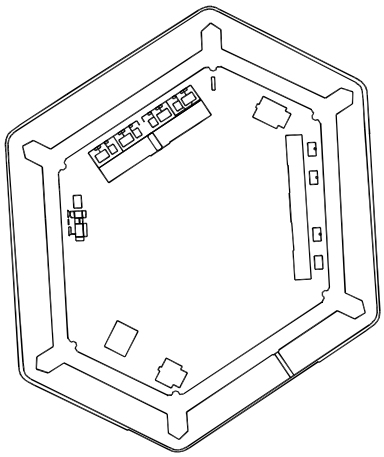
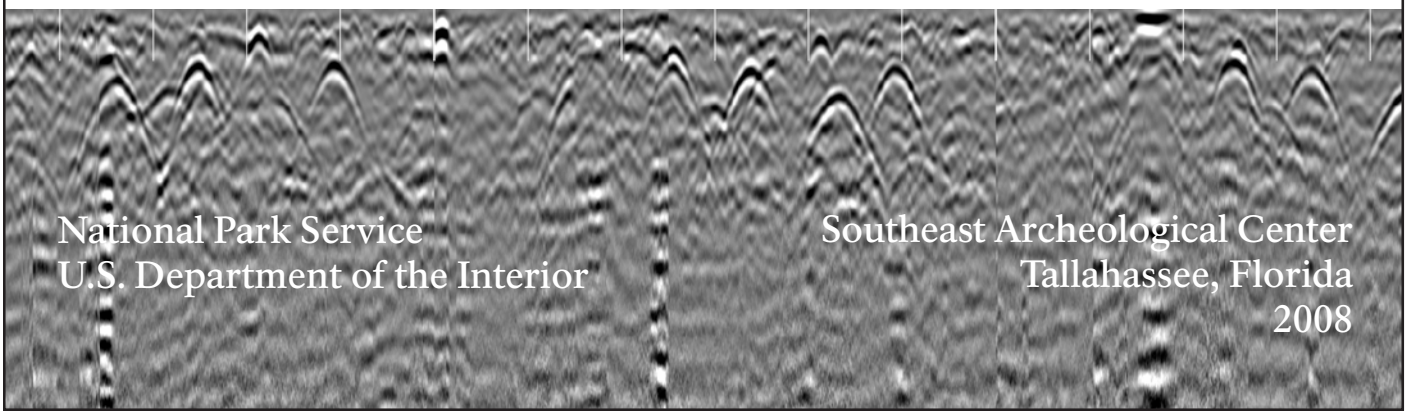
A Geophysical Investigation of the Parade Ground at Fort Jefferson

Dry Tortugas National Park, Florida





National Park Service
U.S. Department of the Interior

Southeast Archeological Center
Tallahassee, Florida
2008

SOUTHEAST ARCHEOLOGICAL CENTER

The Southeast Archeological Center (SEAC) is a support operation of the National Park Service's Southeast Region. In assisting parks with their cultural resource management needs, SEAC facilitates long-term protection of archeological resources and compiles and utilizes the archeological information obtained from these resources. In addition to annually generating numerous archeological reports, as mandated by federal law and park operations, SEAC is the repository for over six million artifacts that make up the Southeast Region's research collections and contribute to its cultural database. SEAC is staffed by professional NPS archeologists and regularly employs archeology students from Florida State University and other anthropology programs throughout the Southeast.

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by

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Management Summary

In December of 2006, the Southeast Archeological Center (SEAC) conducted a ground penetrating radar (GPR) survey at Fort Jefferson in Dry Tortugas National Park (DRTO). The survey was designed to include all open and clear ground surfaces of the fort's parade ground, and a limited area outside the fort's walls in the campground and picnic area. The goal of the project was to identify subsurface historic features that could be imaged using GPR and to provide maps of these features to the park to aid in the management and protection of buried historic fabric at the fort. Just over five acres (20,500 square meters) of Fort Jefferson's parade ground, and 2,450 square meters (.61 acres) of land outside the fort's walls, were surveyed with the GPR. The parade ground survey coverage represents 63.4 percent of the full eight acres of interior space at the fort, but most of the unsurveyed property was covered with existing buildings, ruins, or impenetrable vegetation.

