The Role of GPR in Community-Driven Compliance Archaeology with Tribal and Non-tribal Communities in Central California

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ABSTRACT

For tribes whose preservation values and mitigation strategies for managing cultural heritage are built on an ethic of avoidance and minimal disturbance, geophysical technologies can be key components of the research design. These technologies, most notably ground-penetrating radar, have been used with great success in identifying and evaluating the depth, extent, and composition of some of those resources for heritage research and management purposes, easing tensions when working with sensitive ancestral places. Additionally, research in archaeological geophysics has shifted from feature finding in order to excavate targets of interest to the recognition that geophysical survey can provide data and interpretations for whole sites and landscapes complementary to or beyond that of excavation, especially regarding the intactness and sensitivity of cultural heritage sites. This use of geophysics as a primary method for research rather than a precursor to archaeological research has empowered tribes with another tool to advocate for low-impact investigation of ancestral sites and landscapes that position tribes as pro-science. Geophysical technologies provide scientifically rigorous yet minimally impactful strategies for investigating heritage while satisfying the requirements of academic and compliance archaeology in ways that can also be culturally appropriate for a much broader spectrum of tribal cultural heritage under consideration.

Keywords: Indigenous archaeology, California archaeology, cultural resource management, ground-penetrating radar, geophysical archaeology

Para algunas tribus cuyos valores de preservación y estrategias de mitigación para la gestión del patrimonio cultural tribal se basan en una ética de evitación y perturbación mínima, las tecnologías geofísicas han demostrado ser componentes clave del diseño de la investigación. Estas tecnologías, entre las que destaca el radar de penetración terrestre, se han utilizado con gran éxito para identificar y evaluar la profundidad, la extensión y la composición de algunos de esos recursos con fines de investigación y gestión del patrimonio, aliviando las tensiones cuando se trabaja con lugares ancestrales sensibles. Adicionalmente, el cambio en la geofísica arqueológica, que ha pasado de la búsqueda de rasgos para excavar objetivos de interés al reconocimiento de que la prospección geofísica puede proporcionar datos e interpretaciones de sitios y paisajes enteros complementarios o superiores a los de la excavación, especialmente en lo que respecta a la integridad y la sensibilidad de los sitios del patrimonio cultural, ha dotado a las tribus de otra herramienta para abogar por la investigación no destructiva y de bajo impacto de los sitios y paisajes ancestrales que sitúan a las tribus a favor de la ciencia. Las tecnologías geofísicas proporcionan estrategias científicamente rigurosas, pero de mínimo impacto para investigar el patrimonio en el paisaje, a la vez que satisfacen los requisitos de la arqueología académica, gestión de recursos culturales (CRM, por sus siglas en inglés) y de cumplimiento arqueológico, de manera que también pueden ser culturalmente apropiadas para abarcar un espectro mucho más amplio del patrimonio cultural tribal en consideración.

Palabras clave: arqueología indígena, arqueología de California, gestión de recursos culturales, radar de penetración terrestre, arqueología geofísica

Native American and First Nations tribes and their partners have been utilizing geophysical, remote sensing, and mapping technologies more frequently over the past few decades to learn about, manage, and protect cultural heritage (e.g., Backhouse et al. 2017; Gonzalez 2016; Lightfoot 2006, 2008; Quackenbush 2014; Taylor et al. 2017; Wadsworth 2019). Geophysical technologies provide heritage managers and researchers with a suite of noninvasive strategies for creating predictive models for finding new sites, prospecting for and/or evaluating both human-modified and nonmodified landscapes with cultural significance, and investigating the various components of those landscapes. For many Native American tribes and communities that want to reduce the impacts to cultural heritage from both archaeological study and public and private development, these technologies have proved to be essential in providing data to satisfy the compliance requirements mandated by cultural resource laws and

Advances in Archaeological Practice 9(3), 2021, pp. 215–225

DOI:10.1017/aap.2021.14

studies (Backhouse et al. 2017; Quackenbush 2014). This use of technology to facilitate archaeological research also demonstrates that tribes are pro-science and supportive of research that aligns with tribal knowledge, epistemologies, and preservation values. This arena of technologized, noninvasive research can be a productive space for the intersection of Native American perspectives and values with those of Native American and non-Native archaeologists, leading to collaborations that serve community needs and protect cultural heritage from unnecessary disturbance (Gonzalez 2016; Lightfoot 2008; Nelson 2020).

During the 1960s and 1970s, when many historic preservation laws were expanded and the cultural resource management (CRM) industry grew out of previous salvage operations, archaeology itself was undergoing internal debates about the positivism of processual theory and scientistic discourse that separated the New Archaeology from European antiquarianism (King 2008; Moratto 1992; Smith 2004; Trigger 2006). The universal relevance of this scientific rhetoric allowed archaeologists to see themselves as stewards of a universal human past and stake claims to Native American heritage, redefining it as the archaeological record (Smith 2004:88). The theoretical positions of the New Archaeology were also incorporated directly into cultural resource legislation and the practice of compliance archaeology in the United States. These new regulations established archaeologists as the subject matter experts in this emerging compliance field and mobilized the discipline of archaeology as a technology of government to speak for and claim Native American heritage (Smith 2004:90–92).

Although more and more channels have been opened for Native American consultation within the CRM industry, there is still tension regarding how tribal cultural heritage should be managed and protected, especially in the case of development projects that require mitigation (Dongoske 2020). Mitigation strategies can include a wide range of treatments such as avoidance, knowledge reclamation projects, archaeological data recovery through noninvasive techniques, or excavation. Although Native American heritage managers more often advocate for avoidance in managing cultural heritage, mitigation measures are often proposed that are incommensurate with Native American goals of preservation. Cultural resource laws were developed with processual archaeology values and standards for professionalization and expertise, condoning the archaeological recovery of information as a valid exchange for the damage caused by a project (Bergman and Doershuk 2003; Dongoske 2020; Milholland 2010). In consultation about which mitigation strategies are used, the stakes are high for Native American peoples, whose knowledge and heritage are inextricably tied to places on the landscape—as opposed to Christianity and Western science, which do not depend so heavily on a particular cultural landscape (Deloria 2003). Consequently, every site that is impacted represents significant knowledge loss for Native American peoples that cannot be recovered.

