is moderate and available water capacity is high. This soil is occasionally flooded for brief periods during the winter and spring."

2. Soils observed were well drained; however, conditions were wet due to recent rains. Rafted debris, indicative of overland flow, was observed on the fence row along the north edge of the field.
3. The radar records from this site were of good interpretative quality.
4. Based on the holes augured along the transect, the radar record from this site, and from sites viewed in November 2013 along Big Creek in the same vicinity, the horizonation of the soils seems to be fairly consistent for the first 170-m of the transect.
5. An "A" horizon with a depth of around 0-20 cm seems to be consistent across most of the transect. Field textures observed were silt loam, with fine sandy loam surface texture becoming more common in closer proximity to the creek (after the 150-m mark).
6. The argillic layer along the transect commonly begins at 20-30 cm (Figure 13). Field textures observed between 20-80-cm of the argillic horizon were silty clay loam.
7. The radar suggests that the solum along the transect is deeper than 1.5-m. Two test holes were augered to greater than 1-m.
8. Several hyperbola shaped anomalies were evident in the radar record, they were likely tree roots.
9. At around the 170-m mark (Figure 14), the soil horizons become more wavy in nature. This change could be related to more recent scouring and deposition from Big Creek.
10. An anomaly at the 170-m mark, at around 1-m deep, could be a pocket of coarse fragments deposited by Big Creek (Figure 14).
11. An anomaly was noted on the radar record at the end of survey 3 upon data collection (Figure 15). It resembled possible coarse fragment deposits from the previous field visit. A test whole was augered at around the 225-m mark. The upper soil horizons (0-55-cm) were more sandy in nature than observations further from the creek along this transect. Subsurface textures were sandy loam. At 55-cm, augering was not possible due to coarse fragment content. Coarse fragment content was estimated at 35-45%.

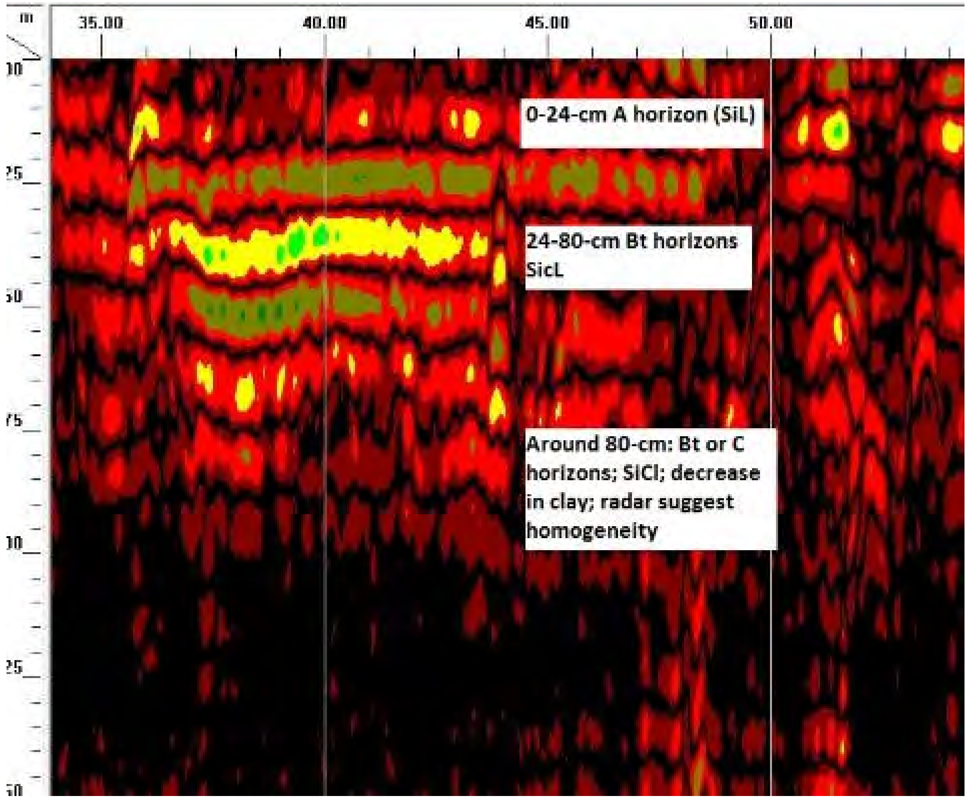

Figure 13. Typical profile from transect #3. A test hole was observed near the 50-m mark.

