Friday, July 24, 2020

24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

City of Liberty, MO
Attn: Tom Garland CPRP
1600 S Withers Road
Liberty, MO 64068

Executive Summary:

Echo GPR Services performed a Ground Penetrating Radar (GPR) scan to identify anomalies that could be consistent with potential unmarked graves at the New Hope/Fairview Cemetery. The eastern portion of the cemetery was scanned in 3 separate sections for ease in collecting and processing the data. Based on the GPR data collected on site several anomalies were observed in the data over both marked and unmarked grave areas. These anomalies are consistent with possible graves or other disturbances not consistent with the surrounding soils

GPR Information and Equipment Used:

The GPR system used for this project has the ability to image targets (anomalies) to a maximum depth of 40 feet. However, the capability of the GPR may be limited to less depth in the field based on surface disruptions (rough or uneven surfaces) and/or subsurface conditions (conductivity and/or dielectric values of subsurface materials or anomalous areas not consistent with surrounding soils). The GPR used was equipped with a 350 megahertz (MHz) hyperstack antenna that broadcasts pulsed radar energy. This energy pulse is timed as it propagates through a material noting when a return pulse arrives. The time and strength of the return pulse is captured and analyzed and interpreted graphically.

Each anomaly is defined by a change in a dielectric of the material. The dielectric value of a material is defined by the speed in which a radar wave passes through a material. Because every material has its own dielectric value it is impossible with radar to identify exact materials or anomalies without physical evidence to support the GPR signals. The determination of the cause of the changes in dielectric values can only be verified through physical testing methods. Therefore, subsurface targets are always referred to as anomalies or unknown targets. In addition, these changes in dielectric values also change the speeds in which radar can pass through materials, making depth readings estimated values. Depth readings are a calculated estimate of the velocity of the signal through a material over a known time. The contrast of different dielectrics is shown by the radar wave and can then be used to define the limits of contrasting materials underground. These boundaries formed by the radar signal are then used to identify anomalous features underground.

The penetration depth of GPR is determined by antenna frequencies and the electrical conductivity of the materials being profiled. Materials having high electrical conductivity rapidly attenuate radar energy, restrict penetration depths, and severely limit the effectiveness of GPR. The electrical conductivity of a material increases with water content, clay and soluble salt contents. Depths are always estimates as the depth calculation is measured by calculating the signal return in time and estimating the dielectric of a material to calculate an estimate of the GPR signal's velocity.

24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

Project Layout:

Figure 1 below shows the 3 separate areas scanned. Figure 1 is rotated 90 degrees so north is pointing to the left. This is to aid in display in the report. The 3 areas will be referred to as the North, Middle and South (New Hope) sections. Each section was scanned in north and south passes at 2ft intervals. These individual files were then used to re-create each section with the GPR data and create slices of GPR data of below the surface anomalies.

Figure 1

The 3 grid paths are shown below in Figures 2-4. These path maps are re-orientated with north in the standard orientation. The South section grid path map is shown below in Figure 2. 94 individual scans totaling 3.4 miles of data was collected for this section.

24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

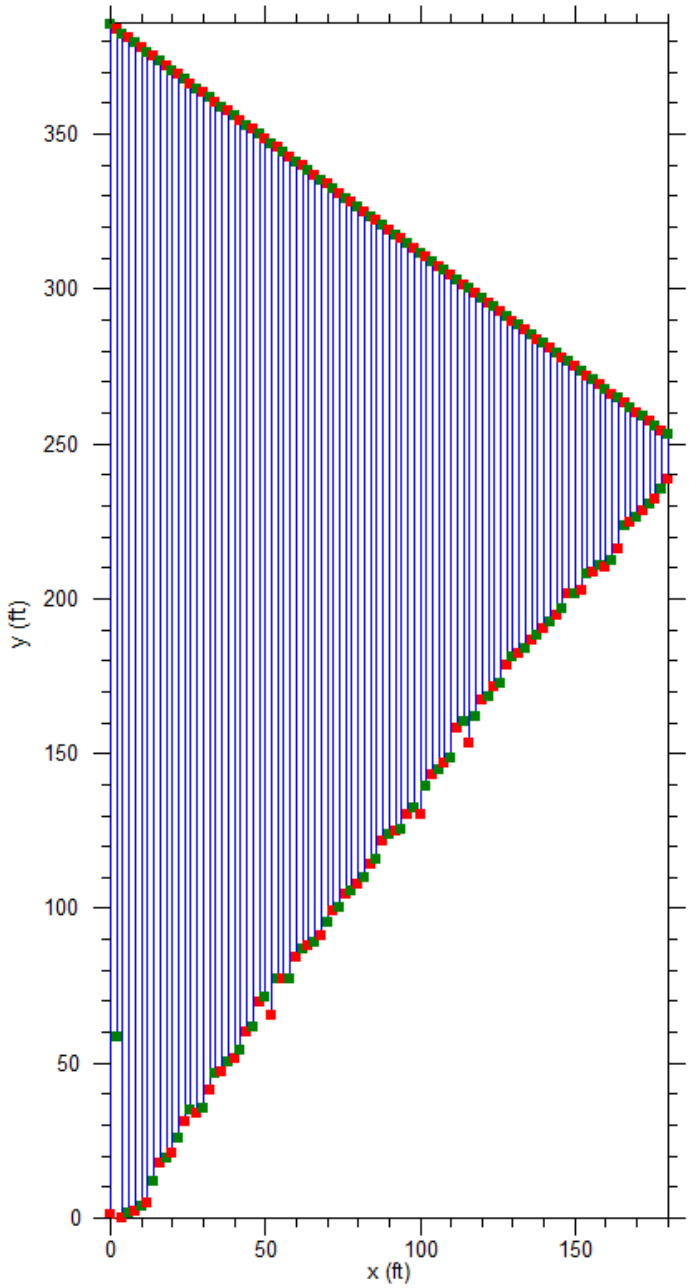


Figure 2

24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

The Middle section grid path map is shown below in Figure 3. 143 individual scans totaling 1.9 miles of data was collected for this section. Intermittent gaps in the profile are spaces working around obstacles such as trees or headstones with a large flower area around them.

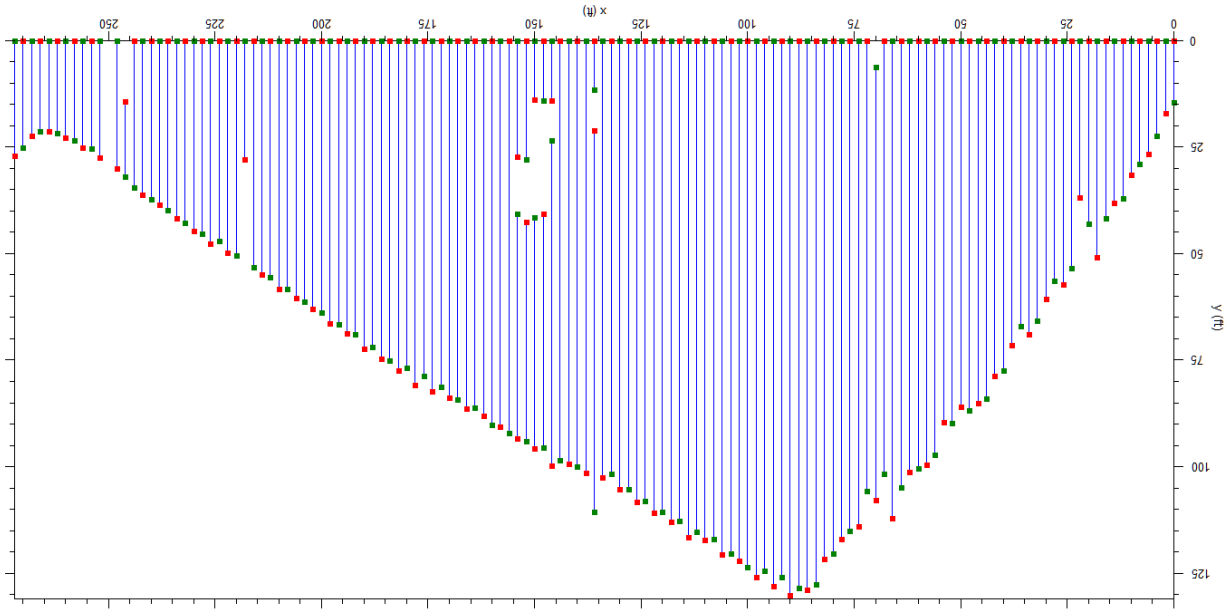


Figure 3

The North section grid path map is shown below in Figure 4. 78 individual scans totaling 5.2 miles of data was collected for this section.

