GPR Investigation of Penfield's Historic African American Cemetery.

November 2023

Prepared By:
Dr. Sean McConnel
Robert Theberge
Mark Pifer

INTRODUCTION

Bigman Geophysical, LLC was contracted to conduct a Ground-Penetrating Radar (GPR) investigation in order to determine the approximate number and distribution of individual burials within the African American section of the historic Penfield Cemetery.

The Penfield Cemetery is a historic rural cemetery situated in Greene County, GA (Figure 1). Penfield is characterized by physically segregated White and Black sections which differ with respect to landscape, topography, mortuary treatment, visibility, and access. Penfield's African American section embodies many of the common features of African American cemeteries in the rural South, as it is situated on heavily wooded land with steep topography and includes a relatively wide range of burial morphology. While the founding date for Penfield's African American section is presently unknown, it likely predates the Civil War, spans Emancipation, and appears to have fallen to disuse sometime in the 1950's. In 1948, the construction of a stone, brick, and mortar wall resulted in reduced access to Penfield's African American section amidst the continued migration of Black communities out of the South. Historic aerial imagery (Figure 2) appears to suggest that in the years after the construction of the wall, Penfield's African American section fell to disuse, where it was subject to increased forestation and overgrowth, which has contributed to many of the burials being hidden, and difficult to identify in the present.

The lack of identifiable burials in this section of Penfield necessitated archaeological methods of inquiry to answer questions regarding the number and distribution of buried individuals within the space.

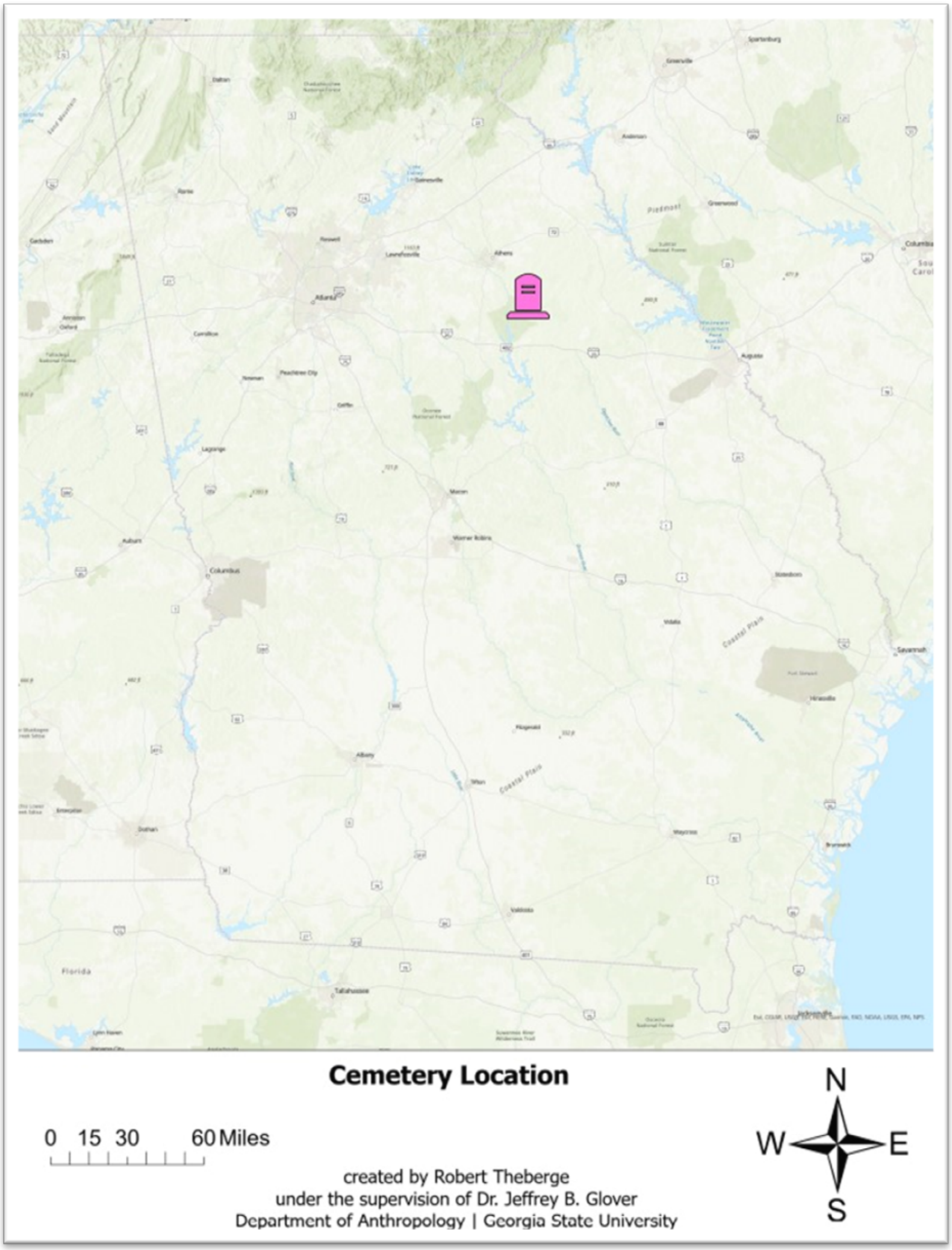

Figure 1: Penfield's approximate location within the state of Georgia.