A variety of historic subsurface features no longer visible on the modern ground surface were revealed during the radar investigation. These included relict footpaths and roads, possible privies and/or cisterns, a probable grave, foundation remains of extinct buildings (the original lighthouse and other possible historic structures associated with the lighthouse keeper's home and temporary structures that were in place during the construction of the fort), as well as a number of buried anomalies of unknown origin probably associated with historic refuse dumps. In addition, numerous historic and modern sewage, electrical, and water distribution utilities were identified during the survey.

Prior to initiating the field portion of the radar survey, historic maps drawn during the construction and military occupation of the fort were collected and digitized into a geographic information system (GIS) that was used to predict the locations of, and later to interpret, anomalies identified during the GPR survey. Upon completion of the survey, highly accurate mapping of the fort's interior and exterior was carried out using a global positioning system (GPS) and a total station. The map produced was used to further refine and adjust the original GIS, and provided an accurate base map upon which historic maps of the fort and the results of the GPR survey could be overlaid. The end result is a layered GIS database/map showing accurate locations of extant and relict historic features in real world coordinates that can be referenced on the ground and navigated to using a GPS unit.

This document includes a brief construction history of the surveyed areas at Fort Jefferson, maps and images produced by the GPR survey and GIS exercise, and an archeological interpretation of the data collected during the survey. The electronic data used in the creation of the GIS has also been provided to DRTO on a DVD so that it may be incorporated into the park's resource management database.

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Acknowledgements

Archeological geophysical survey is a tedious process, with little excitement save a few moments in the evening when the results of a day's worth of walking the same area back and forth can finally be viewed on the computer screen. Special thanks are extended to VIP Christopher Wilmott and SEAC archeologist Brian Worthington, my crew of dedicated "cone movers." I would also like to thank Midwest Archeological Center (MWAC) Archeologist and geophysical guru Steve DeVore for taking a week out of his schedule to visit our project and ensure that we were operating our radar unit to its highest potential.

I would also like to thank several staff members of Everglades National Park (EVER), particularly Michael Jester and Ross Hunt, for arranging the purchase of the ground penetrating radar unit. SEAC has wanted to obtain this equipment for some time but has not had the opportunity to do so; the center appreciates the purchase, as will many other Southeast Region Parks who will benefit from future surveys utilizing the GPR unit. Thanks are also extended to Nancy Russell, curator at EVER, for providing the historic images presented in this report. I would also like to thank Melissa Memory, EVER Cultural Resource Manager, for her support during the project and her patience during the preparation of this document.

I would also like to express gratitude to Jim Pomfret, Georgia Department of Transportation Archeologist (GDOT), for his guidance during the data processing phase of this project, and for so freely sharing his hints and data files for coaxing attractive images out of the GPR data.

Lastly, I would like to thank John E. Ehrenhard, former Director of the Southeast Archeological Center, and Dr. Bennie Keel, current Director and Southeast Regional Archeologist, for allowing me to conduct this project and prepare this document. I also thank the following archeologists who reviewed drafts of this report: Ariana S. Lawson; John E. Cornelison, Section 106 Compliance Coordinator, SEAC; and Dr. George S. Smith, Associate Director, Investigation and Evaluation Division, SEAC; Steve DeVore, Archeologist, MWAC; Jim Pomfret, GDOT; and Robert Nickel, retired MWAC Archeologist.

Chapter 1
Introduction

In December of 2006, the Southeast Archeological Center (SEAC) conducted a ground penetrating radar (GPR) survey at Fort Jefferson National Monument in the Dry Tortugas National Park (DRTO) (Figure 1). DRTO arranged for the survey in order to identify the location of subsurface historic fabric in the parade ground of the fort. The park wished to inventory any such archeological features to facilitate their proper management and avoid future impacts to them associated with routine maintenance and stabilization projects at the fort. The park was also interested in identifying the locations of historic and modern utilities whose locations were generally known, but not specifically identified on any maps.