24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

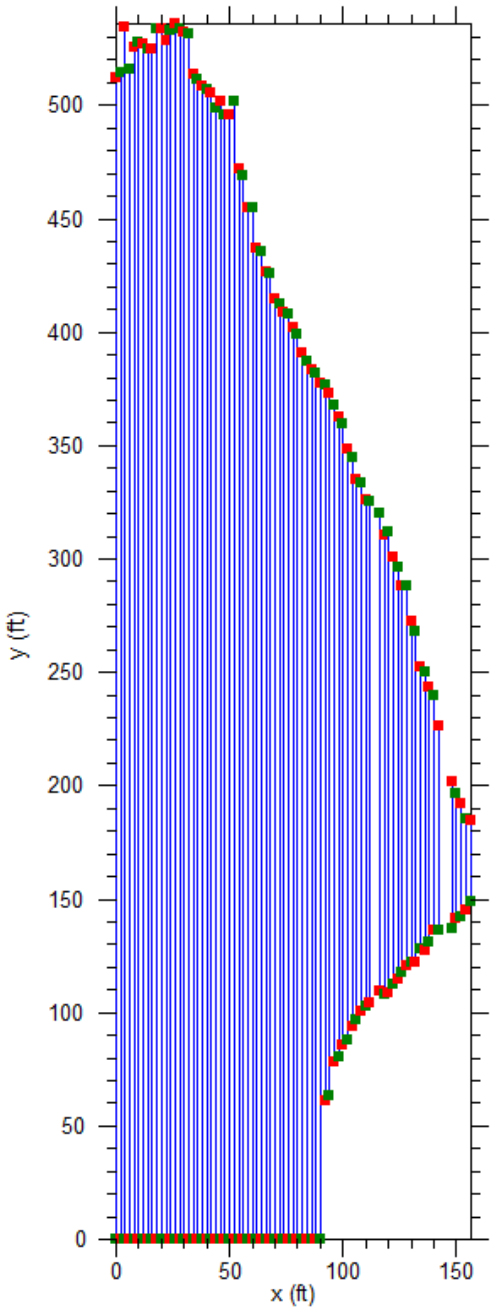


Figure 4

24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

Project Results/Conclusion:

Analysis of the data consisted of applying GPS coordinates to the grids which were collected on a local coordinate grid, filtering data and "slicing" the data to look for anomalies. In displaying the data each image is overlaid onto Google Earth for ease in viewing the data and understanding where anomalies are located. Because the GPR was overlaid using GPS data provided to Echo GPR from Liberty, the accuracy of the GPS should be considered as well as how accurate Google Earth's disclaimer on GPS accuracy.

Using a color table to show relative reflections under ground Figure 5 shows the color scale used to identify strong vs weak reflections under the surface. The colors to the right represent the highest reflections of the GPR data while the colors to the left represent the lowest reflections. These reflections relative to the surrounding soils show an anomaly underground. This anomaly may or may not correspond to a marked or unmarked grave.

Figure 5 – Assigned Color Table

Figure 6 shows an aggregate overlay of all 3 sections scanned of all strong reflectors from the near surface to the depth of the GPR systems data. Notable high reflections are very observant along the edges of the tree lines, indicative of reflections likely caused by vegetation root systems.

24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

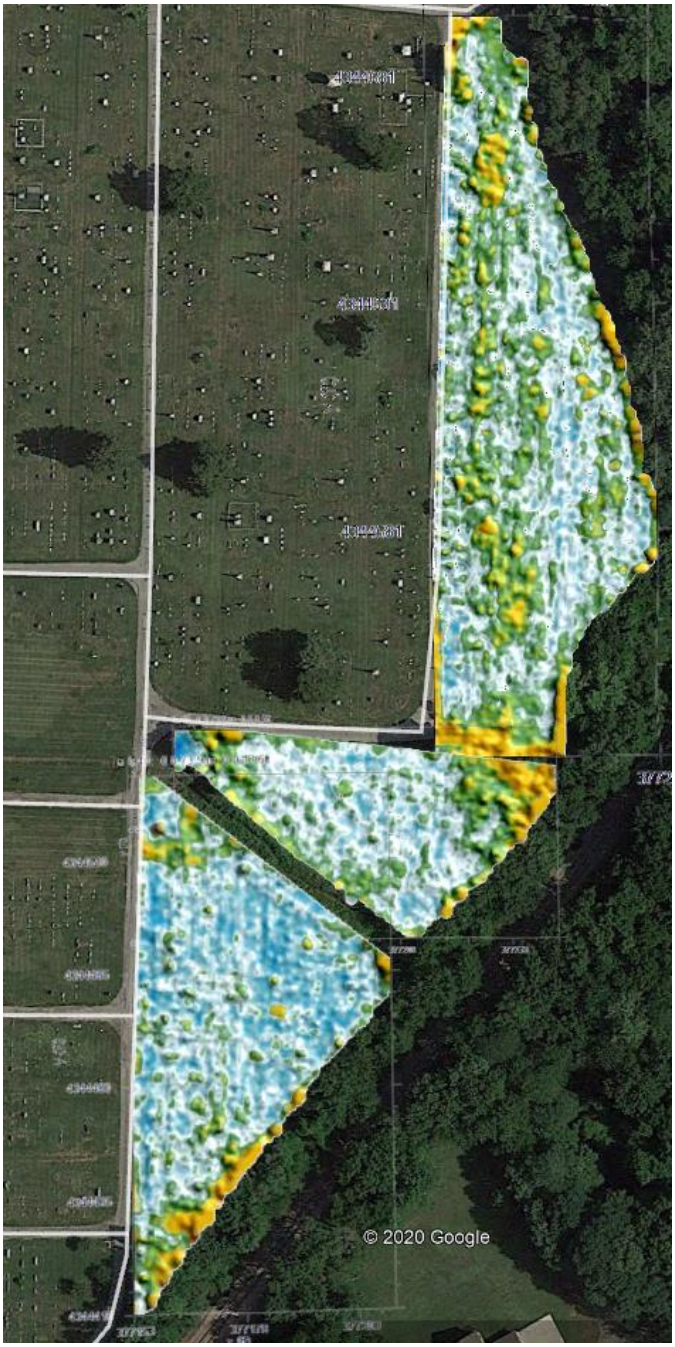


Figure 6

24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

In the South (New Hope) section (Figure 7) of the data there is strong reflections in the very northwestern tip of the data near the drainage culvert. Based on a 1963 aerial (from historicalaerials.com) there appears to be a building or other structure that was at one time located in this area. The high reflections may indicate a possible foundation or debris left from the construction or removal of this structure. The 1963 aerial is shown in Figure 9.

Another relatively new technique in analyzing older historical cemeteries is to analyze the data showing the aggregate overlay of only the weakest reflectors. This technique is used to help determine areas of possible backfill and show disturbances that may not be present in overlays of strong reflectors. This overlay is shown in Figure 8.

Based on the GPR data it does not appear that there are any significant anomalies consistent with graves in this South (New Hope section) that do not already correspond with headstones at the site. This does not rule out the possibility that unmarked graves could be in the area, just that the GPR data does not clearly indicate any possible anomalies.