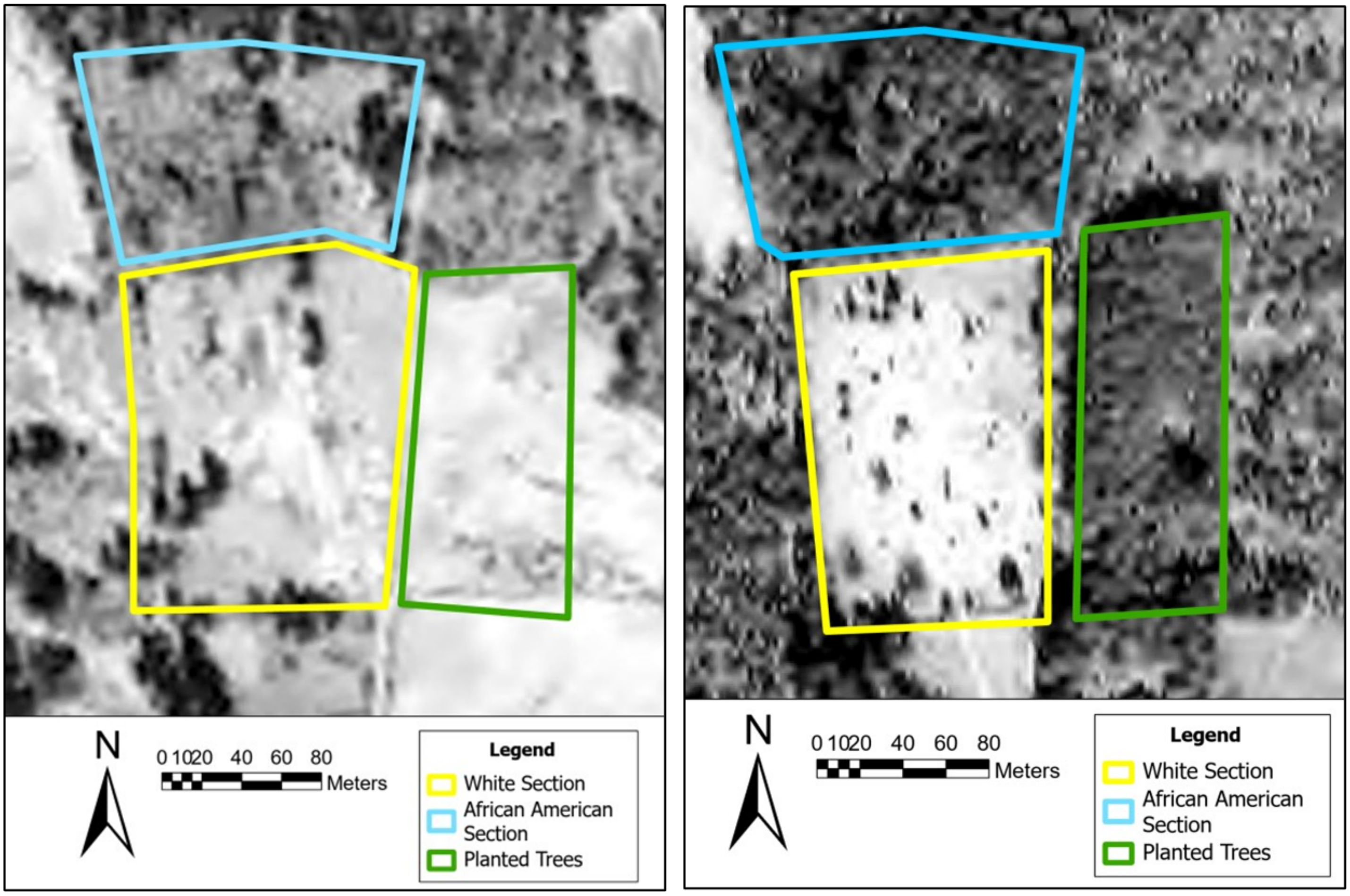

Figure 2: Historical imagery of the Penfield area from 1942 (left) and 1966 (right). Notice the apparent difference in tree cover within the African American section of the cemetery (blue outline), as well as the reduced visibility of the historic cart path at the eastern margin of the cemetery area. Images courtesy of Dr. Spencer Roberts, Emory University.

METHODS

The initial component of fieldwork within the African American section of the Penfield Cemetery involved manual labor in the form of clearing the landscape of debris, underbrush, and large fallen trees. This served the dual purpose of facilitating further archaeological research, while also contributing to the beautification and maintenance of the cemetery grounds.

Visible areas of burial within the African American section of the cemetery were then mapped into ArcGIS in order to arrive at an approximate number of known, marked burials in the research area of interest (AOI).

Ground Penetrating Radar (GPR)

Ground-Penetrating Radar was conducted in order to approximate the number of buried individuals which currently have no visible marker, and are not currently visible through depressions in the earth or other indicators. A robust subset of research conducted since the late 20th century has led to a precedent for the application of geophysical methods in efforts to preserve historic cemeteries (Bevan 1991; Bigman 2014; Conyers 2006, Spera et al. 2022). The nature of Ground-Penetrating-Radar to detect buried objects, soil disturbances, as well as void spaces while also allowing the user to estimate depth and orientation, makes this an ideal geophysical technique for use in cemeteries.

This survey utilized GPR to record information about the subsurface environment in the area of investigation, which was then projected and evaluated in a three-dimensional computer model. GPR sends electromagnetic pulses to a transmitting antenna at the ground surface, which produces a radio wave that travels through the subsurface (Koppenjan 2009). Wave speed depends on the ability of a given medium to transfer energy (Annan 2009, Conyers 2004). When an approaching wave encounters a discontinuity in the physical properties of the soil, and the wave's speed changes, some of the wave front's energy is reflected back toward the ground surface (Annan 2009). According to classic works by Borne and Wolf (1959) and Crawford (1968), the amount of energy reflected when an approaching wave encounters a contrast in dielectric permittivity will vary based on how different the two materials are on either side of the interface. A large difference in dielectric permittivity will result in a large amount of energy reflected off the interface, whereas a small difference on either side of the boundary will result in a small amount of energy being reflected. The two-way travel time (usually recorded in nanoseconds) and the reflection amplitude is recorded at the surface by a receiver antenna. Each traverse with the GPR provides a two-dimensional profile of the subsurface. When traverses are collected adjacent to each other, data can be resampled to create pseudo-3D visuals called time-slices (Conyers 2004).

GPR is a popular and often successful technique for identifying utilities and other manmade subsurface features (Hebsur 2013, Metwaly 2015, Rashed 2013, Wai-Lok Lai 2018, Wei Jaw 2013). However, there are limits to the resolution of any non-destructive testing and the physical properties of subsurface materials, surface conditions at a site, and the complexity or orientation of targets can impact the overall quality of results from a GPR survey.

DATA COLLECTION AND FILTERING PARAMETERS

Data collection was performed by Bigman Geophysical using a dual-frequency Leica DS2000 (figure 3). The equipment was chosen for its quality of output, to allow for the highest resolution of subsurface features at the site location, to a depth of approximately eight feet below the surface in this context. The software program used to process data was Geolitix, a cloud-based software package designed to efficiently process and interpret GPR data from a wide range of manufacturers (Figure 4).

Figure 3: Sean McConnel, PhD operates a Leica DS2000 dual channel GPR at Penfield.

The software program used to process data was Geolitix, a third-party software designed to project GPR data in a 3D environment and provide advanced tools for drawing and exporting detected features. The radargrams were corrected for time-zero and then gained manually. They were then given a second energy-decay curve to highlight deeper features. A bandpass filter was applied to cut off both high and low-frequency interference, and a background removal was applied with an appropriate window to remove banding but avoid filtering planar signatures. Data migration using a velocity found with the hyperbola fitting method and a Hilbert transform was applied to all data to create time slices. Radargrams were left unmigrated to allow consideration of hyperbolic responses during profile analysis in the 3D environment.

The radargrams were corrected for time-zero and then gained manually. They were then given a second energy-decay curve to highlight deeper features. A bandpass filter was applied to cut off both high and low-frequency interference, and a background removal was applied with an appropriate window to remove banding but avoid filtering planar signatures. Time slices (amplitude maps) were created with 5 cm cell sizes exposed to a 1m search radius using the Kriging method. A plan-view map was created for every XXcm depth, averaging XXcm above and below for each slice. Finally, signatures were treated to a 5x5 low-pass filter to smooth features and better represent their shape in the ground.