A total of 41 grids of various sizes (ranging from 40-by-40 meters to 3-by-21 meters) were established to collect the radar data (Figure 2). Thirty-six grids were located in the parade ground of the fort, four were placed in the campground and picnic area outside the fort's sally port entrance, and one grid was placed inside the first tier construction above the buried cisterns west of the park's office space. The GPR data were collected using a Geophysical Survey Systems, Inc. (GSSI) model SIR-3000 unit with a 400 MHz antennae. Radar data was collected in several series of parallel linear transects that were combined to build grids which were then digitally processed as individual units for visual display. In all of the grids, except the one placed in the first tier, transects were spaced one half meter apart. Transect spacing in the first tier grid was one quarter meter. The data were processed using Radan software, developed by GSSI for use with the SIR-3000. Using Radan, each grid was subjected to a series of post processing steps intended to improve feature resolution, remove background noise, and accurately identify feature depth and size. The grids were then combined into larger units to aid in the identification of anomalies that stretched across multiple survey grids. The data was then exported to the contour mapping software Surfer, in which additional refinement could be made to further resolve some features.

Following completion of the survey, a total station and a global positioning unit (GPS) were used to create a detailed map of the project area grid, as well as the locations of ruins, existing buildings, existing vegetation and tree stumps, existing walkways, the fort walls, the seawall, and any other above ground features (including all of the utility boxes and covers) inside the fort or in the campground and picnic area. This map was later used as the base for a geographic information system (GIS) that included the results of the GPR survey and superimposed nineteenth century maps of the fort displaying the locations of previously existing structures and features in the parade ground and what is now the picnic area and campground at the fort.