Furthermore, Native American heritage is often categorized under Criterion D of the National Register of Historic Places (36 CFR 60.4; NRHP)—that is, districts, sites, buildings, structures, and objects that "have yielded or may be likely to yield information important in history and/or prehistory." In other words, this criterion recognizes Native American heritage for its value within archaeological studies and excavations that damage sites in order to recover information about the past. This has led to the colloquialism among heritage managers that Criterion D stands for "Dig." Although these NRHP criteria may seem to be very narrowly conceptualized, their broad definitions remain open to creative interpretations of what qualifies as culturally significant. For instance, the Confederated Salish and Kootenai Tribes of the Flathead Nation in northwestern Montana have been successful in arguing that natural geological landforms created by Coyote have significance as distinctive built structures under Criterion C (Pablo 2001). From creative reassessments of the NRHP criteria, creative mitigation strategies can also be envisioned to address the culturally appropriate treatment of potential impacts, such as the knowledge reclamation and public outreach booklet project designed to present traditional Yokut and Western Mono stories to the public as part of mitigation by Caltrans and Far Western Anthropological Group Inc. for the Wahtoke Creek Archaeological Project (Waechter 2017).

Archaeological geophysics is another form of creative mitigation that tribes can employ when an evaluation of Criterion D and the integrity of a resource is required. Although some California tribes are now using geophysical methods on a consistent basis, few examples of these studies are published in scholarly journals by tribes themselves because of constraints on staff time to write anything beyond a report and the restrictions on sharing information from these studies that may be confidential in nature. To demonstrate the utility of geophysical technologies, especially ground-penetrating radar (GPR), in compliance archaeology and the way that tribes are using these technologies to evaluate, manage, and protect Native American heritage, I will draw on examples from community-driven research and compliance work at sites in Point Reyes National Seashore and Santa Rosa, California. In doing so, I will address the following questions: First, how can GPR be used to evaluate and make determinations about tribal cultural heritage sites and employed as a creative option in compliance that shift the methods and outcomes of evaluations and data recovery to those that are more community-driven and culturally appropriate? Second, what skepticism still exists about deploying these technologies as standard practice in compliance archaeology, and how can it be addressed? I will conclude with some final thoughts about the place of geophysical technologies in compliance archaeology and how it can create new spaces for research that is community driven, culturally appropriate, and scientifically rigorous.

ARCHAEOLOGICAL GEOPHYSICS IN CALIFORNIA

Archaeologists have employed geophysical technologies in field surveys for at least the past three decades in California, even though these applications were not frequent or widespread in the early years. Two outstanding examples of early geophysical survey in the 1990s were conducted as studies of house pits and floors in the Channel Islands (Arnold et al. 1997) and in Orange County (Grenda et al. 1998). In addition to continuing academic and compliance projects in the state (Byram et al. 2018; Lightfoot 2008; Lightfoot et al. 2013; Sunseri and Byram 2017), several graduate students conducted geophysical research collaboratively with California tribes investigating a broad range of precontact and postcontact sites and features (e.g., Cuthrell 2013; Gonzalez 2011; Nelson 2017; Panich 2009; Schneider 2010; Silliman 2000).

Throughout these years of collaborative and community-based research in California, tribes have appreciated the low-impact methodology applied to the study of cultural heritage by these scholars and practitioners, and these methods have become more commonplace in not only academic but also compliance archaeology in the region.

In the case of my own work with the Federated Indians of Graton Rancheria (FIGR) in Marin and Southern Sonoma Counties of California, I have conducted several geophysical surveys in five geographically distinct areas of FIGR territory with magnetometry, electrical resistivity, and ground-penetrating radar (GPR) for academic and compliance purposes since 2012. Although the focus of this article is GPR and not magnetometry or electrical resistivity, these tools can be extremely useful given the right conditions, and I will mention them briefly in this discussion. For a more complete comparison, see Nelson's (2017) study of sites within Tolay Lake Regional Park in Sonoma County, California.

Although I have utilized magnetometry and electrical resistivity, GPR has proven to be a premier tool among geophysical techniques for my applications in Central California because it is fast paced, highly mobile, and capable of estimating precise depths of features as well as the extent of a site's overall boundaries. GPR can produce single profiles within seconds, leading to preliminary in-field assessments of subsurface features during active compliance projects, although it is common practice to download and post-process these profiles further with software (e.g., GPR Viewer, GPR Process, RADAN, GPR-SLICE) on a laptop or desktop computer in order to achieve more precise and meaningful final interpretations. These data can be post-processed as single profiles or as plan-view grids composed of multiple profiles stitched together for either 2D viewing only at several predetermined depths or interactive 2D and 3D viewing, depending on the software used. Another component of post-field data management and interpretation may involve preparing data and importing it into mapping software (e.g., Surfer, ArcGIS, or QGIS) in order to place these data visually in their locational context. This additional step can be extremely useful for comparative assessments across multiple datasets derived from additional methods such as magnetometry, electrical resistivity, topographic mapping, surface artifact collection, and excavation.

In Central California, excessive metal on ranching sites and in urban areas can prove challenging for magnetometry, and excessive rocks and rubble in some midden sites can damage electrical resistivity electrodes or prevent them from penetrating the ground easily. These are obstacles that GPR can overcome, and it can produce great data while doing it. One disadvantage of GPR along the Central California coast, however, is susceptibility to saturated sites in wet seasons or saltwater infiltration in soils along the coast. GPR also has the disadvantage of needing close and consistent contact with the ground, so topography and vegetation can be difficult for these surveys. Some uneven topography and light brush can be easier for magnetometry to navigate, but the ideal setting for GPR is a perfectly manicured or bare-earth situation, which is rarely if ever present along the coast or deep in open space or park areas, necessitating more careful preparation of field sites before survey. However, GPR's ability to quickly exchange different frequencies of antennae also affords GPR great versatility, range, and resolution, which gives it the capacity to detect small and large features in very shallow, near-surface deposits as well as those that are buried several meters in the ground (Conyers 2004, 2012; Conyers and Goodman 1997). For these reasons, GPR has proven to be the most flexible geophysical tool in my experience, providing good-quality data for most of these contexts along the Central California coast.