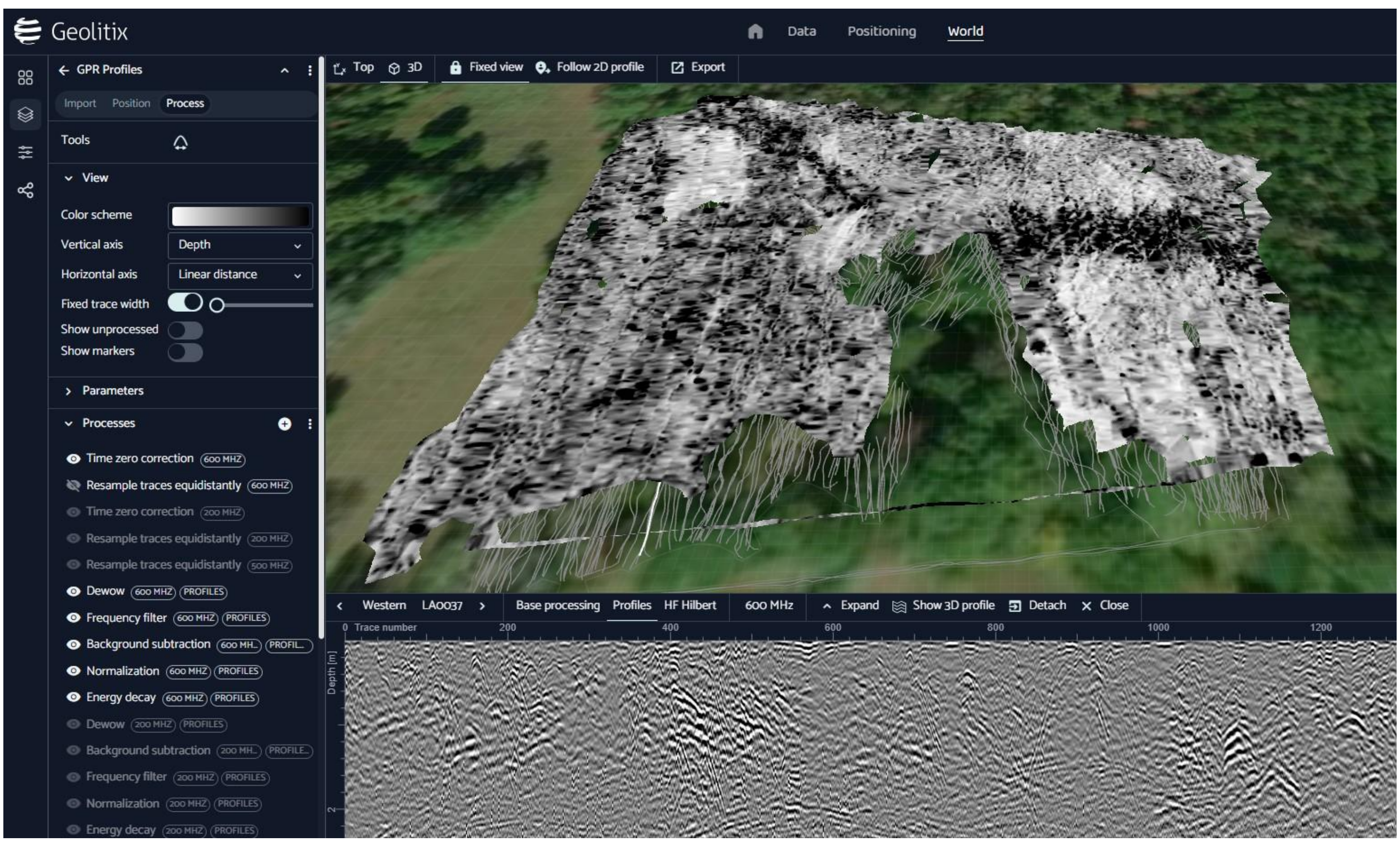

Figure 4: The three-dimensional computer modeling of the subsurface environment.

RESULTS

The GPR investigation resulted in the identification of approximately 1029 individual burials within the AOI (Figure 5). Of these, it appears that approximately 700 were not associated with markers or other indications visible at surface. The GPR investigation thus was able to identify approximately 700 burials within the AOI which had no visible surface marker at the time of data collection.

Concentrations of visible grave markers correlated strongly with GPR signatures indicative of burials at Penfield. This suggests that reflections from historic burials were able to be identified successfully during this investigation. Additionally, a number of signatures which met expectations for those generated by human burials were identified in areas with no visible indicators of burials at surface. These were distributed throughout the AOI, although not evenly. Burial signatures were concentrated in some areas and appear more diffuse in others.

Reflections indicative of burials were varied at Penfield. Not all signatures displayed the hyperbolic shape often characteristic of burials with in-tact caskets. Three reflection variations were used as the primary indicators of burials at Penfield (Figures 5 & 6).

Reflections of interest which were not indicative of burials, but which appear to lend some information about the cemetery itself are outlined in Figure 7. This figure highlights a possible road or path through the Penfield Cemetery which is now buried below soil deposition.

Figure 5 and 6 highlight examples of reflections which matched expectations for burials at Penfield.

Figure 7 represents examples of planar signatures potentially indicative of a buried path or roadway at Penfield.

Figure 8 highlights the distribution of GPR reflections indicative of burials as well as the distribution of visible indicators of burials within Penfield.

Figure 9 shows the overall distribution of individual burials at Penfield.

Figure 10 highlights concentrations of positive GPR signatures as well as visible surface indicators of graves in the form of a heat map.