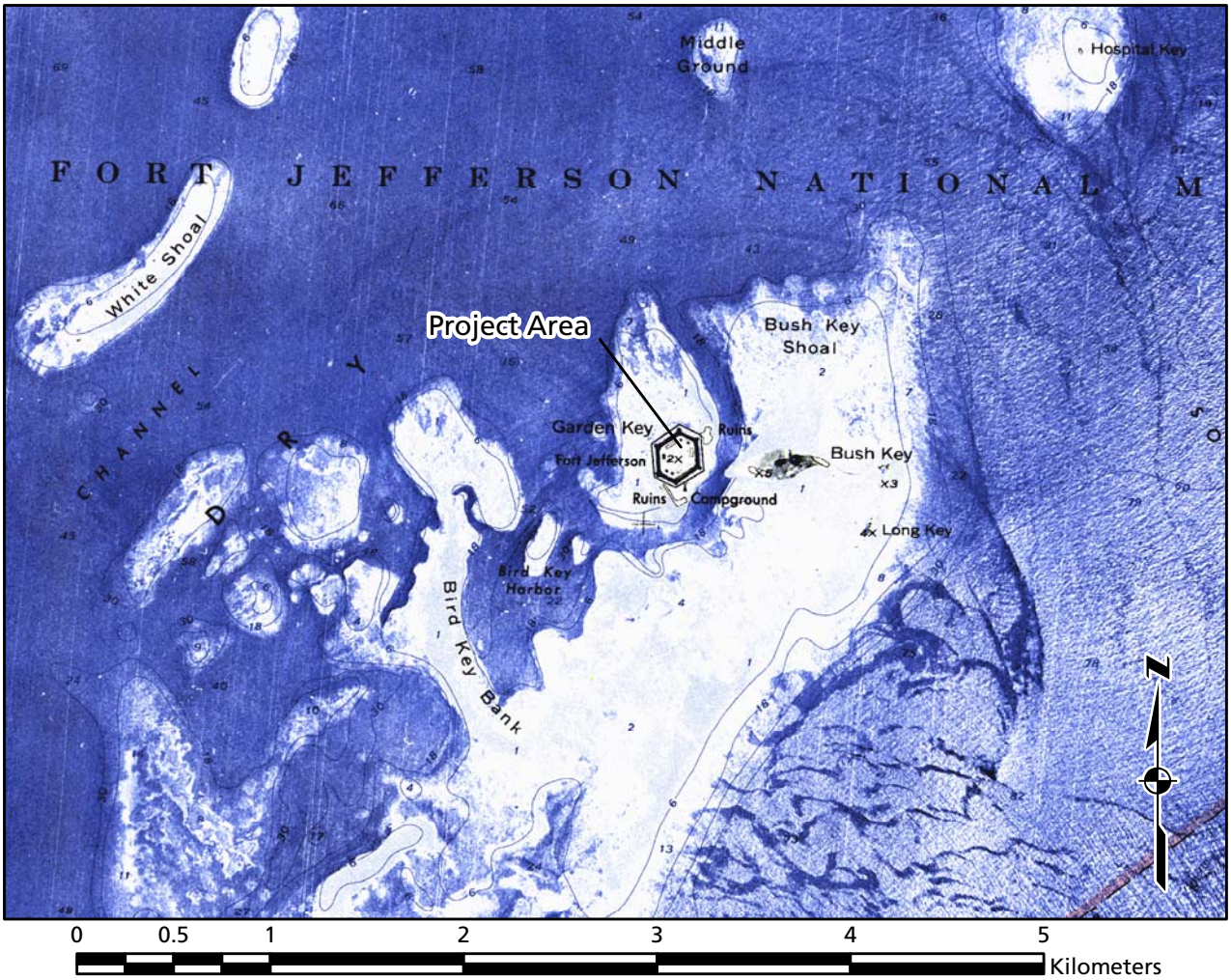

Figure 1. The location of Fort Jefferson, in the Dry Tortugas National Park, approximately 70 miles west of Key West, FL.