24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

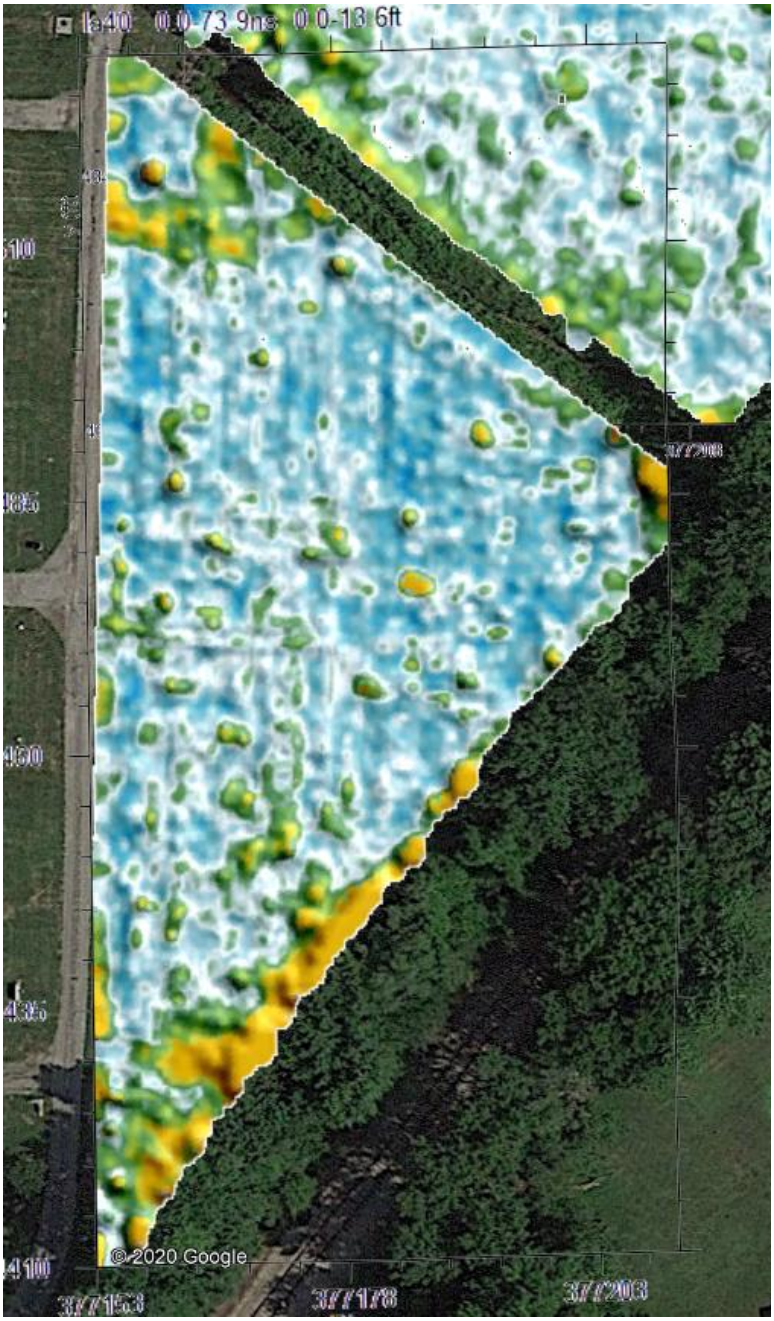


Figure 7

24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

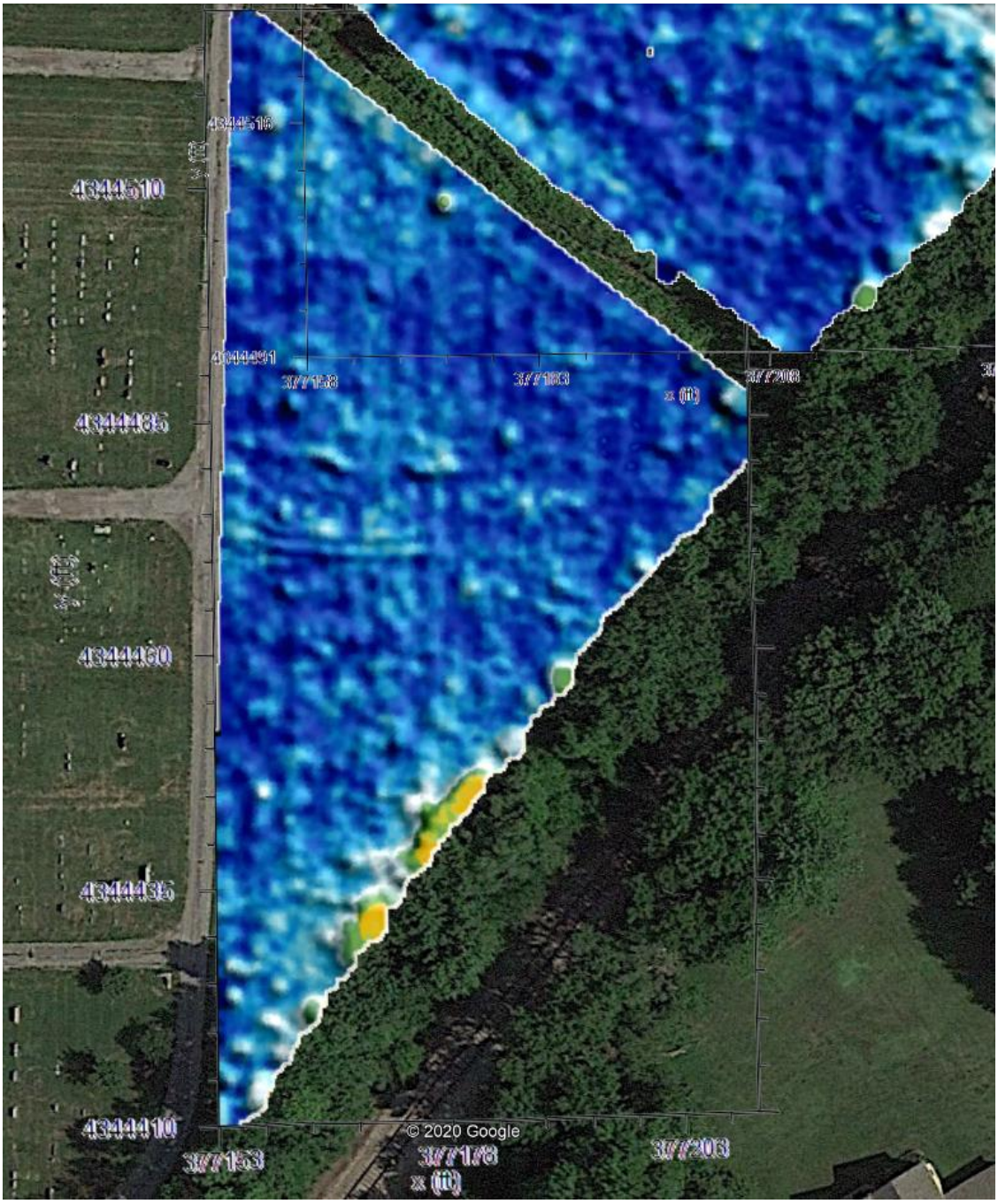


Figure 8

24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

Figure 9

The middle section (Fairview Cemetery) for aggregate strongest reflectors is shown below in Figure 10. This area shows a significant amount of reflections around the perimeter especially to the east, west and southern edge. The areas to the east and west are interpreted to be the tree root systems underground. Analysis in this area is difficult due to the large structure of roots and no interpretation of unmarked graves in these areas can be provided. There are other anomalies identified with red arrows that show disturbances underground that could be identified as anomalies underground not consistent with the surrounding soils. Each red arrow points to areas in green that could be possible unmarked graves. Those

24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

anomalies in green that do not have a corresponding arrow are relatively close (within GPS error) to known marked out graves or are close enough to the tree roots to be unable to analyze.

Figure 11 shows the aggregate image of relatively weakest reflectors in the same area. In this image there does not appear to be anomalies in this data analysis to add any other areas of interest in this area.

Based on the GPR data of this middle section there are some anomalies that are consistent with possible unmarked graves. This does not conclude that these anomalies are graves, just that the anomalies in these areas do not appear to be consistent with surrounding soils.