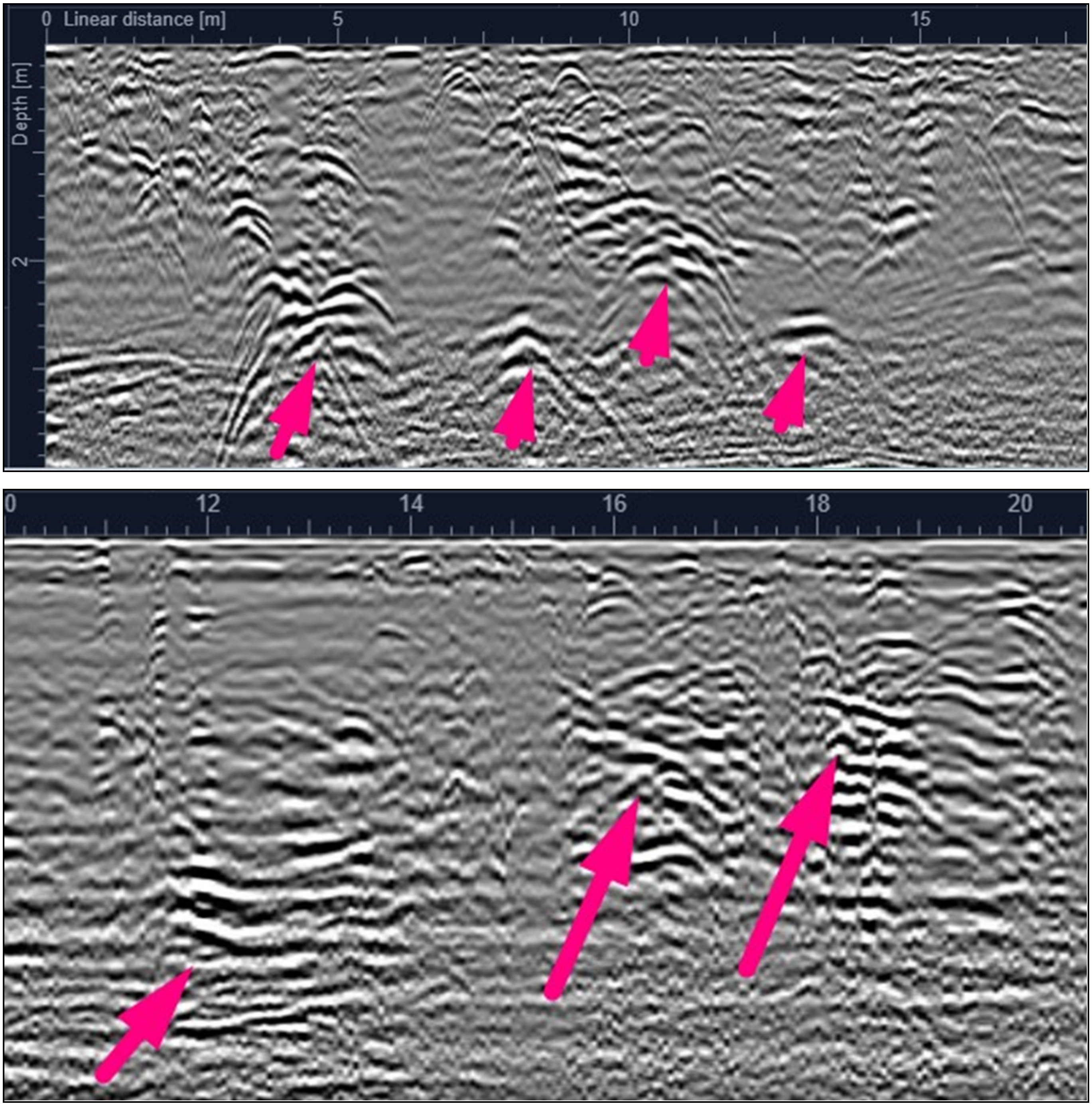

Figure 5: This image highlights examples of reflections interpreted as positive signatures for burials within the Penfield Cemetery. **Top:** Hyperbolic signatures with somewhat regular spacing and at depths expected for burials. **Bottom:** Planar or somewhat horizontal signatures whose size and depth match expectations for burials.

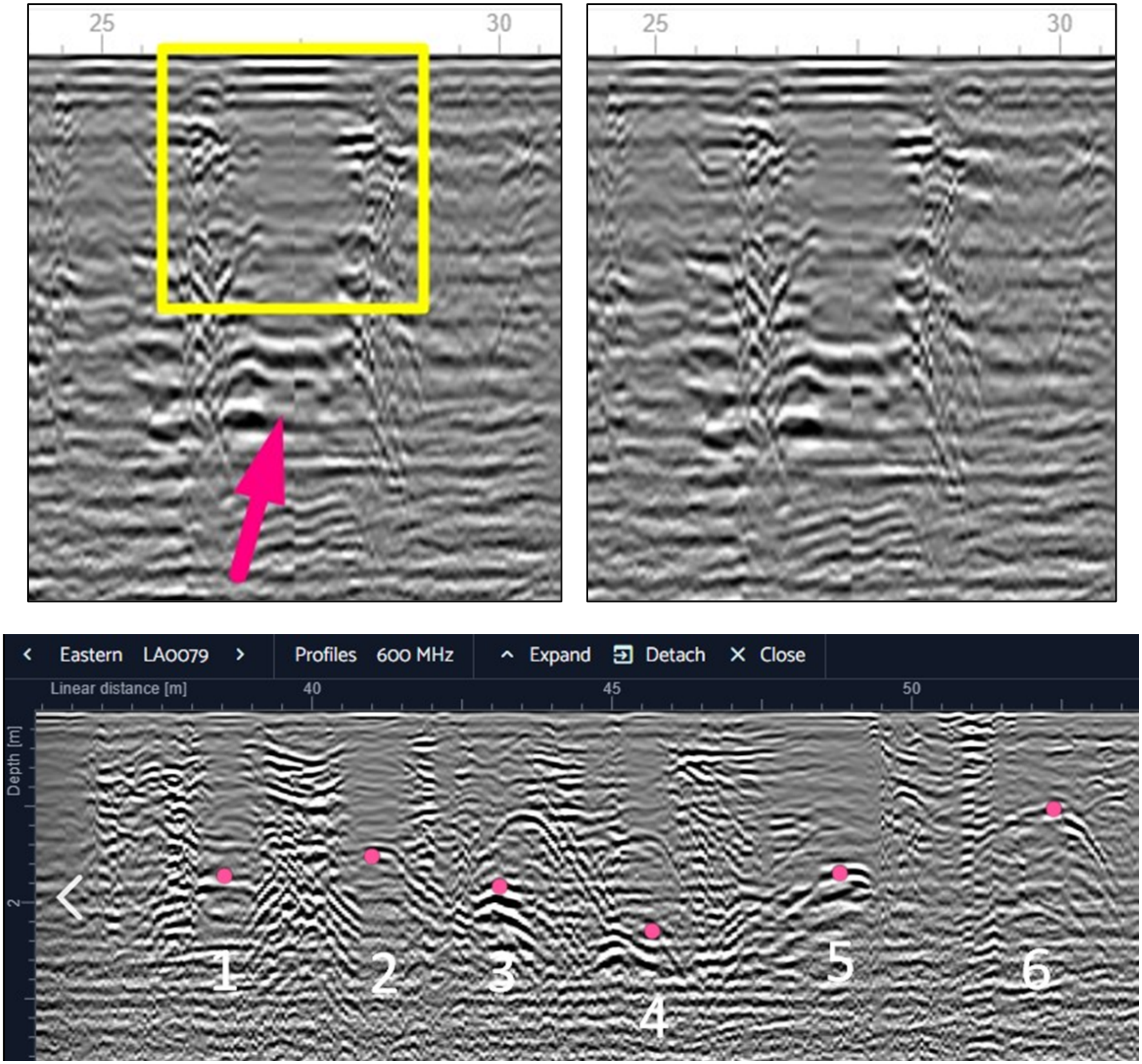

Figure 6: This image highlights examples of reflections interpreted as positive signatures of burials within the Penfield Cemetery. **Top:** Signatures with approximately horizontal edges indicative of a burial shaft with a high amplitude reflection near the bottom were found throughout the AOI. **Bottom:** A “row” of this type of signature with regular spacing at Penfield.