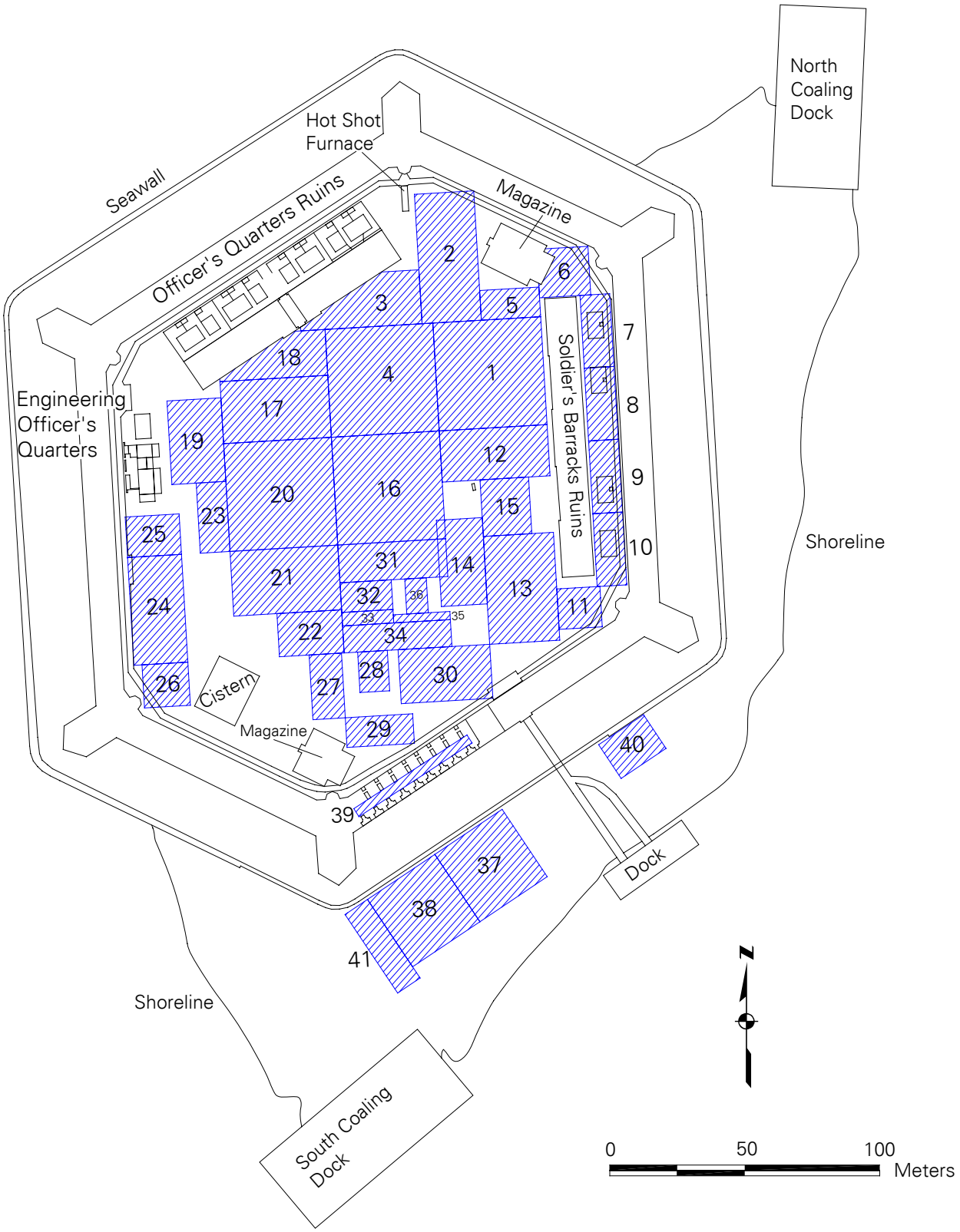

Figure 2. The project area at Fort Jefferson. The locations of the 41 GPR grids from which data was collected are highlighted in blue.

Chapter 2
A Brief Construction History of Fort Jefferson's Parade Ground

The Dry Tortugas National Park (DRTO) manages just over 100 square miles of property, including the seven small islands that make up the Dry Tortugas, the westernmost section of the Florida Keys. One of the islands, Garden Key, is home to Fort Jefferson, the largest masonry structure in the Western Hemisphere. The fort is a six-bastioned elongated hexagon made of brick, coral and cement concrete, and stone, and was constructed between the years of 1846 and 1875. The fort was never completed and was abandoned by the U.S. Army in 1875 because similar masonry forts had been found obsolete; they could not stand up to powerful rifled cannons developed during the Civil War.

The construction of Fort Jefferson began during the height of a coastal defense strategy known as the Third System (1816-1867). Earlier American forts of the First System (1794-1807) were usually earthworks with limited wood and masonry components; these forts were abandoned after tensions with Europe subsided following the Revolutionary War. During the buildup to the War of 1812, the Second System forts were constructed; these too began as earthworks but incorporated increasingly more masonry components as the war neared. After the War of 1812, and the burning of the capitol, Congress and the President became convinced of the need for a strong coastal defense system. A board of military engineers was established to propose, design, and lobby Congress to fund the construction of a number of large masonry forts along the eastern coast of the United States (Reid 2006). Fort Jefferson was to be the largest of these construction projects, and a personal project of Fortification Board member Brevet Lieutenant Colonel Joseph Gilbert Totten, whose influence with Congress proved so persuasive that funding for construction activities at Fort Jefferson continued nearly ten years after both Totten's death and the realization of the obsolescence of masonry forts.

The U.S. military's earliest experience in the Dry Tortugas came in 1824, when U.S. Navy Commodore David Porter inspected the Dry Tortugas islands. Porter was the commander of a naval squadron assigned the task of removing the threat of piracy from the Caribbean. He was unimpressed with conditions on the islands and reported that they were not suitable for fortifications of any kind. Nevertheless, in 1822, Congress had already approved funding for the construction of a brick lighthouse and keeper's residence on Garden Key. These buildings were completed in 1825 and represent the first permanent structures built in the Dry Tortugas (Vinson 1992). Neither structure exists today, but the lighthouse was present and operational inside the fort until 1876 when it was damaged by a hurricane and replaced with the iron harbor light now standing on Bastion 6. The lighthouse and keeper's quarters were the property of the Department of the Treasury's Lighthouse Board. Army engineers were forbidden to interfere with the operation of the lighthouse during the construction of the fort and were ordered to fence the property to avoid damaging it (Bearss 1983). The original keeper's residence was present until 1872, after which it was replaced by a new structure that burned in 1912.