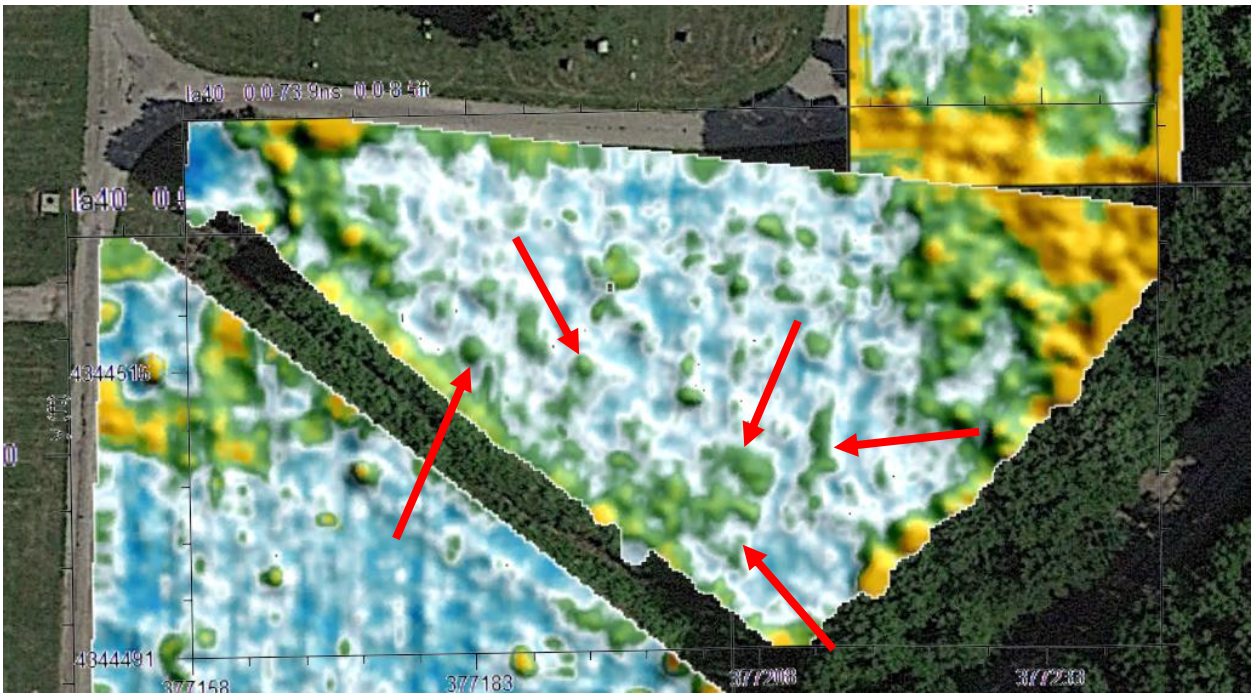


Figure 10

24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

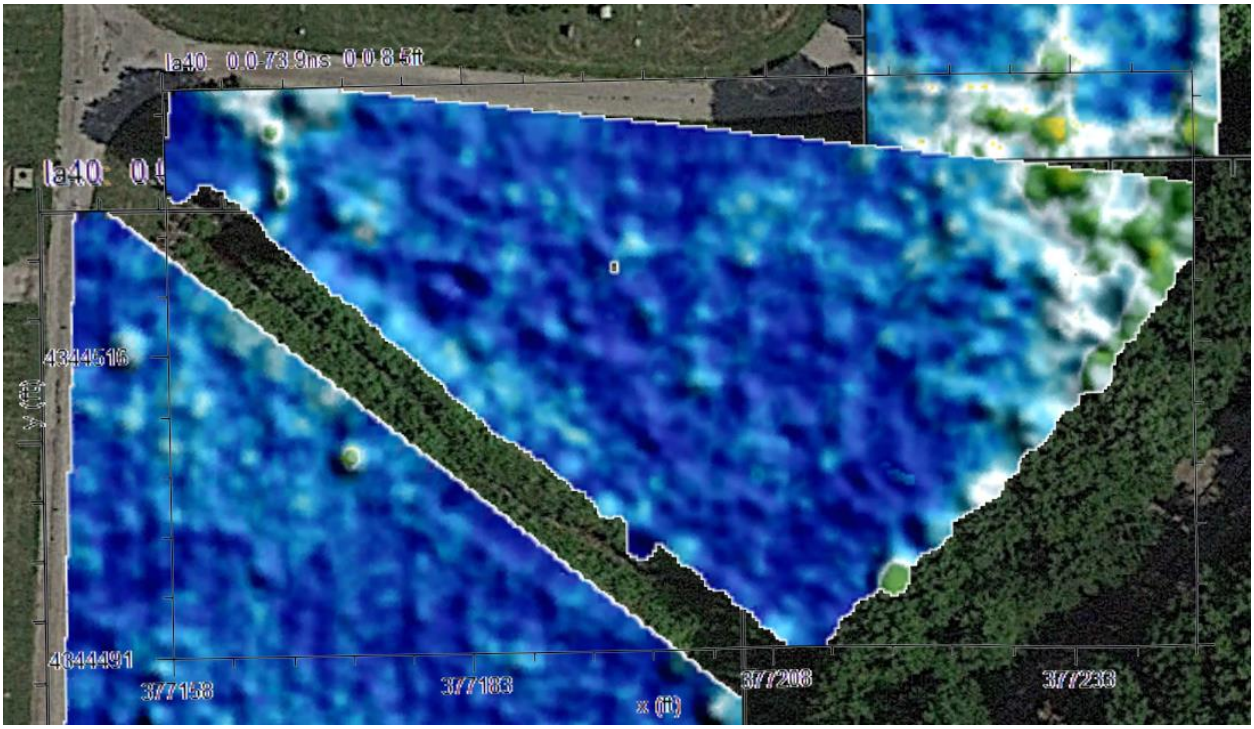


Figure 11

The north section (Fairview Cemetery) for aggregate strongest reflectors is shown below in Figure 12. The same strong reflections on the east and south portions of the image correspond with proximity to vegetation and again are likely reflections from the roots underground. This area shows more anomalies in the data than the other 2 sections scanned. Two areas circled in red are in areas where there were existing trees on the site. The reflections in these areas are likely of the roots from these trees. A red center line is overlaid onto the data where a "path" appears to cut through this cemetery. A historical image from 1960 shows a possible paved path going through this section of the cemetery and the GPR indicates this could be the approximate path of the road as minimal subsurface disturbances are seen along this line. There is a significant amount of disturbances in this section both east and west of the interpreted path. Some of these anomalies appear to be consistent with possible graves as there is a "linear" feature in which these anomalies appear in rows from north to south, consistent with cemetery burials.

In Figure 13, which is the aggregate overlay of weakest reflections, some reflections on the east side of the section appear which indicates some backfill in this area. This may or may not be correlated to unmarked graves but does show disruption in this area not consistent with surrounding soils.

24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

Based on the GPR data of this north section there are anomalies that are consistent with possible unmarked graves. This does not conclude that these anomalies are graves, just that the anomalies in these areas do not appear to be consistent with surrounding soils.