ARCHAEOLOGICAL GEOPHYSICS IN ACADEMIC AND COMPLIANCE SETTINGS

When applied in both academic and compliance archaeology, GPR can provide stand-alone and complementary data that enhance our knowledge of cultural resources in terms of the depth, extent, composition, type, and integrity of previously recorded sites, sensitive areas of those sites, and/or the potential for additional buried resources outside of the site boundaries. Researchers can ask questions such as (1) What is the structure of each site? and (2) How have various formation processes shaped the site over time? In considerations of several sites, researchers can also ask questions such as (1) Are there patterns in the distribution of sites with or without house floors and other architectural features? and (2) What can this tell us about settlement patterns and social organization? For the purposes of this discussion, the scope is limited to data from two sites that can address questions about site structure and formation processes. One of these sites is located in Point Reyes National Seashore in Marin County, California, and the other is the Carrillo Adobe in Sonoma County, California. These sites will illustrate the versatility of GPR data and interpretation of subsurface features as well as the potential for this information to strengthen both academic and compliance research and community engagement.

During this discussion of specific precontact sites, information such as site names and locations are kept confidential at the request of FIGR in order to protect these sites from further damage by looters if information about these sites becomes publicly available. FIGR also retains the right to determine who can access and use the data generated from these projects because it concerns FIGR heritage.

For both of the examples discussed, a GSSI SIR 3000 model GPR with survey wheel was used to collect data with a 400 MHz antenna. Although these data were collected at different sites, the operator settings that best suited both these sites were the same. The range was set at 30 nanoseconds (ns) with a dielectric constant of 8.0, and the instrument collected 512 samples per scan in the vertical direction at a rate of 120 scans per second in the horizontal direction. During post-processing with GPR Viewer, a background removal filter was applied to identify and remove flat-lying horizontal reflections or bands that extend the entire length of the profile while preserving real data. A range gain process was performed to enhance the visibility of important features. And a manual time zero / position correction was also performed on the profiles to define the ground surface accurately and correct the estimated depth of the profiles. Any further processing of data from each site is discussed below.

POINT REYES NATIONAL SEASHORE

At Point Reyes National Seashore in Marin County, California, many sites continue to be impacted by climate change and coastal erosion (Newland 2014). In its internal guiding policies on cultural resources, the National Park Service (NPS) has a fiduciary responsibility to manage these nonrenewable resources in culturally appropriate ways in consultation with the tribe. Consequently, NPS and FIGR developed projects collaboratively in partnership with compliance and academic archaeologists to systematically identify, study, and protect these resources. The first two efforts in Point Reyes were an ongoing site stewardship program and a coastal climate change assessment survey of archaeological sites in the park led by Michael Newland (2014), who was previously employed by Sonoma State University's Anthropological Studies Center (ASC) and now by Environmental Science Associates (ESA). Following these efforts, a collaborative project between FIGR, NPS, and UC Berkeley was implemented in the summer of 2015 to gather more information about understudied sites in the park before they were further impacted. In this sense, the project represents a community-driven compliance project, because FIGR called on UC Berkeley researchers to assist with the compliance responsibilities of FIGR and NPS to manage and care for these sites. FIGR had full control over treatment of these sites, and FIGR tribal citizens were involved in the design, consultation, and implementation of this project as well. Unlike compliance in many development projects that produces unwanted impacts to sites and leads to unsatisfactory mitigation measures, the research questions and low-impact methods in this community-driven compliance project were designed in collaboration with UC Berkeley, FIGR, and NPS to ensure that they would be culturally appropriate for the resources considered at that time. Non-Native archaeologists and cultural resource managers might value data recovery more than low-impact strategies in a case where the entire site would be eroded away by winter storms. It was important, however, for FIGR representatives—including the author, who was the chairman of the Sacred Sites Protection Committee at the time of the project—that the methods employed were sensitive and respectful of ancestral places so that we would not be the agents of greater destruction to these sites than was necessary.

Many of these recorded precontact Coast Miwok sites are composed of dark, organic rich soils, fire-affected rock (FAR), chipped stone, shell, bone and charred vegetable materials. Despite variable amounts of information about each site under investigation in 2015, erosion from climate change, cattle, and other forces were changing the condition of these sites yearly, necessitating continual data collection and evaluation (whether noninvasive or low impact). Pedestrian surface survey, intensive surface collection and catch-and-release surveys, shovel test pits, auguring, and limited excavation are the standard methods for determining the depth, extent, composition, type, and integrity of sites through a hands-on analysis of the physical materials within or on top of a site, and some of these methods were also used during the 2015 fieldwork. However, some of these methods, even though they are low impact, can still be destructive and should be used as a last resort in a management or monitoring plan, especially in parks where there are few development pressures that might necessitate greater impact. As was the methodology in 2015, the priority should be to learn as much as possible through noninvasive methods before more aggressive techniques are used—if they are used at all. In this context, GPR provided a wealth of information that satisfied the requirements of compliance and regular management of sites under investigation and even provided information that was not possible to obtain through standard survey methodologies and archaeological sampling techniques.

When surveying midden sites in the park, GPR profiles display a complex array of components, objects, and stratigraphy below the surface of the ground, as can be seen in the example from one midden site in Figures 1 and 2. For greater clarity in discussing the internal structural elements in these figures, horizontal reflections representing depositional layers of stratigraphy and hyperbolic point reflections representing interior structural elements or objects within these sites are either labeled with red arrows or traced with a single thin red line. For this discussion, I am focusing on the major stratigraphic components that I have highlighted rather than other minor components that may be visible in the profile and could be the subject of further discussion elsewhere.