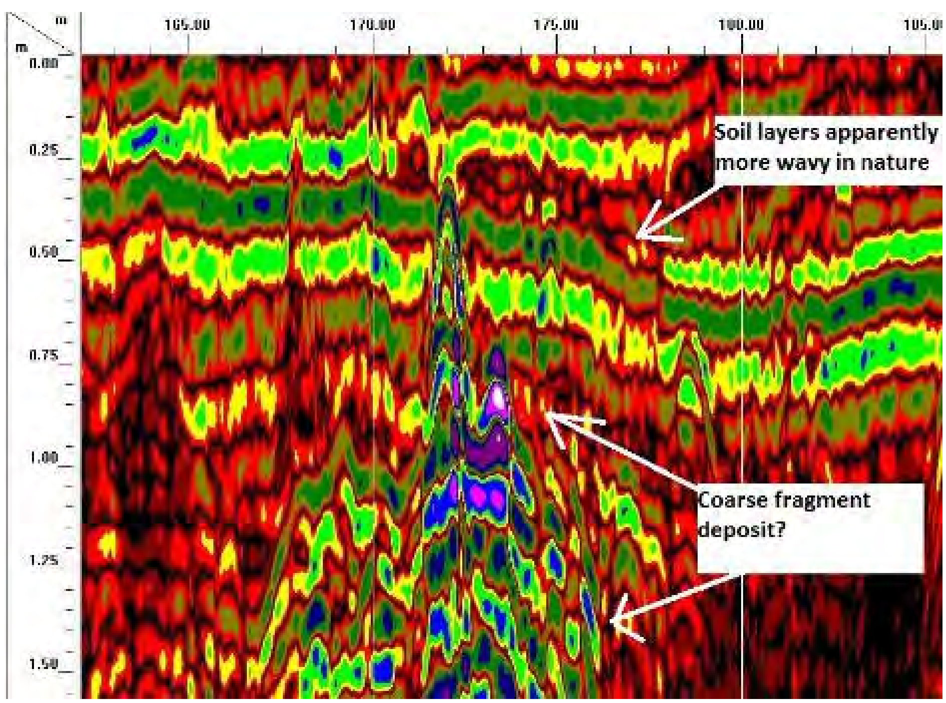

Figure 14. Along Transect 3, possible gravel layers were noted as the survey approaches Big Creek.