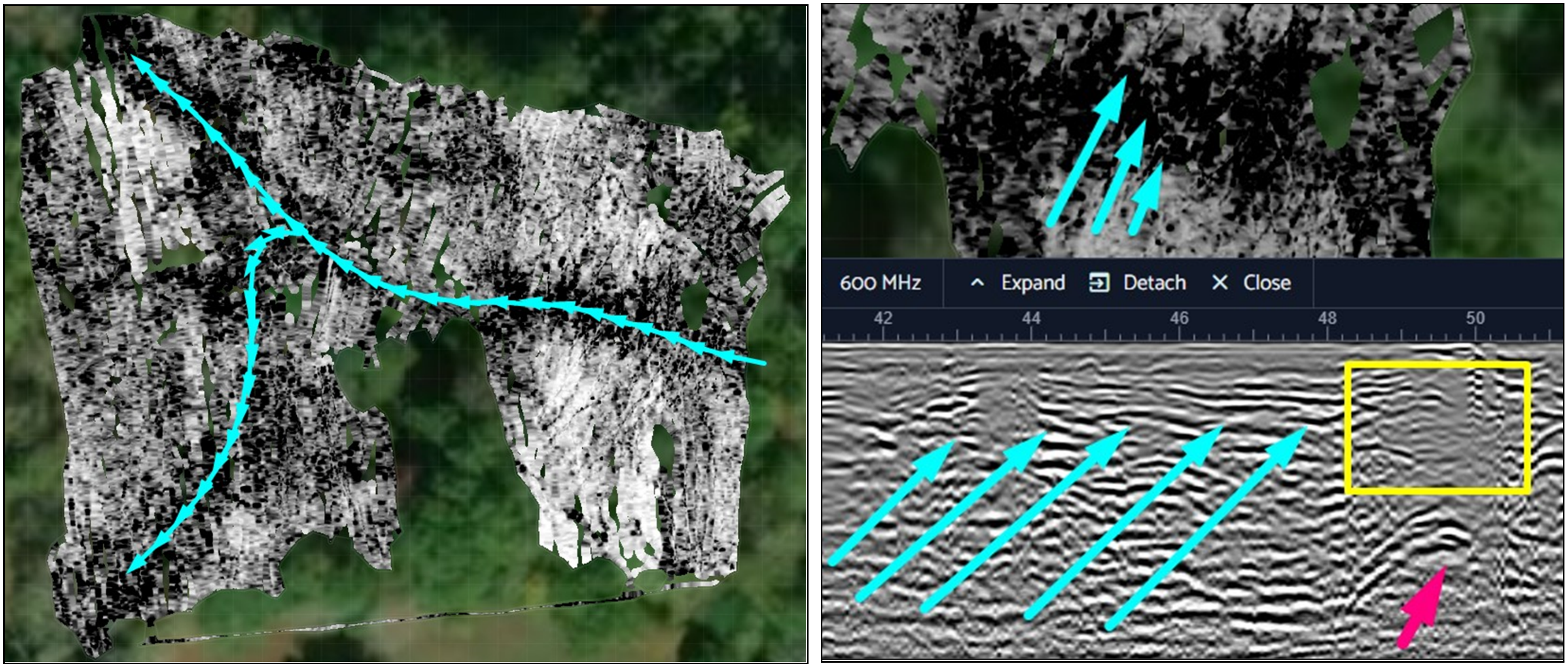

Figure 7: This image highlights "planar" or continuous horizontal signatures which were found throughout the AOI at Penfield indicative of a buried surface. When viewed in an overhead "time slice" these signatures appear to represent a pathway or road, possibly indicative of an access route or cart path through the cemetery covered by soil deposition.