The profile in Figure 1, located in the middle of the midden site, shows one long horizontal or planar reflection that represents the upper extent of intact midden soils in a convex or "D" shape. This reflection gradually descends in depth toward the edges of the profile and extends beyond the length of the 20 m profile. In the middle of this profile, the upper extent of the intact midden soils meets the present-day ground surface. At this point in the profile from approximately 4.5 to 13.5 m, the intact midden soils lose their contour and remain flat at the top of the profile for about 9 m. Only short sections of this portion of the mound are shown because the upper extent of intact midden soils remains the same at this point and breaking the profile was necessary to fit it on a single page. This long flat middle area is significant, though, because it represents a disturbance to the natural curve of the mound—that is, years of cattle grazing on and around the site have eroded soils from the top of the intact midden and carried them down the sides of the midden. In Figure 1, the eroded soils from the top of the midden can be seen in the horizontal bands at the edges of the profile. These bands are parallel to the present-day ground surface and terminate on top of the sloping contour of the intact midden soils.

Similarly, the profile in Figure 2, located on the eastern edge of the midden site, shows intact midden soils (labeled 1–4) and eroded soils (labeled 5–7). Rather than tracing a single upper extent of the intact midden soils, four separate stratigraphic components of the intact midden soils are clearly defined and highlighted in this profile. These stratigraphic components (labeled 1–4) have the appearance of overlapping hills that also directly correlate to their depositional age in the profile. The deepest stratigraphic component 1, which underlies all the others, is the oldest. Component 2 is younger than 1, followed by component 3, which rests on top of 1 and 2. Component 4 overlies all the others, and it is the youngest intact stratigraphic component.

The eroded soils at the end of the profile (labeled 5–7) are almost completely flat and parallel to the ground surface, giving them the appearance of a horizontal band beginning at the right side of the profile and terminating at or overlapping the top-left edge of the intact midden soils of component 4. Given that these three final stratigraphic components overlie component 4, they are all younger than the intact midden soils, strengthening the case that they developed after the occupation of the midden

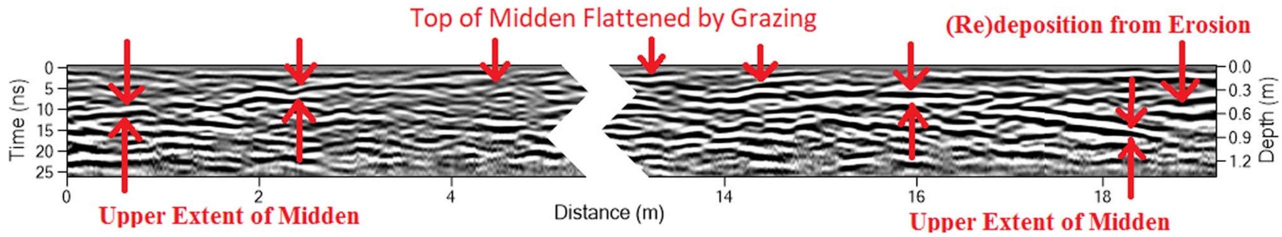

FIGURE 1. GPR Profile at 6.0 m E within a 10 m grid at the Point Reyes site. Double arrows point to the upper extent of the midden soils, and single arrows point out impacts to the site from grazing and erosion. The white zigzag cuts out about 9 m of data between distance (m) marks 4 and 14 that remain consistent (i.e., the top of midden remains at the surface of the profile without any change). This omission from the profile provides more space for viewing the significant changes occurring at both ends of the profile. Also note that the intact midden soil in this profile extends at least 18–20 m, if not more. This is the middle and most extensive portion of the mound.

site. Identifying intact as opposed to disturbed components of these midden sites, as well as being able to sequence the different components, is a tremendous tool for researchers and resource managers alike. These data allow them to define intact site boundaries, identify heavily disturbed areas, plan excavations and test units much more precisely, target the most useful areas to sample for radiocarbon dates, and accomplish their goals with fewer holes in the ground.

CARRILLO ADOBE

In Santa Rosa, county seat of Sonoma County, California, the Carrillo Adobe remains the oldest standing European, Mexican, or American structure in town and represents the establishment of permanent non-Native settlement in this area in the 1830s. A developer's proposal to build 140 condominiums on the site prompted an archaeological study and evaluation of the area in 2006 by Archaeological Resource Service (Roop and Wick 2008), including magnetometry and electrical resistivity survey conducted by Lewis Somers (2008). Due to public opposition to the development project, local archaeologists, historians, community members of the Santa Rosa Historical Society, Santa Rosa High School students, and individuals from the Native American community came together to conduct restoration at the grounds and formally nominate the property to the National Register of Historic Places.

Coinciding with the compliance and community efforts to preserve this site, the Santa Rosa Historical Society hosted a public archaeology and history event, "A Day at the Adobe," on-site to which they invited the general public to explore the standing architecture and ruins of the site, see an active geophysical survey in progress, and hear lectures on the site's history, as well as on early California and the local Native American communities. The community organizers asked me, as a citizen of the Federated Indians of Graton Rancheria whose Southern Pomo territory extends into this area, to offer a prayer to open the event, give a lecture on local Native American peoples and the environment at the time of contact with Europeans, and conduct the geophysical survey of a portion of the site adjacent to the standing architecture of the adobe. Although the 2015 survey was not required follow-up to the compliance survey performed originally in 2008, it was part of a community-driven effort to raise awareness and admiration for the city's past in support of the National Register of Historic Places nomination and the fight to preserve this piece of Santa Rosa's cultural heritage. Thus, it was part of a larger non-mandated community-based or community-driven effort to engage in compliance archaeology and heritage protection.