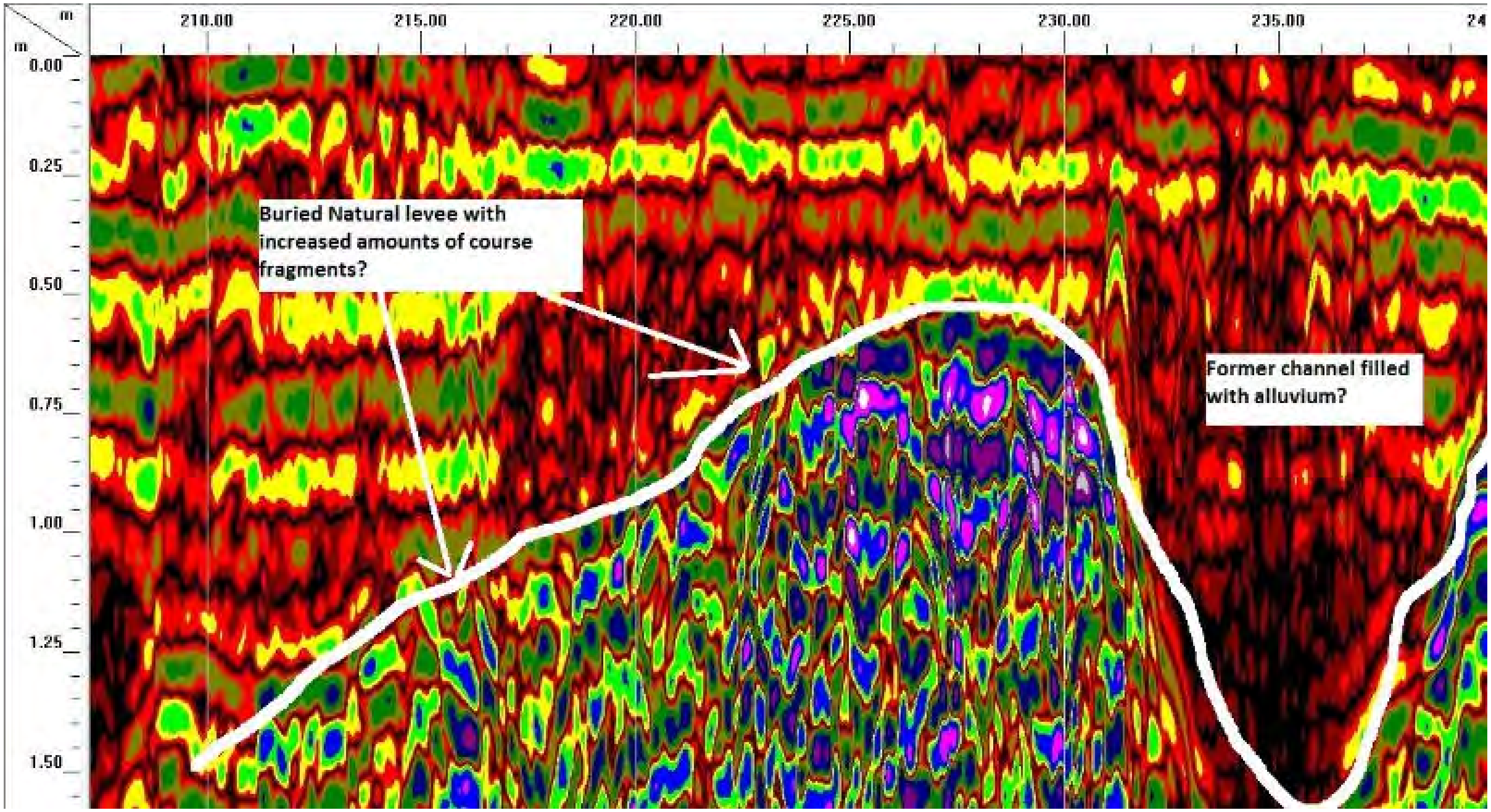

Figure 15. This anomaly at the end of Survey 3 may be a gravel bar deposited by Big Creek.

Summary: Transect 4

1. The soils along this transect appear to be uniformly stratified for about the first 120-m of the survey (Figure 16).
2. Test holes observed generally followed the Spadra series concept, except for one where gravels were observed in the subsoil
3. Based on the radar record, soil horizons apparently become more wavy in nature between 120 and 130-m along the transect (Figure 17). This area is also underlain by radar signature that was found to be indicative of gravel deposits in previous test holes.
4. A test hole was augured at the 200-m mark on transect 4, as summarized below. A suspected area of gravel deposition was confirmed to be present (Figure 18). The upper 80-cm was covered with loamy alluvium.

A: 0-25-cm; Fine sandy loam
Bt1: 25-50-cm; Sandy clay loam
Bt2: 50-80-cm Sandy clay loam (marked clay increase)
BC: 80-120-cm Very gravelly Sandy loam 35% fragments
C: 120-cm plus; Very gravelly (or cobbly) Sandy loam >40% fragments