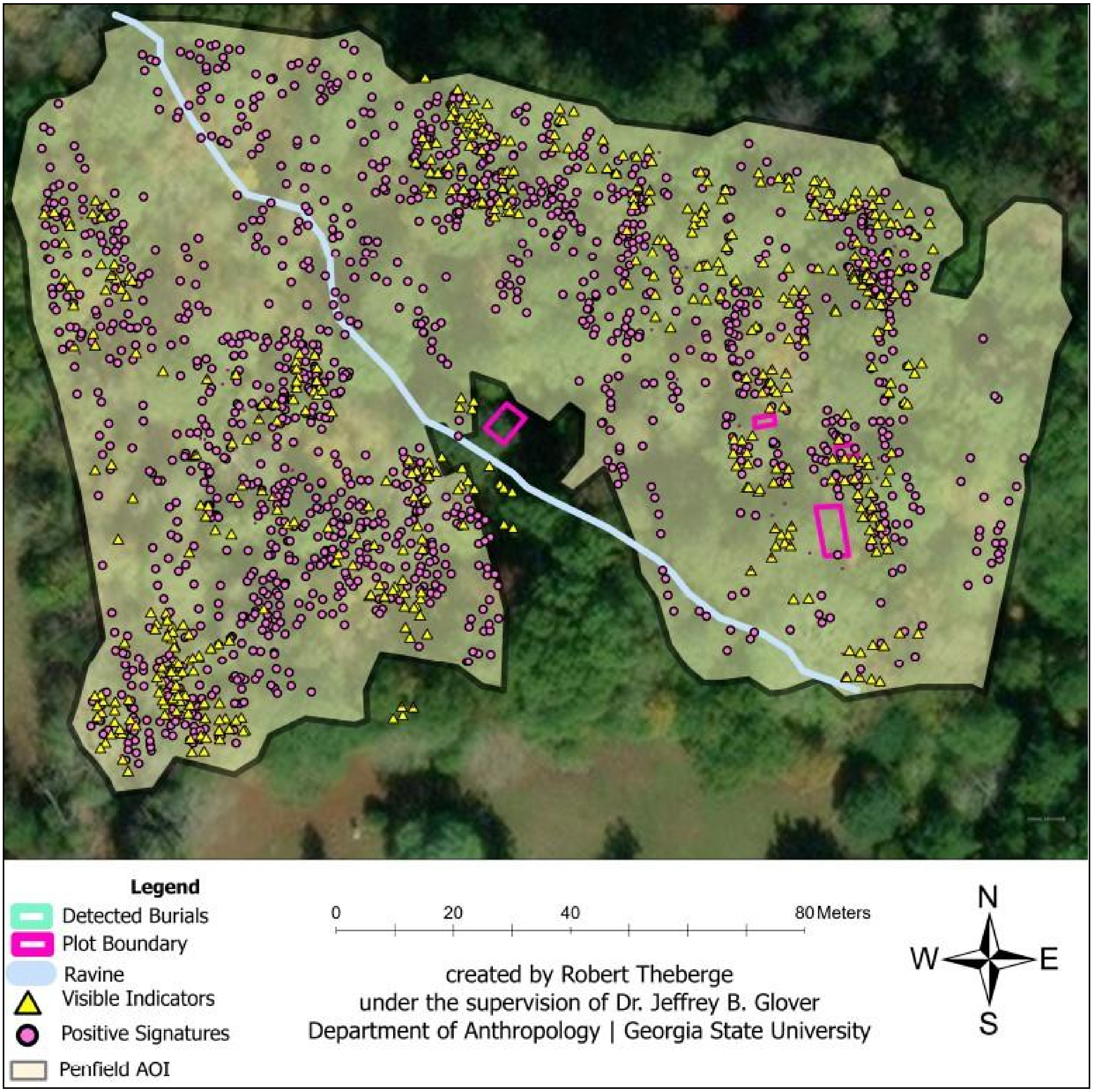

Figure 8: This image highlights the locations of signatures or groups of signatures which were interpreted as individual burials at Penfield (pink dots) as well as the locations of visible grave indicators at the time of the investigation (yellow triangles). A strong correlation between visible markers and positive signatures is evident. Additionally, many positive signatures were recorded in regions with no visible markers.

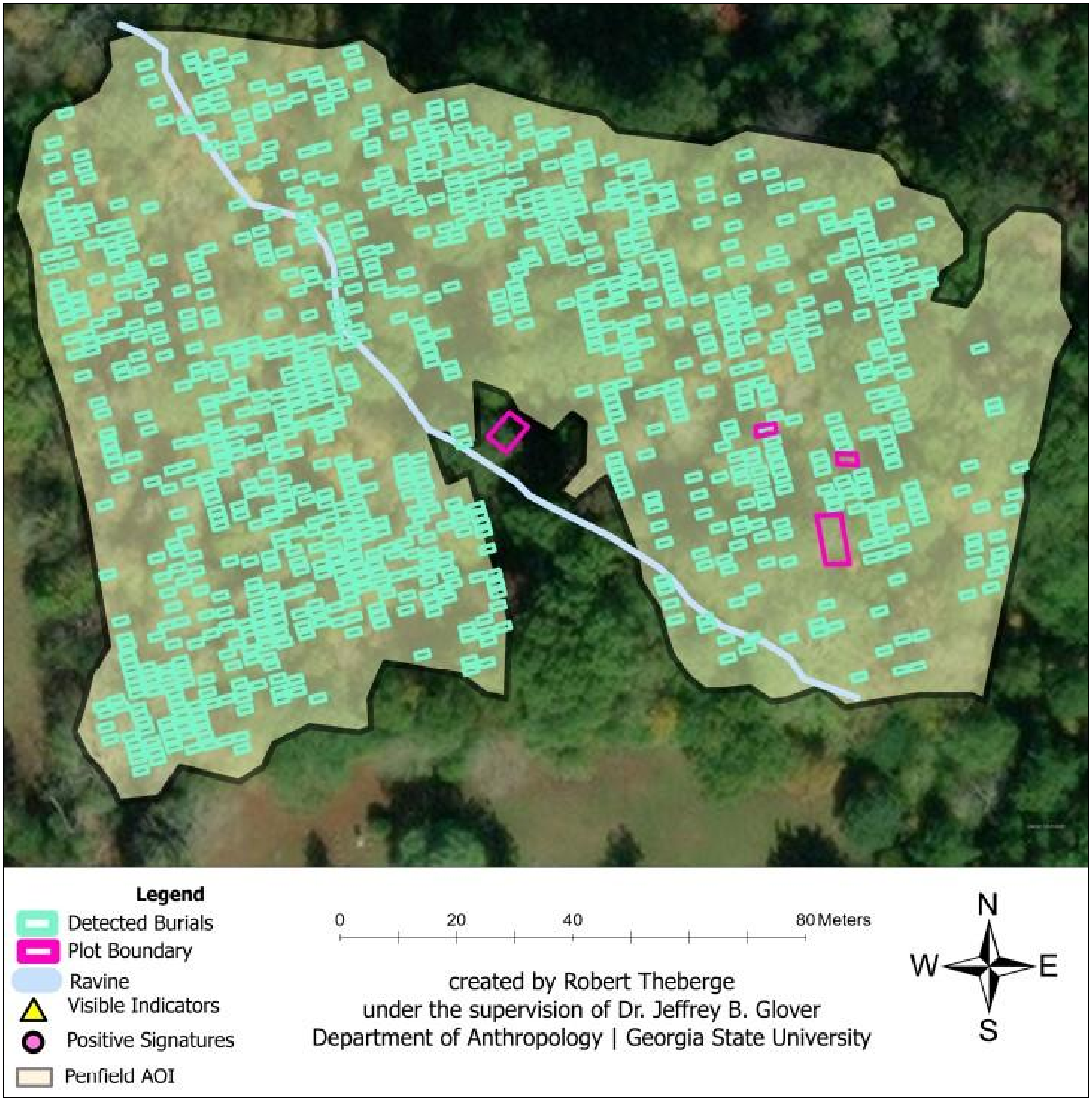

Figure 9: This image highlights the locations and number of individual burials identified through the GPR investigation at Penfield (n=1029). Purple regions highlight areas of relatively low concentration of graves along low-lying sections of the cemetery along a landscape feature interpreted as a path for water runoff.