My position as a Native American person and enrolled citizen of a local tribe, and as the archaeologist and GPR operator, allowed me to challenge visitors at this event to think critically about their place in history and in a contemporary settler colonial society in relation to Native American peoples. Although the commemoration of this site instilled a sense of pride in the community, I conveyed the positive as well as the negative aspects of California's colonial history in this place to the public so that this history would not be whitewashed. As was stated earlier, the Carrillo Adobe is the oldest standing structure in the town of Santa Rosa. The distinction that I conveyed to the public, however, was that this building represents the first *European* structure built in the town of Santa Rosa, not the first structure *ever* built in this area. Native American architecture and settlements are often lost in such celebratory narratives of colonial first accomplishments at commemoration events, and Native American peoples are relegated to existing in a time before such colonial accomplishments. As a Native American GPR operator and archaeologist interpreting the significance of this place for the largely non-Native public, I disrupted their preconceived or misconceived notions of who Native American people are and can be and reaffirmed our place in contemporary society as contributors to contemporary scientific knowledge production.

The survey grid established for the 2015 GPR survey at the Carrillo Adobe was aligned along the same axis as the historic adobe building, and it covered a flat grassy portion to the south of the structure where there were no visible structural elements protruding from the ground. The grid was surveyed in an approximately east-west direction with 25 cm spacing between each of the survey lines, and it was processed and mapped with a combination of Larry Conyers's GPR Process software Golden Software's Surfer 8 and ArcGIS. The image in Figure 3 shows the GPR data superimposed on a satellite image of the Carrillo Adobe site. The green, yellow, and red colors in the GPR data represent higher-amplitude values, whereas purple and blue represent low-amplitude values. This image shows a rectilinear feature that corresponds to the shape and placement of similar rock foundations beyond the standing architecture of the historic building found in the 2006 geophysical survey and excavations (Roop and Wick 2008; Somers 2008).

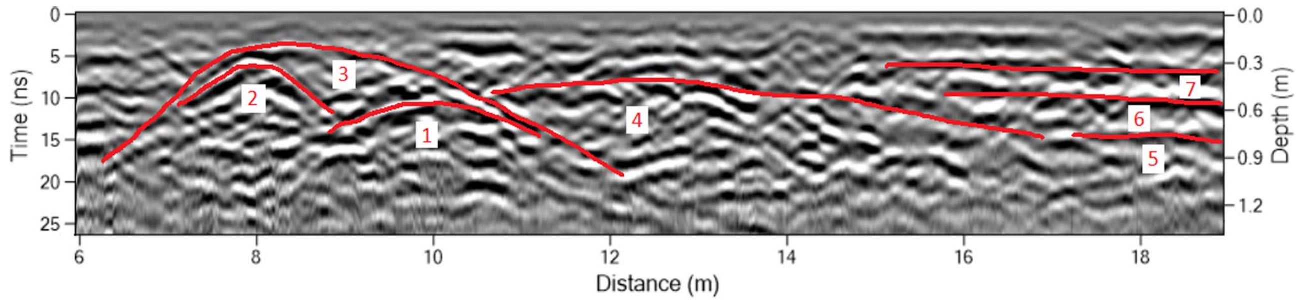

FIGURE 2. GPR Profile at 9.0 m E within a 10 m grid at the Point Reyes site with guidelines overlying horizontal reflections that represent layers of stratigraphy or different episodes of site deposition. Also note that components 1–4, which constitute intact midden soil, extend for about 12 m in the profile. This profile is positioned toward the end of the mound, and intact midden soils here are less extensive than those in the middle of the mound represented in Figure 1.

The GPR profile in Figure 4 represents a section of data marked in Figure 3 by a white line. From 5.5 to 12.5 m of this profile, there is a continuous rock foundation, or footing, that separates two compartments of what would have been an adobe building above. These high-amplitude features representing the rock foundation begin at approximately 15 cm in the GPR data and continue to variable depths (30 cm of depth at 6 m E, 50 cm of depth at 8 m E, etc.). Figure 5 represents the profile 25 cm to the north of and parallel to the one in Figure 4. This profile shows what the rock foundations look like in cross section. There are the two outer wall foundations that run perpendicular to the compartment wall foundation in Figure 4.

Roop and Wick (2008:156) report that the rock foundation or footings they excavated in the southern portion of the Carrillo Adobe were approximately 17–30 cm. Their excavation units were located to the southeast of this GPR survey, and they confirmed the location of features identified by the previous magnetometry and electrical resistivity survey. The starting depths of the rock foundations from excavation and these GPR profiles align very well; however, there may be some variation in the termination of these features where the GPR survey was conducted.

Although the adobe had been surveyed with other geophysical equipment, there were still some voids in the previous magnetometry and electrical resistivity surveys where the GPR was able to detect more of the general shape of these rock foundations and, in some cases, with better resolution. As these results highlight, it is never too redundant to resurvey with different types of geophysical equipment, with different settings, or even in different seasons if the instruments are affected by local conditions such as water content in the soil, which is the case with GPR (Conyers 2012:34–40).

DO WE NEED SHOVELS TO BE ARCHAEOLOGISTS?

As the examples from Point Reyes and the Carrillo Adobe illustrate, GPR data can offer a tremendous amount of information about tribal cultural heritage and archaeological sites. Although other complementary datasets are useful in interpreting these data, the analysis of GPR data independent of other datasets in each of these projects could provide information about the depth, extent, composition, and integrity of these sites with a high degree of confidence and reliability. These are the components that constitute cultural resource assessments in compliance archaeology, and they could be compiled independently of any impact to one of these sites. Other scholars have also found that GPR data can and should provide broader interpretations of overall site patterns rather than be reduced to feature finders that only produce targets for the "real" archaeology or excavation to immediately follow (Conyers 2012; Sunseri and Byram 2017).

Of course, there will always be a place for archaeological excavation and subsurface testing in extreme compliance situations where no other method or course of action would be effective, and descendant communities support the use of these methods. GPR and other geophysical techniques, however, can offer communities a middle ground for participating in research and prospection that is low impact or noninvasive, shifting from mitigation strategies that favor the values and methods of archaeologists to those that are community driven. In cases where tribes choose geophysics as the mitigation strategy rather than excavation, archaeologists may see this as a loss of data and knowledge. Any impact to sites, however, could constitute a loss of knowledge that is not recoverable for Native American peoples through archaeology, and the incarceration of ancestral materials in museums after projects are completed could cause even more distress and harm to the community as a whole. Therefore, it is the most ethical course of action and still scientifically rigorous to start from the position that the least invasive method—such as geophysics, remote sensing, and surface-level mapping—should be standard operating procedure for data collection, adding more invasive methods as needed and appropriate.