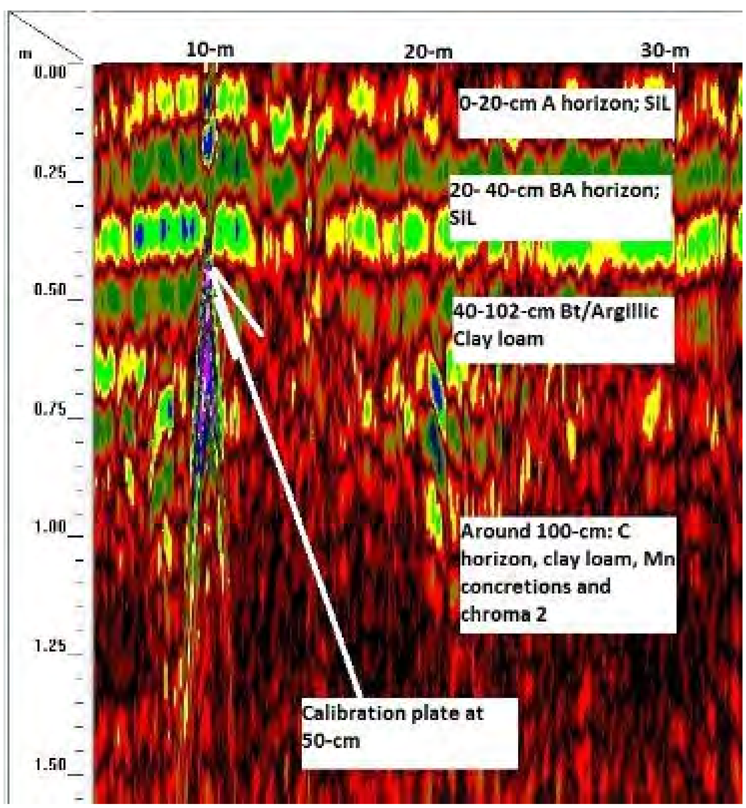

Figure 16. The first 30-m of survey number 4.

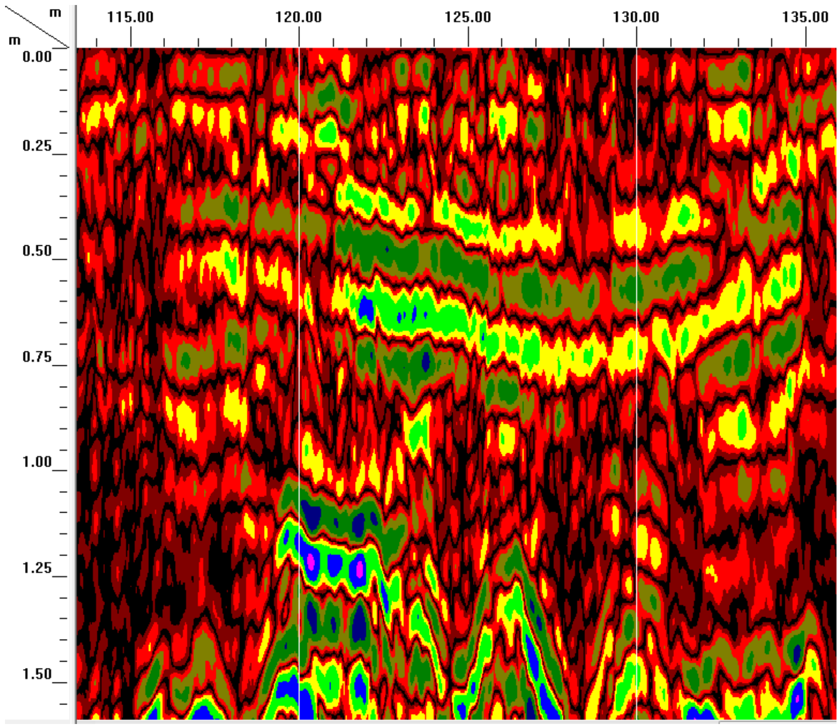

Figure 17. Features at bottom may be gravel deposits along survey number 4.