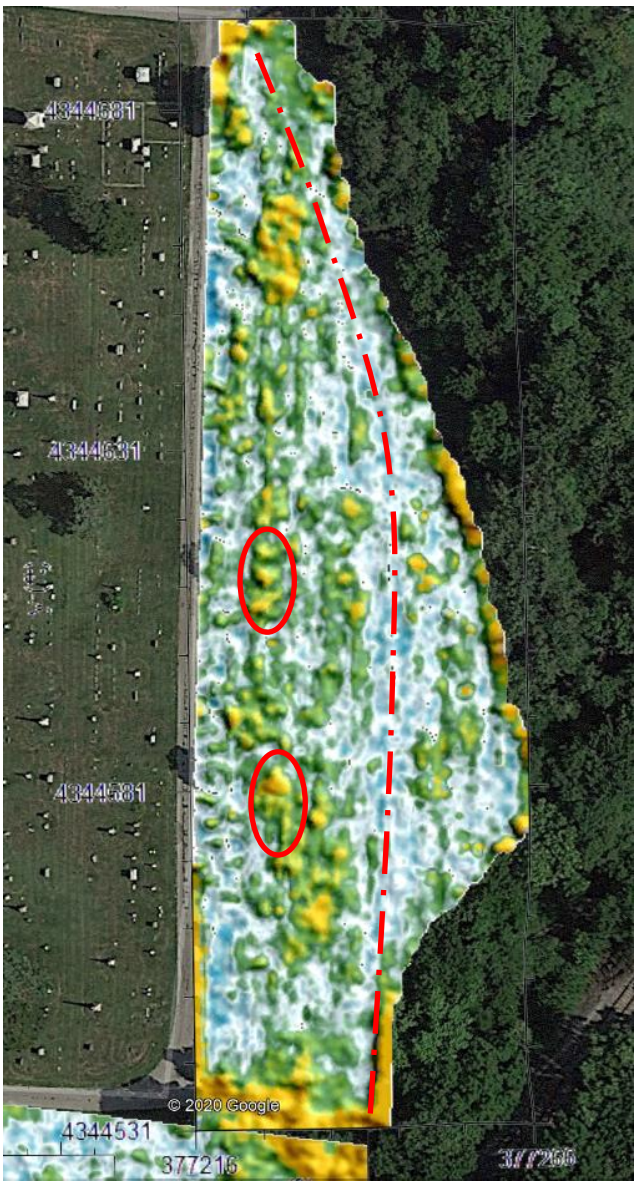


Figure 12

24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

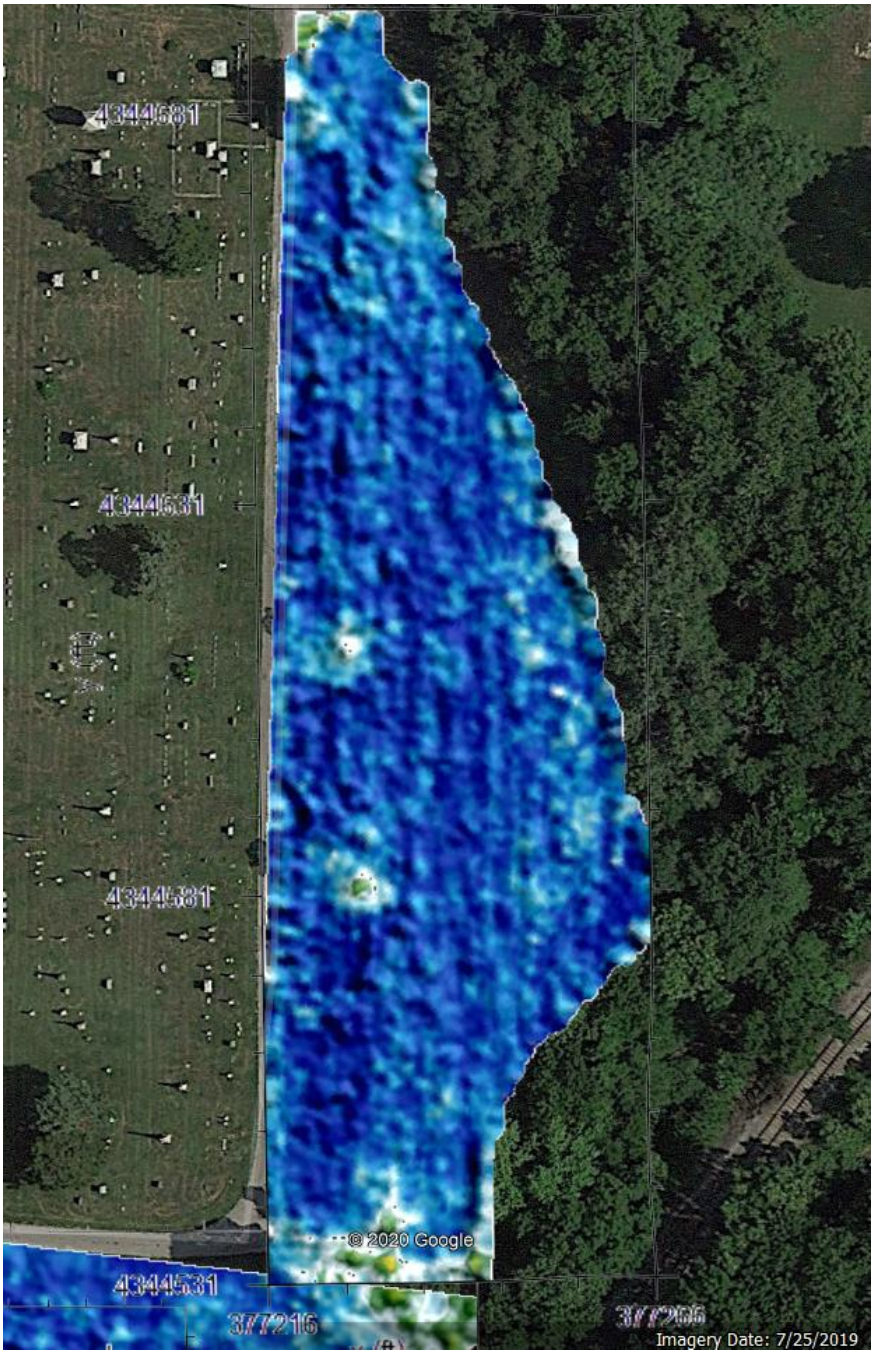


Figure 13

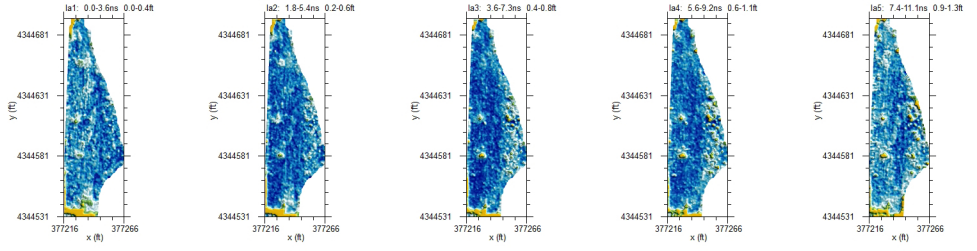
Friday, July 24, 2020

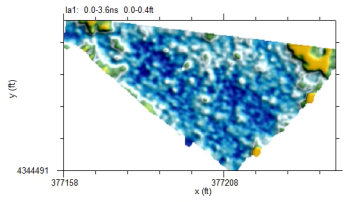
24564 Lackman Rd • Paola, KS 66071
Office 913.879.2200 • **Mobile** 913.209.2309
mark@echogpr.com • www.echogpr.com

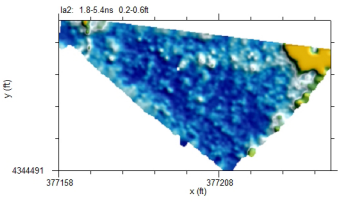
Attached in separate files are the individual time slices of data from the surface through the bottom of the GPR data range.