"LIMITATIONS" OF GPR AND SKEPTICISM IN THE CRM INDUSTRY ABOUT ADOPTING THESE TECHNOLOGIES

Geophysical survey completed in collaborative or community-based projects with tribes, universities, and agency partners has grown substantially, so it might seem that an increase of this same kind of work in compliance archaeology should follow. However, the CRM industry has been slow to adopt geophysical technologies in California. I have listened to plenty of my compliance colleagues' complaints about having tried GPR and how the

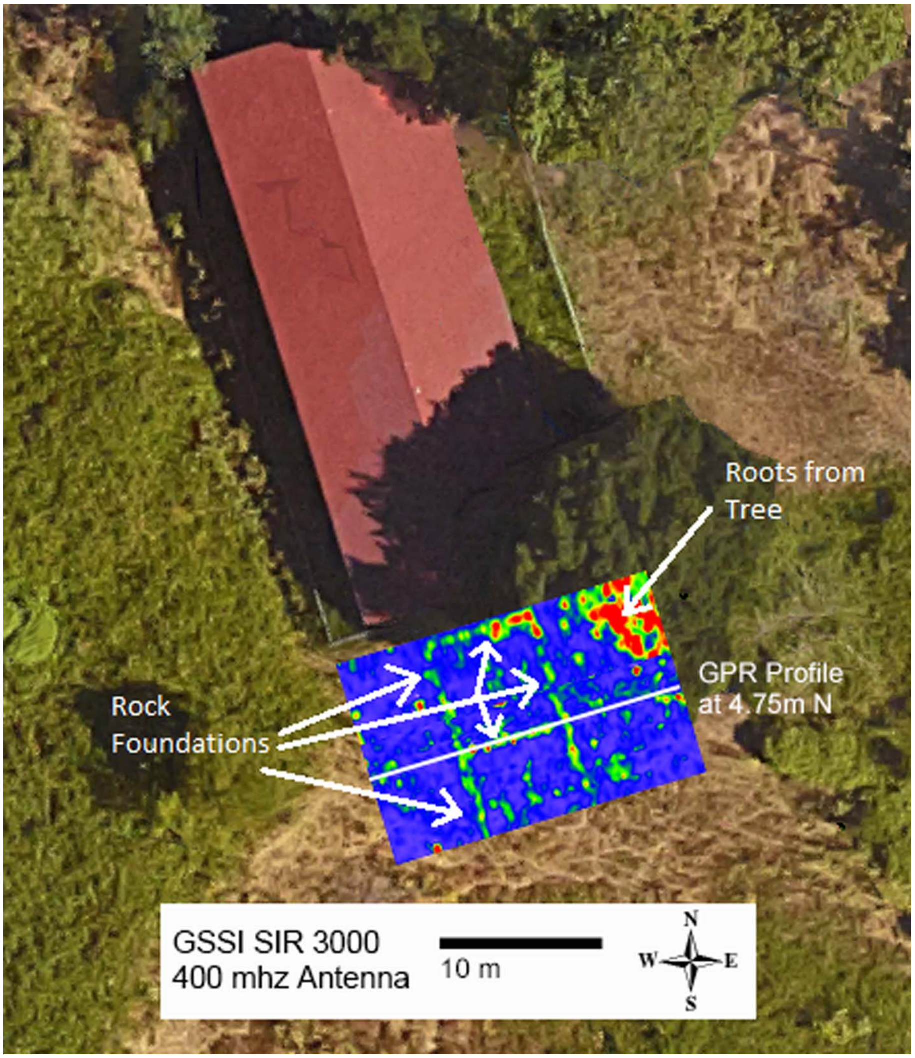

FIGURE 3. Plan view of GPR data overlain on top of satellite imagery from a field survey at the Carrillo Adobe, located in Santa Rosa, California. The reddish roof in the satellite image is a modern protective structure built around the standing remnants of historic adobe walls. This structure follows the same alignment as the standing historic adobe walls and the subsurface rock foundations identified in the GPR data shown here in plan view.

technology did not "work." Rephrasing this statement in a more constructive way, such as "how and in what contexts different geophysical techniques can prove most efficient and successful for the goals of each kind of project," I would argue that geophysics always "works." These techniques provide useful data, even if the findings are negative for cultural materials when "ground truthed" or if the data produced did not address any of the goals of the current project. Negative findings are commonplace in compliance archaeology in shovel test pits and broad-scale pedestrian surveys, so why should negative findings in geophysics be any more reason to dismiss this technology in favor of the excavation unit? Every time geophysical surveys are conducted, in the same way that every level of a shovel test pit or auger is excavated, something is revealed about the soil and geology of an area—although I would argue that GPR has the upper hand in the sense that no ground disturbance was necessary in the initial stages of research through geophysical prospection. In sum, GPR deserves its place in the standard archaeological tool kit, and like any archaeological technique in that tool kit, GPR has to be used and evaluated appropriately for what it can be expected to accomplish, not dismissed as though it is wholly ineffectual.