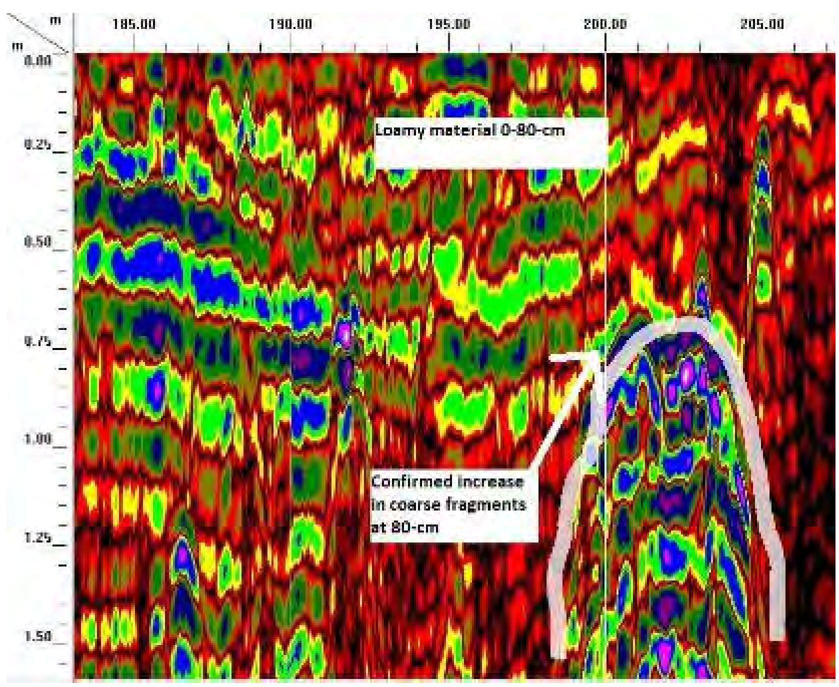

Figure 18. A subsurface horizon with increased fragment content was suspected and confirmed in the field along survey # 4.

Summary: Transect 5

1. No points were ground-truthed along this radar survey

2. The data indicates that most of this soil is uniformly layered, with a radar record resembling surveys # 3 and # 4. The survey indicates that the argillic layer usually starts around 25-cm.

3. There were no anomalies associated with gravel at the end of this radar survey.

4. There were highly contrasting materials noted at a depth of >1-m over the first 30-m of this transect (Figure 19). This could be layers that greatly increase in clay content, or layers that increase in coarse fragments that are alluvial in nature . Less likely at this position would be “valley fill” material from nearby uplands that is overlain by alluvium.