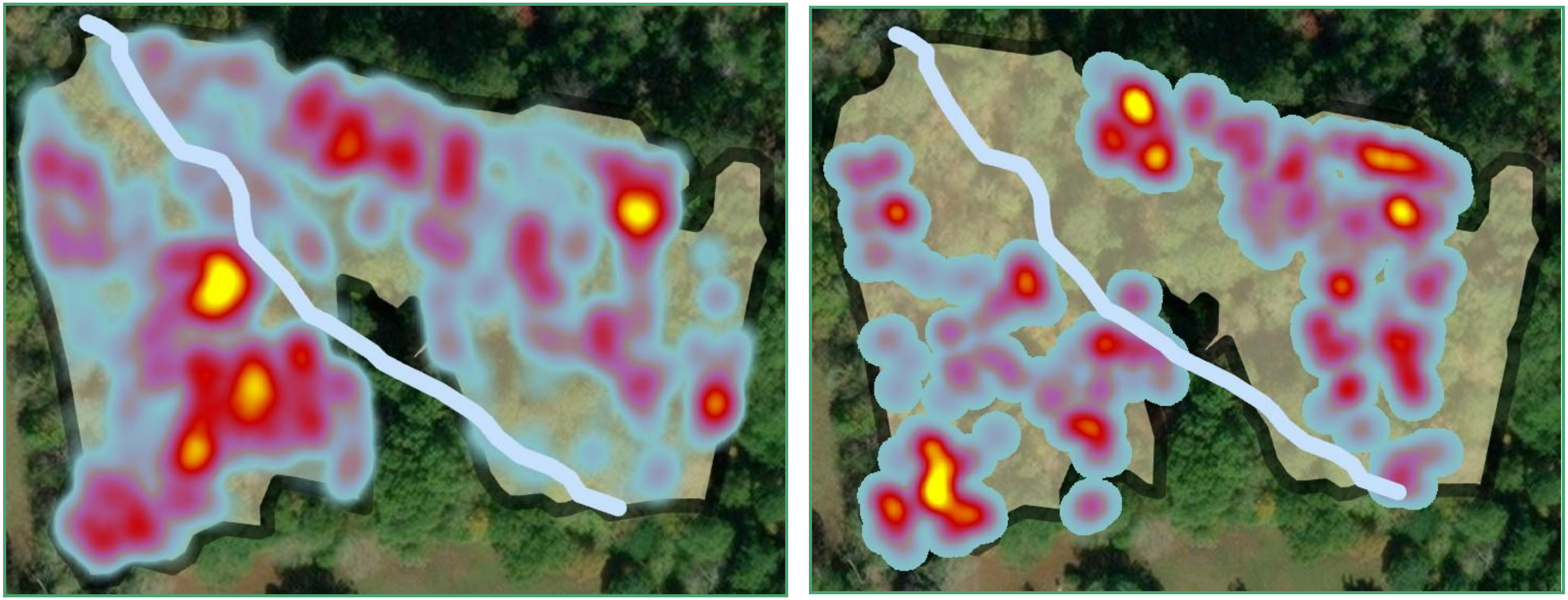

Figure 10:

Left: This image represents the distribution of positive GPR signatures within the AOI as a heat map.
Right: This image represents the distribution of visible indicators of burials within the AOI. A strong correlation between visible indicators and positive signatures is evident, however, positive GPR signatures appear more evenly distributed throughout the AOI. It is possible that visible indicators of graves have been buried under soil deposition, especially in low-lying areas associated with an apparent water runoff channel indicated by a blue line running diagonally through the above images.

Conclusions

The GPR recorded signatures throughout the AOI which met expectations for human burials. Approximately 1029 individual graves were identified through the analysis of GPR data collected within Penfield's African American section.

Concentrations of positive signatures are apparent in the data (Figures 8 and 10). With respect to positive signatures recorded by the GPR as well as visible indicators of graves, evidence for burials becomes more diffuse toward the low-lying central region of the cemetery. This is the area associated with the apparent water runoff channel indicated by the diagonal blue line in Figure 10. Soil deposition in the low-lying areas may account for the reduced visibility of burial signatures in GPR data, as well as for the lack of visibility of grave markers or depressions in these areas. Thus, it is possible that more burials exist than were identified during this investigation. It is also possible that these regions were simply not utilized to the extent of more elevated plots at Penfield.

It is possible that more graves exist outside of the AOI, however, we were not able to continue the investigation outside of the cemetery's property boundary. Furthermore, the southern / central region of the cemetery was not accessible to GPR during the time of this investigation due to fallen trees and debris, and has thus been omitted from this report. Visible indicators for graves do exist in this region however, and concentrations are likely consistent with those found in the rest of the cemetery.

This investigation revealed evidence for a buried surface within the AOI (Figure 7). This surface appears to have a linear orientation which spans the cemetery, potentially indicative of an access road or cart path used for cemetery access and management, and/or as an access road for logging activities. Signatures related to this path appear approximately 0.5 meters below surface, indicating that significant soil deposition has occurred since the time of its creation and use.

The results of this investigation are not absolute, and it is likely that many burials were not able to be identified by the GPR due in part to decomposition and degradation of burials over time, soil deposition and erosion, and buried natural features such as roots and rocks which can obscure positive signatures. When planning future maintenance activities, consultation with qualified archaeologists should be taken before planning any ground-disturbing activities near the marked cemetery, and archaeological monitoring should be employed during any ground disturbing activities which may take place within the cemetery.

REFERENCES

Akom, Antwi. (2011). Black Emancipatory Action Research: Integrating a theory of structural racialisation into ethnographic and participatory action research methods. Ethnography and Education. 6. 113-131. 10.1080/17457823.2011.553083.

Annan AP (2009) Electromagnetic Principles of Ground Penetrating Radar. In: Jol HM (ed) Ground Penetrating Radar: Theory and Applications, Elsevier, Amsterdam, pp 3-40

Baba, Marietta. (1994). The Fifth Subdiscipline: Anthropological Practice and the Future of Anthropology. Human organization. 53. 174.

Babson, David W. 1990 The Archaeology of Racism and Ethnicity on Southern Plantations. Historical Archaeology 24(4).

Ballard, Darrell, Zondria Bond, and Erika Massie 2016 African American Cemeteries and the Restoration Movement. Death and Human History in Athens. University of Georgia. https://digilab.libs.uga.edu/cemetery/exhibits/show/brooklyn/african-americancemeteries-an.

Berezowski, Victoria & Mallett, Xanthé & Ellis, Justin & Moffat, Ian. (2021). Using Ground Penetrating Radar and Resistivity Methods to Locate Unmarked Graves: A Review. Remote Sensing. 13. 2880. 10.3390/rs13152880.

Bevan BW (1991) The search for graves. Geophysics 56:1310–1319.

Bigman, Daniel P 2014. Mapping social relationships: geophysical survey of a nineteenth-century American slave cemetery. Archaeological and Anthropological Sciences 6(1): 17–30.

Booker, Brakkton. 2020. "Excavation Begins For Possible Mass Grave From 1921 Tulsa Race Massacre." NPR. https://www.npr.org/sections/live-updates-protests-for-racial-justice/2020/07/14/890785747/excavation-begins-for-possible-mass-grave-from-1921-tulsa-race-massacre

Brewer, Ross 2019 ArcGIS keeps past alive in Municipal Cemetery. Esri. February 1.

Brooks, Christina 2011 Enclosing Their Immortal Souls: A Survey Of Two African American Cemeteries In Georgetown, South Carolina. Southeastern Archaeology 30(1): 176–186.

Capello, E. (2022), Trans and White Trash: An Ethnography of Trans People in the Deep South. Anthropology and Humanism, 47: 69-84. https://doi.org/10.1111/anhu.12362

Carter, David & Yellowlees, David & Tibbett, Mark. (2007). Cadaver Decomposition in

Terrestrial
Ecosystems. Die Naturwissenschaften. 94. 12-24. 10.1007/s00114-006-0159-1.