Another pervasive misconception about geophysical technologies among some of my compliance archaeology colleagues is that GPR is time consuming and that in order to interpret the data with any level of confidence, the features have to be "ground truthed" or excavated anyway to physically confirm what they are. So, why not just save the time and money by excavating units rather than fiddling with an extra survey? First, GPR has the capacity to produce a full coverage map of an entire site, whereas shovel test pits and excavation units only provide small samples of the entire site. And although there are many reflections in every GPR profile that will remain uninterpretable aside from an abstract description

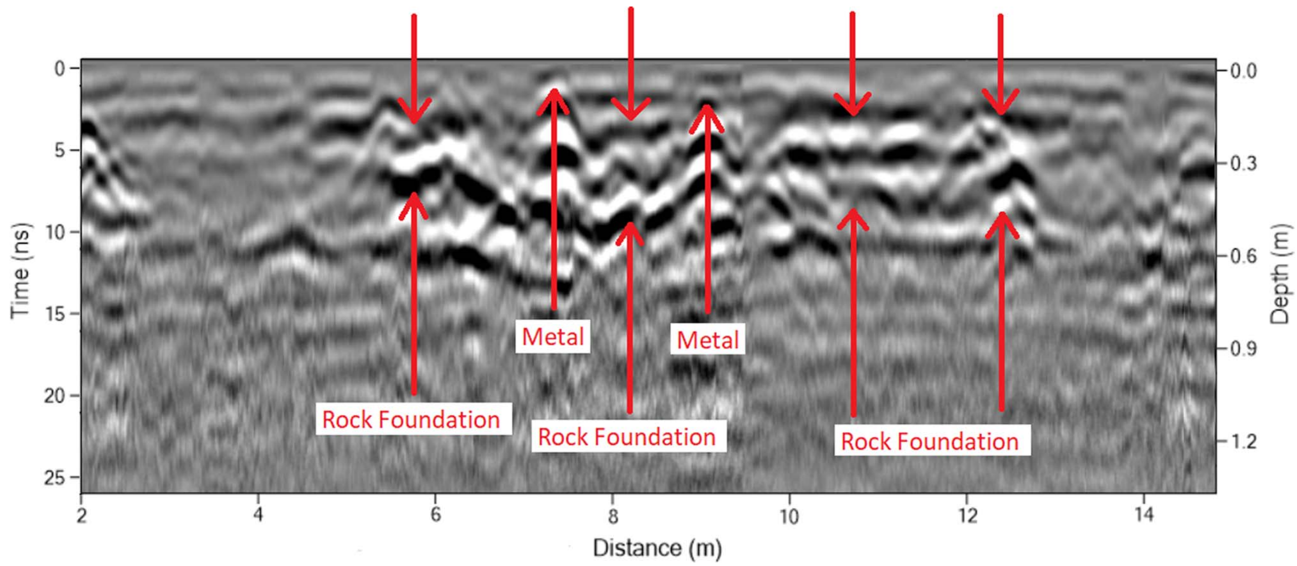

FIGURE 4. GPR profile at 4.75 m N in the GPR grid displayed in Figure 3 at the Carrillo Adobe. Features, most notably a rock foundation of the adobe, are labeled in red. The profile is parallel to the foundation reflections, which are continuous from approximately 5.5 m to 12.5 m in the profile.

such as "point reflection" or "horizontal reflection," there are also many features that can be interpreted based on previous studies in similar conditions and/or controlled nonarchaeological testing and simulation. In the two examples presented from Point Reyes and the Carrillo Adobe, features were identified that constituted the major components of these sites, and their depth and extent was accurately estimated by the process of velocity analysis and hyperbola fitting. For a more in-depth discussion of velocity analysis and simulations see Conyers (2004, 2012), Conyers and Goodman (1997), and Conyers and Lucius (1996). These components of GPR data offer plenty of information for compliance evaluations of site integrity, as in the Point Reyes example showing intact stratigraphy within the midden and layers of disturbed erosion from grazing cattle. And the determinations about these components of sites can be made with good confidence without the need to put a shovel to the ground and disturb these sites more.

There are some legitimate limitations to geophysical technologies, including GPR, that are worth noting, which may also impact their standard adoption by the CRM industry. They are very expensive, and they require specialized training and experience to operate, process, and interpret data, which is a major investment, especially for small companies. This cost does not preclude the possibility of renting equipment or contracting with an freelance scholar who has the expertise to operate the equipment and/or interpret the data. GPR data can also be obscured by different ambient radio or cell-phone frequencies with some antennas, making urban compliance GPR extremely difficult. Also, certain types of soils, saturation or salt water infiltration, and subsurface objects and infrastructure such as metal and conduit lines are not conducive to GPR data collection (Conyers 2012). That being said, it is always worth trying some amount of survey even when predictions foretell that the conditions are not ideal for GPR. This is because some amount of data can usually be recovered in nonideal settings, and some of these situations may in fact be perfectly reasonable for achieving project goals and objectives with GPR (Conyers 2012:98).

CONCLUSION: GPR AND A MORE COMMUNITY-DRIVEN COMPLIANCE ARCHAEOLOGY

In Central California, geophysical technology is bridging the gap between strategies used in collaborative or community-driven archaeology and compliance or government-mandated cultural resource management because of its ability to assess the depth, extent, and composition of sites noninvasively. This has been especially important for tribes that value an ethic of avoidance as the primary strategy for managing tribal cultural heritage. Both projects described here are examples of community-driven compliance facilitated by GPR. The first example, at Point Reyes National Seashore, represents creative use of GPR survey to gather information noninvasively about resources being impacted by climate change and coastal erosion, which is the compliance responsibility of the National Park Service and FIGR working in partnership. The second example highlights a community-driven response to development threatening the Carrillo Adobe by the Santa Rosa Historical Society and individuals from the Native American community and the general public. This response involved promoting awareness of this site's significance with lectures and a noninvasive GPR survey in support of the nomination of this site to the National Register of Historic Places, strengthening a case for preserving the property in the compliance process.