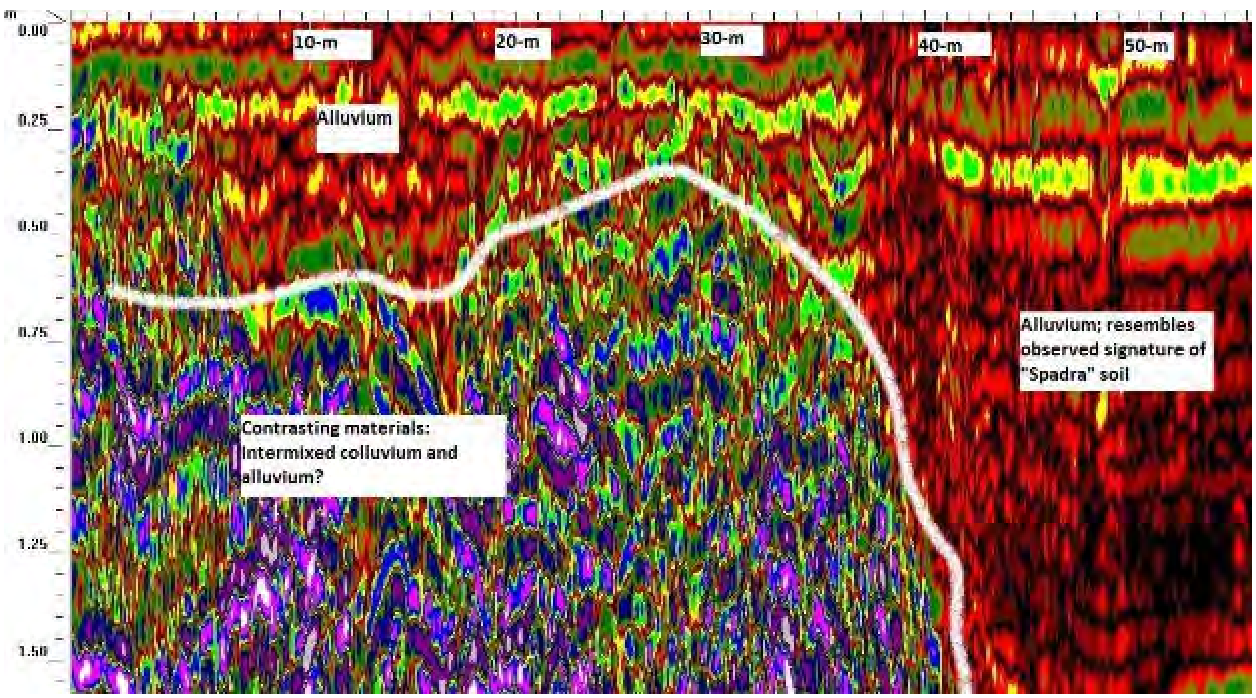

Figure 19. Contrasting, high amplitude features noted at the beginning of transect #5.

Summary: Transect 6

1. No points were ground-truthed along this radar survey

2. The data indicates that most of this soil is uniformly layered, with a radar record resembling surveys # 3 and # 4. The survey indicates that the argillic layer usually starts around 25-cm.

3. There were highly contrasting materials noted at a depth of 60-cm from around the 40-m mark of this transect until around the 90-m mark (Figure 20). This could be layers that greatly increase in clay content, or an increase in coarse fragments that are alluvial in nature.

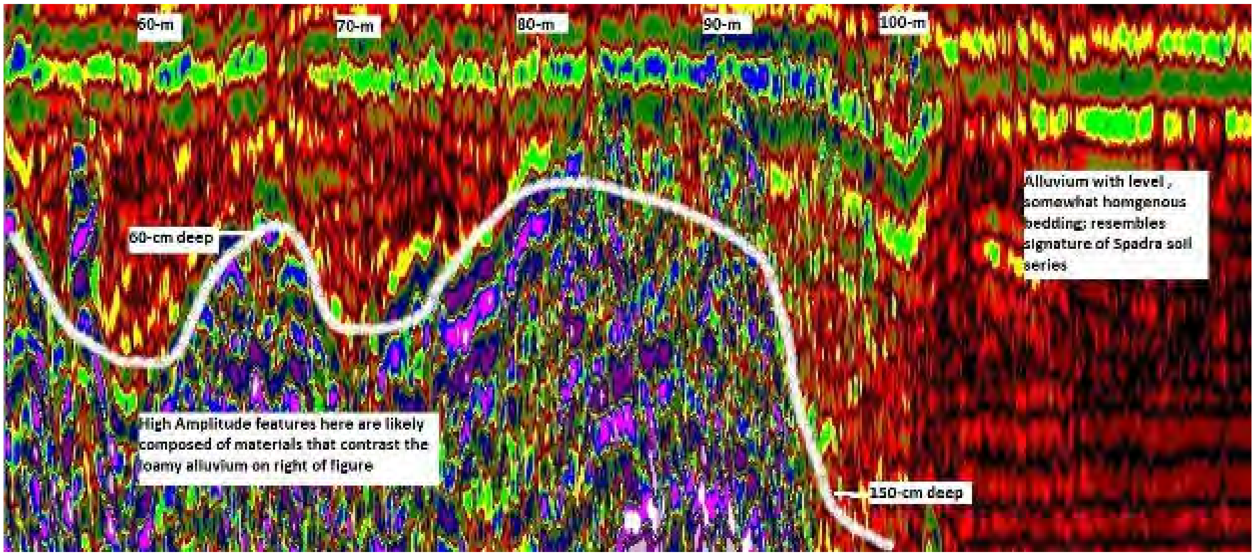

Figure 20. Contrasting materials below loamy alluvium disappear at the 100-m mark on transect #6.

Summary: Transect 7

1. From the 0-m to 80-m mark on this survey, the radar record suggests that most of the soil is level bedded and relatively homogenous. There are areas on this first portion of the transect that exhibit high amplitude and likely contrasting features (Figure 21) that could contain higher amounts of coarse fragments or clay.

2. From the about the 80-m mark through the 130-m mark on the survey, there are subsurface deposits at depths deeper than 100-cm that contrast with what is likely loamy alluvium in the upper portion of the soil profile (Figure 22). Again, speculatively, these contrasting materials could be an increase in coarse fragments, or an increase in clay content.