Colwell, Chip. (2016). Collaborative Archaeologies and Descendant Communities. Annual Review of Anthropology 45(1) DOI: 10.1146/annurev-anthro-102215-095937

Conyers, Lawrence B. 2013 Ground-Penetrating Radar for Archaeology. 3rd ed.. Altamira Press, Lanham, MD. 2014 Interpreting Ground-Penetrating Radar for Archaeology. Left Coast Press, Walnut Creek.

Crawford Jr FS (1968) Waves: Berkeley Physics Course – Volume 3. Education Development Center Inc, Newton.

Dalan RA, De Vore SL, Clay RB (2010) Geophysical identification of unmarked historic graves. Geoarchaeology 25:572–601

Derry, L. (1997). Pre-Emancipation Archaeology: Does It Play in Selma, Alabama? Historical Archaeology, 31(3), 18–26. http://www.jstor.org/stable/25616545

Edwards-Ingram, Y.D. (1997). Toward "true acts of inclusion": The "here" and the "out there" concepts in public archaeology. Historical Archaeology, 31, 27-35.

Foster, G. S., & Eckert, C. M. (2003). Up from the Grave: A Sociohistorical Reconstruction of an African American Community from Cemetery Data in the Rural Midwest. Journal of Black Studies, 33(4), 468–489. http://www.jstor.org/stable/3180875

Fryer, T.C. (2020), Reflecting on Positionality: Archaeological Heritage Praxis in Quintana Roo, Mexico. Archeological Papers of the American Anthropological Association, 31: 26-40. https://doi.org/10.1111/apaa.12126

Glover, Jeffrey B, Kathryn Jackson, and Johnny Waits. (2010), Reclaiming a Sense of Place: Geospatial Technologies and the Flat Rock Cemetery Project. The Proceedings of the 37th Computer Applications in Archaeology Meetings: 93-97.

Gollam, Mark. 2021. "How radar technology is used to discover unmarked graves at former residential schools." CBC News.
https://www.cbc.ca/news/canada/ground-radar-technology-residential-school-remains-1.604977

Howe, Cymene. (2015). Queer Anthropology. International Encyclopedia of the Social & Behavioral Sciences. 10.1016/B978-0-08-097086-8.12219-6.

Jamieson, R.W. (1995). Material culture and social death: African-American burial practices. Historical Archaeology, 29, 39-58.

Jones, D. (2011). The City of the Dead: The Place of Cultural Identity and Environmental

Sustainability in the African-American Cemetery. Landscape Journal, 30(2), 226–240. http://www.jstor.org/stable/43324376

Khan, Ayesha. (2022). Finding Lost Voices: An Archaeological Study of Historic, African American Burial Sites in North Georgia. Thesis, Georgia State University. doi: https://doi.org/10.57709/27385440

Kirsch, Stuart. (2018). Engaged Anthropology : Politics Beyond the Text. University of California Press.

Kozaitis, K.A. (2000), The Rise of Anthropological Praxis. NAPA Bulletin, 18: 45-66. https://doi.org/10.1525/napa.2000.18.1.45

Martin, J. M., & Everett, M. E. (2023). A methodology for the self-training and self-assessing of new GPR practitioners: Measuring diagnostic proficiency illustrated by a case study of a historic African-American cemetery for unmarked graves. Archaeological Prospection, 1– 15. https://doi.org/10.1002/arp.1893

McDavid, C. (2002). Archaeologies That Hurt; Descendants That Matter: A Pragmatic Approach to Collaboration in the Public Interpretation of African-American Archaeology. World Archaeology, 34(2), 303–314. http://www.jstor.org/stable/827914

McGuire, Randall H. (2008), Archaeology As Political Action. University of California Press.

Mckeague, P, van‘t Veer, R, Huvila, I, Moreau, A, Verhagen, P, Bernard, L, Cooper, A, Green, C and van Manen, N. 2019. Mapping Our Heritage: Towards a Sustainable Future for Digital Spatial Information and Technologies in European Archaeological Heritage Management. Journal of Computer Applications in Archaeology, 2(1): 89–104. DOI: https://doi.org/10.5334/jcaa.23

Moser el al. 2002. Transforming archaeology through practice: strategies for collaborative archaeology and the Community Archaeology Project at Quseir, Egypt. World Archaeology Vol. 34, No. 2, Community Archaeology (Oct., 2002), pp. 220-248

Ozga, Andrew T, Raul Y Tito, Brian M Kemp, Hugh Matternes, Alexandra Obregon-Tito, Leslie Neal, and Cecil M Lewis Jr. 2015 Origins of an Unmarked Georgia Cemetery Using Ancient DNA Analysis. Human Biology 87(2): 109.

Patch, Shawn. 2009 Identification of Unmarked Graves at B.F. Randolph Cemetery Using Ground Penetrating Radar (GPR). Electronic Document. Historic Columbia Foundation.http://historicrandolphcemetery.org/documents/research/forms/GPR-Report.pdf, accessed October 1, 2022.

Lynn Rainville. (2014). Hidden History : African American Cemeteries in Central Virginia. University of Virginia Press.

Powell, John. 2008. Structural Racism: Building upon the Insights of John Calmore. North Carolina Law Review. 86.

Rice, Thaddeus Brockett and Williams, Carolyn White. (1979). History of Greene County, Georgia, 1786-1886. The Reprint Company. Spartanburg, SC.
RYLKO-BAUER, B., SINGER, M. and WILLIGEN, J.V. (2006), Reclaiming Applied Anthropology: Its Past, Present, and Future. American Anthropologist, 108: 178-190. https://doi.org/10.1525/aa.2006.108.1.178

Smith, Jonathan. 2009 Hidden and Sacred: African American Cemeteries in Eastern North Carolina. Master's Thesis. Department of Anthropology, East Carolina University, Greenville, NC.

Spera, Stephanie & Franklin, Matthew & Zizzamia, Elizabeth & Smith, Ryan. (2022). Recovering a Black Cemetery: Automated Mapping of Hidden Gravesites Using an sUAV and GIS in East End Cemetery, Richmond, VA. International Journal of Historical Archaeology. 26. 1-22. 10.1007/s10761-021-00642-3.

Stangstad, Lynette. (2013), A Graveyard Preservation Primer, Second Edition. Rowman & Littlefield Publishers, Inc. Lanham, MD.

Trepal, D., Lafreniere, D. and Stone, T., 2021. Mapping Historical Archaeology and Industrial Heritage: The Historical Spatial Data Infrastructure. Journal of Computer Applications in Archaeology, 4(1), pp.202–213. DOI: http://doi.org/10.5334/jcaa.77

Wilkinson, Mark D., Michel Dumontier, I. Jsbrand Jan Aalbersberg, Gabrielle Appleton, Myles Axton, Arie Baak, Niklas Blomberg, et al. 2016. "The FAIR Guiding Principles for Scientific Data Management and Stewardship." Scientific Data 3 (March): 160018.