The implications of these technologies is clear in terms of site stewardship and land management. As was illustrated at both

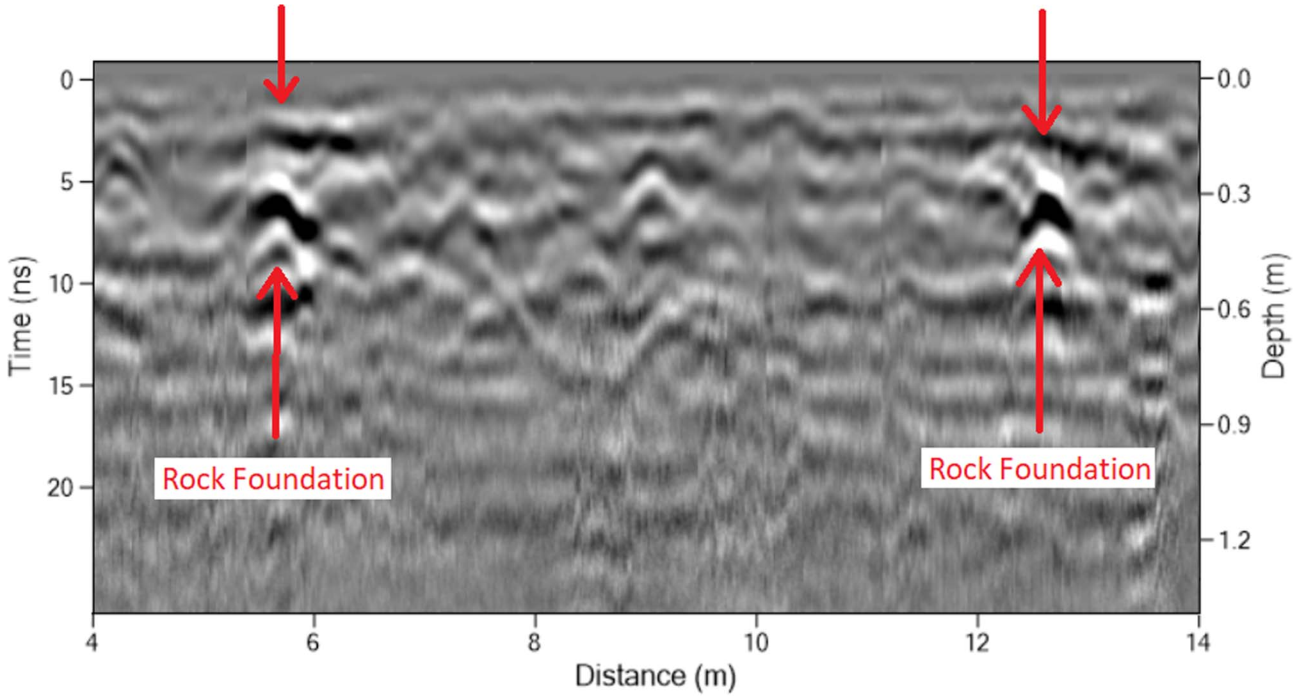

FIGURE 5. GPR profile at 4.50 m N in the GPR grid displayed in Figure 3 at the Carrillo Adobe. This profile shows more rock foundations, labeled with red arrows. This profile is perpendicular to the direction of these foundations, so they appear in cross section with a width of about 50 cm. They appear at approximately 5.5 m and 12.5 m in the profile.

Point Reyes and the Carrillo Adobe, intact, subsurface archaeological features were present. At Point Reyes, the GPR profiles also identified past and ongoing erosion of the sites from grazing cattle that may influence the management of cattle in future NPS grazing plans. The complex site structure and formation processes revealed at the Point Reyes site also have implications for future study. Radiocarbon samples would have to be collected from multiple locations to ensure representation of all components of the midden instead of being collected in a single column from the highest point in the center of the site. The earliest dates for this site may also be located in the disturbed margins of the site that were eroded from the top by cattle. Shell mounds and midden sites in Central California are not perfect half onions that grow up and out from the center. They are complex formations of multiple nodes and threads of activity that weave into one another and that are testaments to the complexities of dwelling within a place and the habitual routines of daily life (Ingold 1993, 2009).

Noninvasive, archaeological geophysics can provide scientifically rigorous information that can be used to determine the physical characteristics of resources without impacting sites by auguring, excavating, or collecting any artifacts. In this way, archaeological geophysics is more inclusive of the values, perspectives, and ethics of different peoples, and it can provide an intersection in these values and a bridge between Native American heritage managers and compliance archaeologists. The deployment of these technologies also recasts Native American tribes and communities as pro-science and shifts the debate from Native Americans versus archaeologists to less invasive research versus more invasive research. Shifting the conversation to a scale and range of values and methods rather than those that are binarily opposed also acknowledges that Indigenous knowledge and science are valid perspectives on the same spectrum as Western science and archaeology perspectives rather than marginalizing Native perspectives as "Other" or subaltern. Thus, GPR allows many more Native American people to access and engage in science and archaeology in culturally appropriate ways and helps reframe the position of Native American cultural resource managers as pro-science even if our ethics, values, and protocols mandate that we not engage in research that is damaging to our cultural heritage. As the industry of compliance archaeology becomes more inclusive of these values, perspectives, and methods as standard and accepts this reframing of the position of Native American peoples as the experts and pro-science knowledge producers in the field, so too will the relationships between Native Americans and archaeologists improve.

Acknowledgments

I would like to acknowledge staff and leaders of the Federated Indians of Graton Rancheria, Gene Buvelot, Lorelle Ross, Buffy McQuillen, and others, for their time meeting with me, NPS, and scholars from UC Berkeley about the project at Point Reyes National Seashore. Their insights over the years have guided how I think about my work, and their review of this manuscript was an essential component of our ongoing collaborative relationship and work in Graton tribal territory. I would like to thank the UC Berkeley-affiliated research team with whom I have worked for many years now on this and other collaborative projects, Kent Lightfoot, Roberta Jewett, Rob Cuthrell, Michael Grone, Nicholas Tripcevich, Scott Byram, and a myriad of undergraduate students. I would also like to thank Nick Tipon, Alex DeGeorgey, and others involved in the Carrillo Adobe Day event who invited me to conduct the GPR survey and speak with the public about this important heritage site in the City of Santa Rosa.

Data Availability Statement

All original data and site location information is retained by the author and the Federated Indians of Graton Rancheria. Some of these data are confidential and restricted at the request of the Federated Indians of Graton Rancheria, and anyone seeking access should contact the Tribal Historic Preservation Office for more information by calling (707) 566-2288, sending an e-mail to thpo@gratonrancheria.com, or sending a physical letter to 6400 Redwood Drive #300, Rohnert Park, CA 94928.

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