3. There were no anomalies noted on the radar record from the 130-m mark to the end of the survey at 170-m (Figure 22). The radar record suggests that most of the soil is level bedded and relatively homogenous in this portion of the survey. The radar record mimics the loamy alluvium that resembled the Spadra series in surveys #3 and #4.

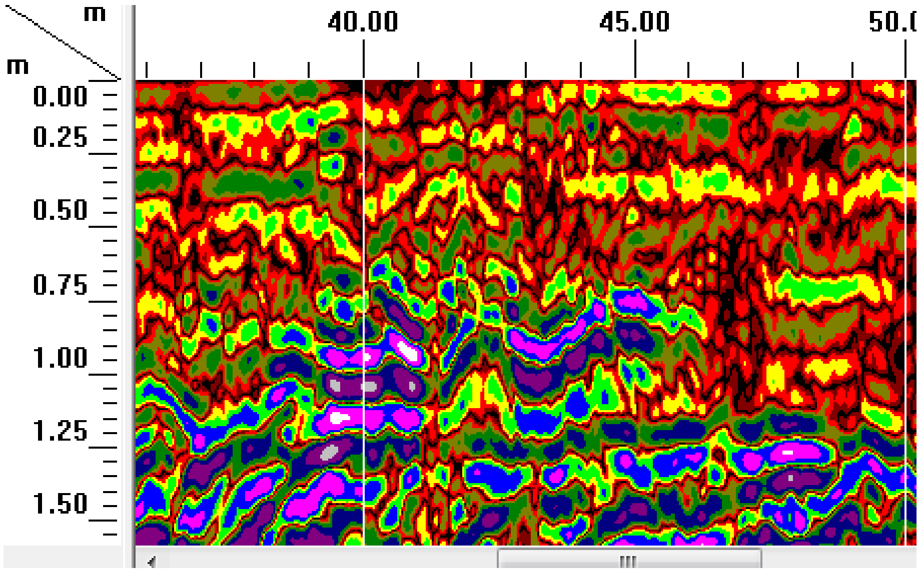

Figure 21. Purple features above could possibly be pockets of increased fragment deposition.

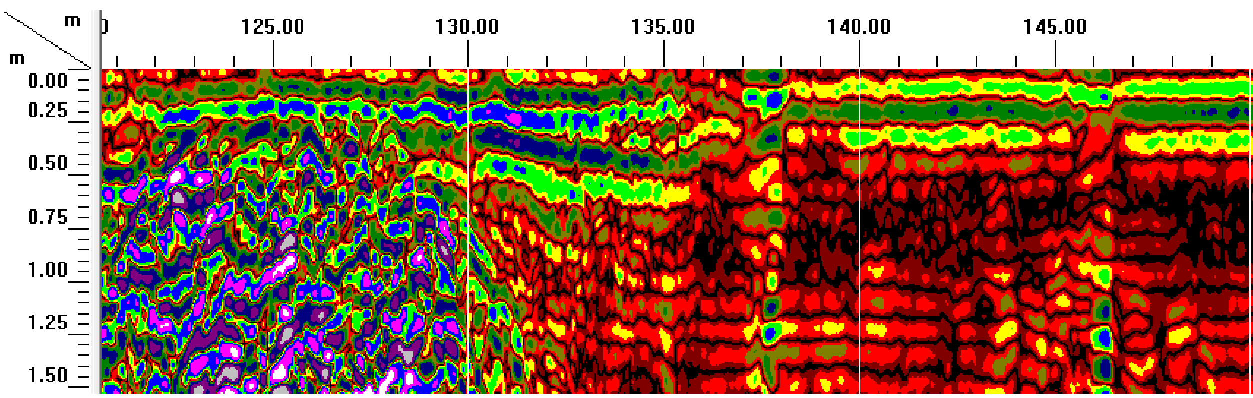

Figure 22. Highly contrasting features (left) were suggested by the radar record from the 80-m to 130-m marks along survey 7. The eastern most portion of the survey appears to be more evenly stratified and mimics similar radar signatures where fine-loamy Ultisols where observed in test holes on previous transects.