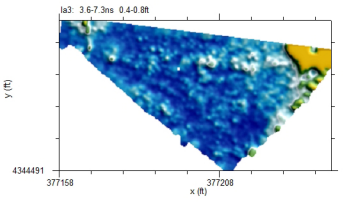
Sincerely,

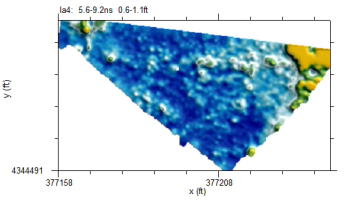
Mark S DeSchepper
Echo GPR Services

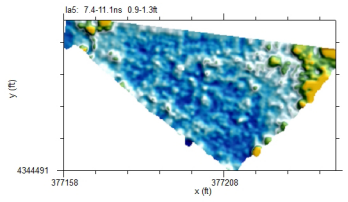

la1: 0.0-3.6ns 0.0-0.4ft
la2: 1.8-5.4ns 0.2-0.6ft
la3: 3.6-7.3ns 0.4-0.8ft
la4: 5.6-9.2ns 0.6-1.1ft
la5: 7.4-11.1ns 0.9-1.3ft
la6: 9.2-12.9ns 1.1-1.5ft
la7: 11.1-14.7ns 1.3-1.7ft
la8: 13.0-16.7ns 1.5-1.9ft
la9: 14.8-18.5ns 1.7-2.1ft
la10: 16.7-20.3ns 1.9-2.3ft
la11: 18.5-22.1ns 2.1-2.5ft
la12: 20.3-23.9ns 2.3-2.7ft
la13: 22.3-25.9ns 2.6-3.0ft
la14: 24.1-27.7ns 2.8-3.2ft
la15: 25.9-29.5ns 3.0-3.4ft
la16: 27.7-31.3ns 3.2-3.6ft
la17: 29.7-33.3ns 3.4-3.8ft
la18: 31.5-35.1ns 3.6-4.0ft
la19: 33.3-37.0ns 3.8-4.2ft
la20: 35.1-38.8ns 4.0-4.5ft
la21: 37.0-40.6ns 4.2-4.7ft
la22: 38.9-42.6ns 4.5-4.9ft
la23: 40.8-44.4ns 4.7-5.1ft
la24: 42.6-46.2ns 4.9-5.3ft
la25: 44.4-48.0ns 5.1-5.5ft
la26: 46.4-50.0ns 5.3-5.7ft
la27: 48.2-51.8ns 5.5-5.9ft
la28: 50.0-53.6ns 5.7-6.2ft
la29: 51.8-55.4ns 5.9-6.4ft
la30: 53.8-57.4ns 6.2-6.6ft
la31: 55.6-59.2ns 6.4-6.8ft
la32: 57.4-61.0ns 6.6-7.0ft
la33: 59.2-62.9ns 6.8-7.2ft
la34: 61.0-64.7ns 7.0-7.4ft
la35: 63.0-66.7ns 7.2-7.7ft
la36: 64.8-68.5ns 7.4-7.9ft
la37: 66.7-70.3ns 7.7-8.1ft
la38: 68.5-72.1ns 7.9-8.3ft
la39: 70.5-73.9ns 8.1-8.5ft
la40: 72.3-73.9ns 8.3-8.5ft
y (ft)
4344681
4344631
4344581
4344531
x (ft)
377216
377266

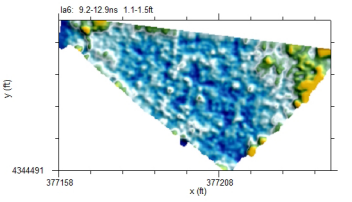

la1: 0.0-3.6ns 0.0-0.4ft
y (ft)
4344491
377158
377208
x (ft)

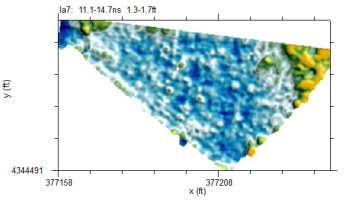

la2: 1.8-5.4ns 0.2-0.6ft
y (ft)
4344491
377158
377208
x (ft)

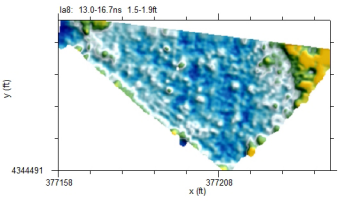

la3: 3.6-7.3ns 0.4-0.8ft
y (ft)
4344491
377158
377208
x (ft)

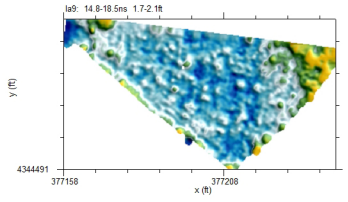

la4: 5.6-9.2ns 0.6-1.1ft
y (ft)
4344491
377158
377208
x (ft)

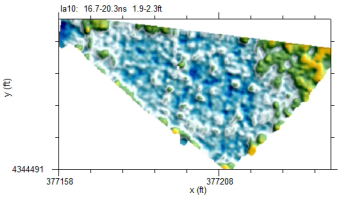

la5: 7.4-11.1ns 0.9-1.3ft
y (ft)
4344491
377158
377208
x (ft)

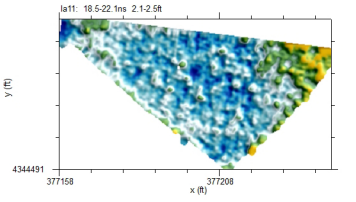

la6: 9.2-12.9ns 1.1-1.5ft
y (ft)
4344491
377158
377208
x (ft)

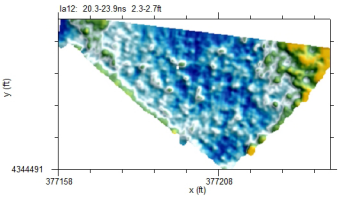

la7: 11.1-14.7ns 1.3-1.7ft
y (ft)
4344491
377158
377208
x (ft)

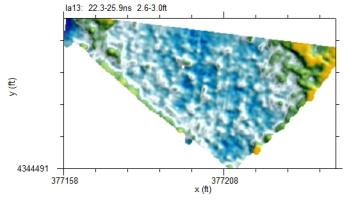

la8: 13.0-16.7ns 1.5-1.9ft
y (ft)
4344491
377158
377208
x (ft)

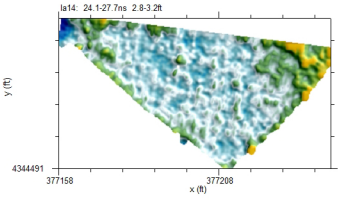

la9: 14.8-18.5ns 1.7-2.1ft
y (ft)
4344491
377158
377208
x (ft)

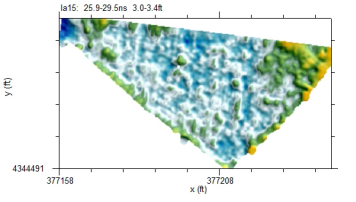

la10: 16.7-20.3ns 1.9-2.3ft
y (ft)
4344491
377158
377208
x (ft)

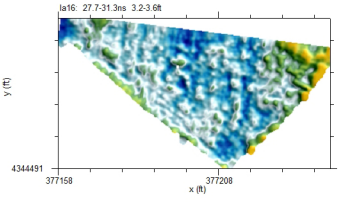

la11: 18.5-22.1ns 2.1-2.5ft
y (ft)
4344491
377158
377208
x (ft)

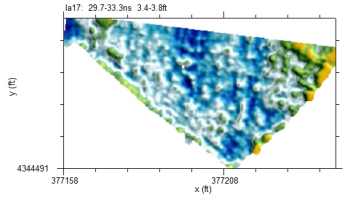

la12: 20.3-23.9ns 2.3-2.7ft
y (ft)
4344491
377158
377208
x (ft)

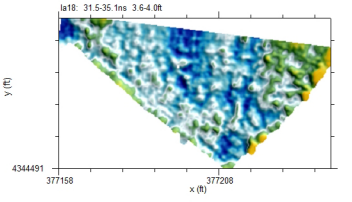

la13: 22.3-25.9ns 2.6-3.0ft
y (ft)
4344491
377158
377208
x (ft)

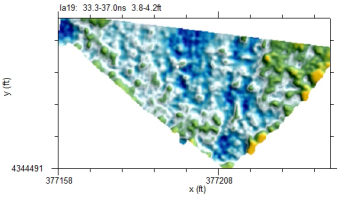

la14: 24.1-27.7ns 2.8-3.2ft
y (ft)
4344491
377158
377208
x (ft)

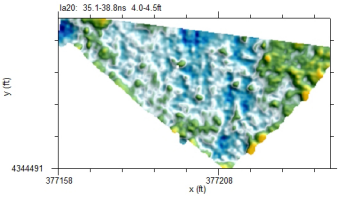

la15: 25.9-29.5ns 3.0-3.4ft
y (ft)
4344491
377158
377208
x (ft)

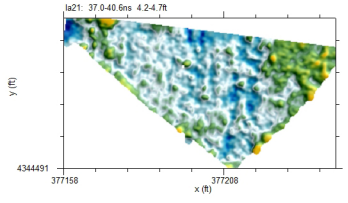

la16: 27.7-31.3ns 3.2-3.6ft
y (ft)
4344491
377158
377208
x (ft)

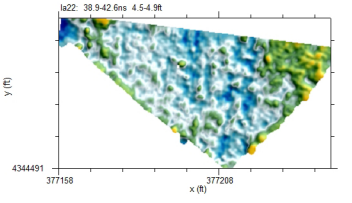

la17: 29.7-33.3ns 3.4-3.8ft
y (ft)
4344491
377158
377208
x (ft)

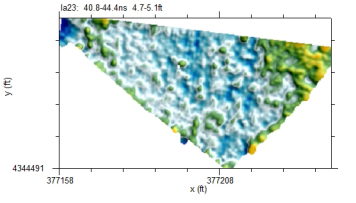

la18: 31.5-35.1ns 3.6-4.0ft
y (ft)
4344491
377158
377208
x (ft)

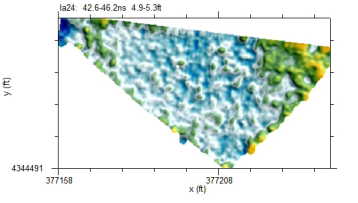

la19: 33.3-37.0ns 3.8-4.2ft
y (ft)
4344491
377158
377208
x (ft)

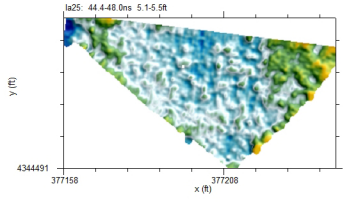

la20: 35.1-38.8ns 4.0-4.5ft
y (ft)
4344491
377158
377208
x (ft)

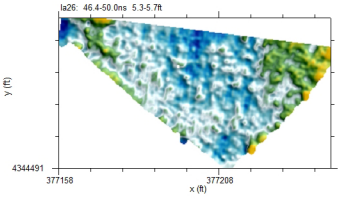

la21: 37.0-40.6ns 4.2-4.7ft
y (ft)
4344491
377158
377208
x (ft)

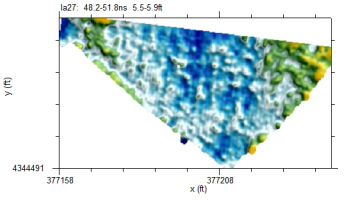

la22: 38.9-42.6ns 4.5-4.9ft
y (ft)
4344491
377158
377208
x (ft)

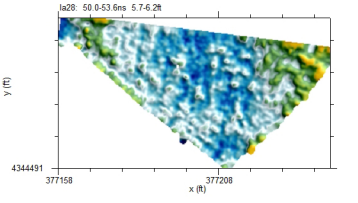

la23: 40.8-44.4ns 4.7-5.1ft
y (ft)
4344491
377158
377208
x (ft)

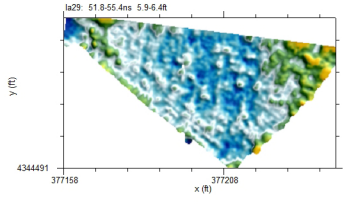

la24: 42.6-46.2ns 4.9-5.3ft
y (ft)
4344491
377158
377208
x (ft)

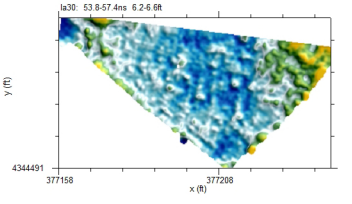

la25: 44.4-48.0ns 5.1-5.5ft
y (ft)
4344491
377158
377208
x (ft)

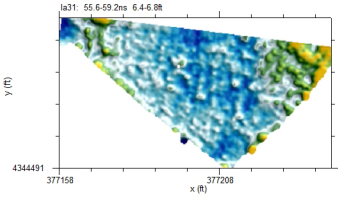

la26: 46.4-50.0ns 5.3-5.7ft
y (ft)
4344491
377158
377208
x (ft)

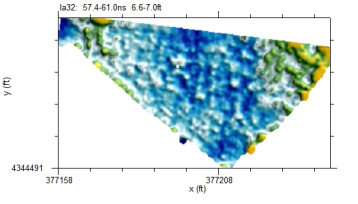

la27: 48.2-51.8ns 5.5-5.9ft
y (ft)
4344491
377158
377208
x (ft)

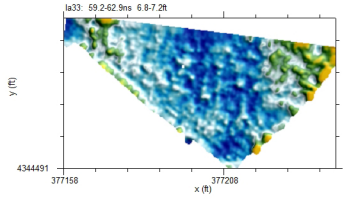

la28: 50.0-53.6ns 5.7-6.2ft
y (ft)
4344491
377158
377208
x (ft)

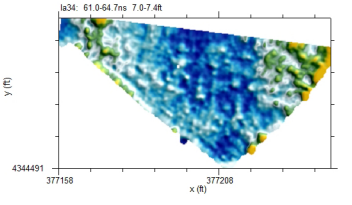

la29: 51.8-55.4ns 5.9-6.4ft
y (ft)
4344491
377158
377208
x (ft)

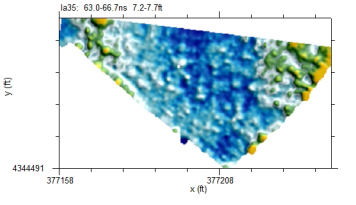

la30: 53.8-57.4ns 6.2-6.6ft
y (ft)
4344491
377158
377208
x (ft)

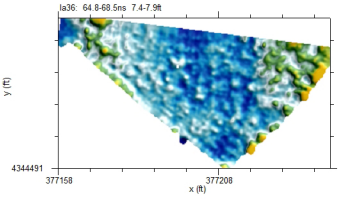

la31: 55.6-59.2ns 6.4-6.8ft
y (ft)
4344491
377158
377208
x (ft)

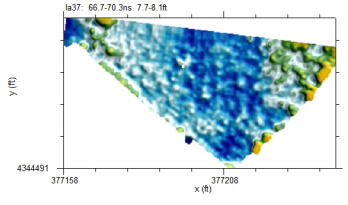

la32: 57.4-61.0ns 6.6-7.0ft
y (ft)
4344491
377158
377208
x (ft)

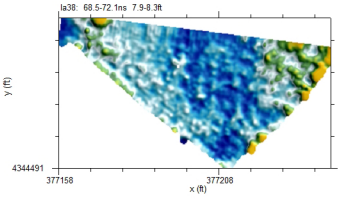

la33: 59.2-62.9ns 6.8-7.2ft
y (ft)
4344491
377158
377208
x (ft)

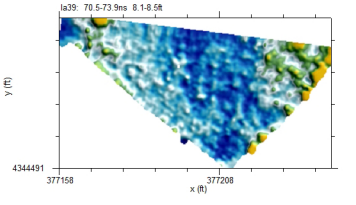

la34: 61.0-64.7ns 7.0-7.4ft
y (ft)
4344491
377158
377208
x (ft)

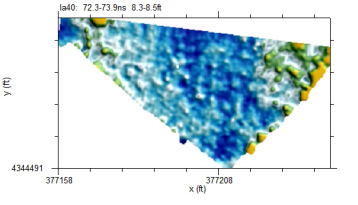

la35: 63.0-66.7ns 7.2-7.7ft
y (ft)
4344491
377158
377208
x (ft)

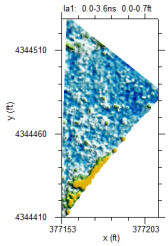

la36: 64.8-68.5ns 7.4-7.9ft
y (ft)
4344491
377158
377208
x (ft)

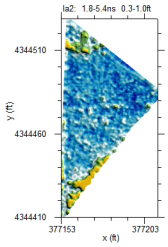

la37: 66.7-70.3ns 7.7-8.1ft
y (ft)
4344491
377158
377208
x (ft)

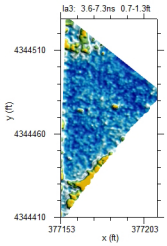

la38: 68.5-72.1ns 7.9-8.3ft
y (ft)
4344491
377158
377208
x (ft)

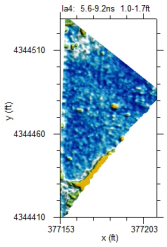

la39: 70.5-73.9ns 8.1-8.5ft
y (ft)
4344491
377158
377208
x (ft)

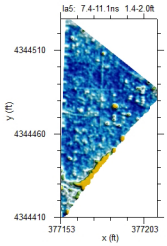

la40: 72.3-73.9ns 8.3-8.5ft
y (ft)
4344491
377158
377208
x (ft)

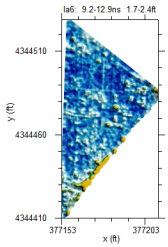

la1: 0.0-3.6ns 0.0-0.7ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

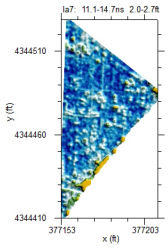

la2: 1.8-5.4ns 0.3-1.0ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

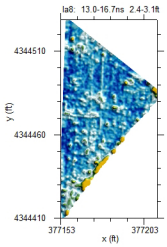

la3: 3.6-7.3ns 0.7-1.3ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

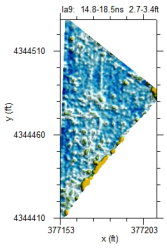

la4: 5.6-9.2ns 1.0-1.7ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

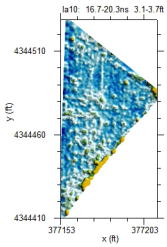

la5: 7.4-11.1ns 1.4-2.0ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

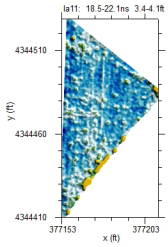

la6: 9.2-12.9ns 1.7-2.4ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

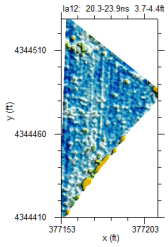

la7: 11.1-14.7ns 2.0-2.7ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

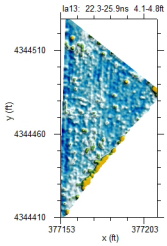

la8: 13.0-16.7ns 2.4-3.1ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

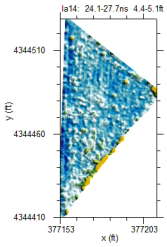

la9: 14.8-18.5ns 2.7-3.4ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

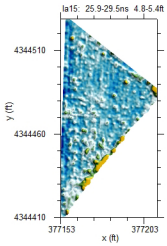

la10: 16.7-20.3ns 3.1-3.7ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

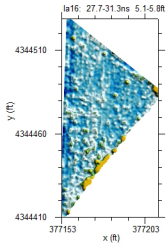

la11: 18.5-22.1ns 3.4-4.1ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

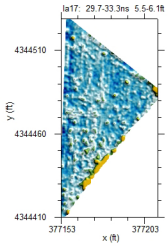

la12: 20.3-23.9ns 3.7-4.4ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

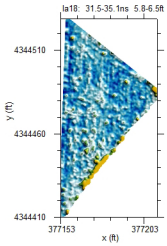

la13: 22.3-25.9ns 4.1-4.8ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

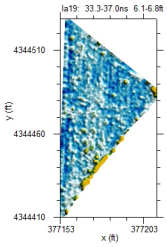

la14: 24.1-27.7ns 4.4-5.1ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

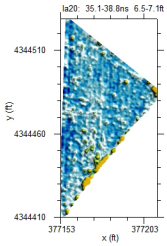

la15: 25.9-29.5ns 4.8-5.4ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

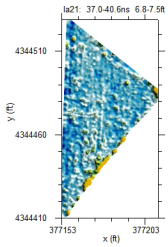

la16: 27.7-31.3ns 5.1-5.8ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

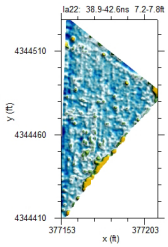

la17: 29.7-33.3ns 5.5-6.1ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

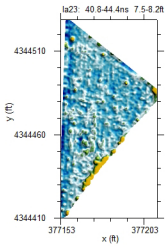

la18: 31.5-35.1ns 5.8-6.5ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

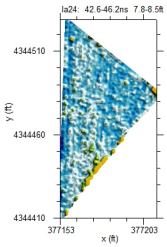

la19: 33.3-37.0ns 6.1-6.8ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

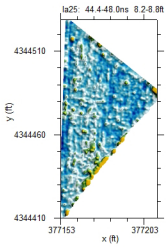

la20: 35.1-38.8ns 6.5-7.1ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

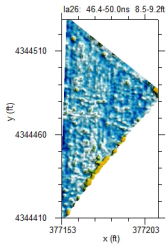

la21: 37.0-40.6ns 6.8-7.5ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

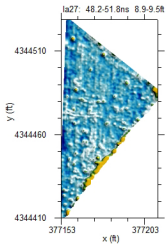

la22: 38.9-42.6ns 7.2-7.8ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

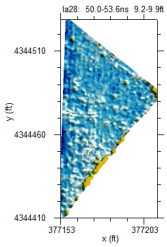

la23: 40.8-44.4ns 7.5-8.2ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

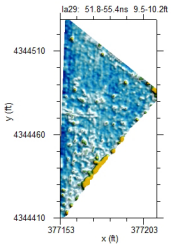

la24: 42.6-46.2ns 7.8-8.5ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

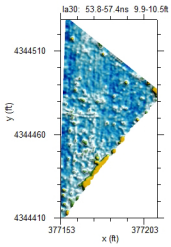

la25: 44.4-48.0ns 8.2-8.8ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

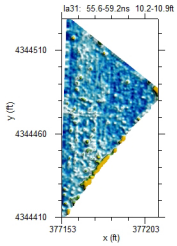

la26: 46.4-50.0ns 8.5-9.2ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

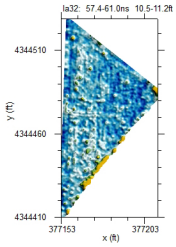

la27: 48.2-51.8ns 8.9-9.5ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

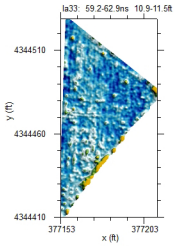

la28: 50.0-53.6ns 9.2-9.9ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

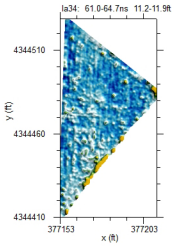

la29: 51.8-55.4ns 9.5-10.2ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

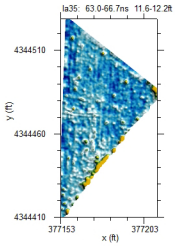

la30: 53.8-57.4ns 9.9-10.5ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

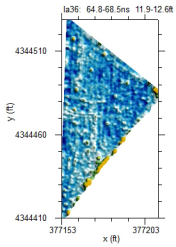

la31: 55.6-59.2ns 10.2-10.9ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

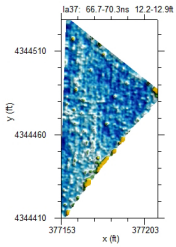

la32: 57.4-61.0ns 10.5-11.2ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

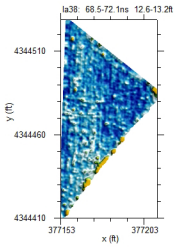

la33: 59.2-62.9ns 10.9-11.5ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

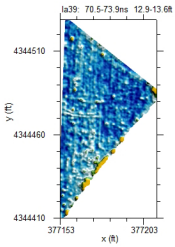

la34: 61.0-64.7ns 11.2-11.9ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)

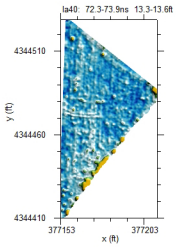

la35: 63.0-66.7ns 11.6-12.2ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)


la36: 64.8-68.5ns 11.9-12.6ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)


la37: 66.7-70.3ns 12.2-12.9ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)


la38: 68.5-72.1ns 12.6-13.2ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)


la39: 70.5-73.9ns 12.9-13.6ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)


la40: 72.3-73.9ns 13.3-13.6ft
4344510
4344460
4344410
y (ft)
377153
377203
x (ft)