In October of 1829, the U.S. sloop of war *Florida* made a stop at Garden Key and Lieutenant Josiah Tatnall spent several days preparing a detailed description of the landmass and harbors of the Tortugas. He reported that the harbors were ideal for securing ships of all types and the island land was ideal for supporting military fortifications (Vinson 1992).

He also reported that the location of the Tortugas would offer an advantageous position for protecting and controlling commerce and U.S. military interests in the Gulf of Mexico. Tratnall's report set into motion what would eventually culminate in the onset of Fort Jefferson's construction in 1846.

In the 17 intervening years between Tratnall's report and the onset of construction, plans evolved from the planned construction of several small batteries on each of the stable islands in the Dry Tortugas into the large single fortress design we see today on Garden Key. The plans for the fort were finalized and approved in November of 1846. The fort was to be a "hexangular casemated work, elongated, but symmetrical having four sides of 467.88 feet and two shorter sides (which are opposite each other) of 324.88 feet each" (Vinson 1992:42-43). Each of the hexagon's angles were set at 120 degrees and would contain a tower bastion. The plans also called for a three-story construction including, from the top, a fully armed terreplain under which would be two tiers of casemates oriented perpendicular to the scarp (outer wall) of the fort. Below the first tier of casemates, large cisterns holding drinking water were to be built. A concrete and brick counterscarp was to be constructed around the fort, enclosing a moat. All of these construction plans were eventually at least partially realized, but plans were also in place for the construction of several buildings on the parade ground including five magazines, a bombproof naval storehouse, two blocks of officer's quarters, a commanding officer's residence, a chapel with office space, a hospital, and a barracks building for enlisted soldiers (Figure 3). As detailed in the following pages, some of these structures were built, some were started and never completed, and others were never begun.

Prior to the onset of construction at Garden Key the only two permanent structures on the island were the lighthouse and the keepers quarters, and the only residents were the lighthouse keeper, John Thompson, his family and slaves, and an ever changing group of fishermen and "wreckers." The wreckers made their living off frequent shipwrecks and groundings on the nearby reefs and shoals. This population was augmented in the summer of 1847 when laborers and construction materials began to arrive at the island. The first military buildings on Garden Key were temporary structures erected by September 7, 1847 (Reid 2006) and included a blacksmith shop, lime house, and carpenter's shop on ground that would eventually be inside the fort on the south half of the parade ground; and worker's barracks and a kitchen in the area that would eventually be the beach outside the Sally Port. By the end of September, three more temporary structures were complete; a bakery and storehouse on the future parade ground and a stable on the beach next to the kitchen and barracks (Figure 4). These temporary structures remained on site throughout the construction of the fort (except the storehouse, which burned in 1857 [Vinson 1992] and nearly set aflame a more recently built lumber house [Bearss 1983]). The blacksmith shop and the bakery (along with a paint shop) were removed in 1870 because they had fallen into an irrecoverable state of disrepair. There were also a number of other frame buildings built throughout the 1850s on the sandy land south of the fort including hospitals for the soldiers and workman, a privately run shop, privies for the soldiers and workmen, barracks for soldiers and engineers, and a number of wharfs for receiving material and labor (Figure 5). Historic photographs of the parade ground also show numerous temporary frame sheds throughout the area. Annual reports to Washington written by the supervisory engineer consistently report that the carpenters were at work building and maintaining temporary structures (Bearss 1983), but the documents do not reveal the function of these buildings or which were built at what time. Presumably, temporary frame structures were built on the parade ground as storage sheds and workspaces; sited for convenience during the construction of the individual permanent features of the fort. In the later years of the Army's occupation of the fort, references were made to dilapidated and dirty temporary structures as possible agents of

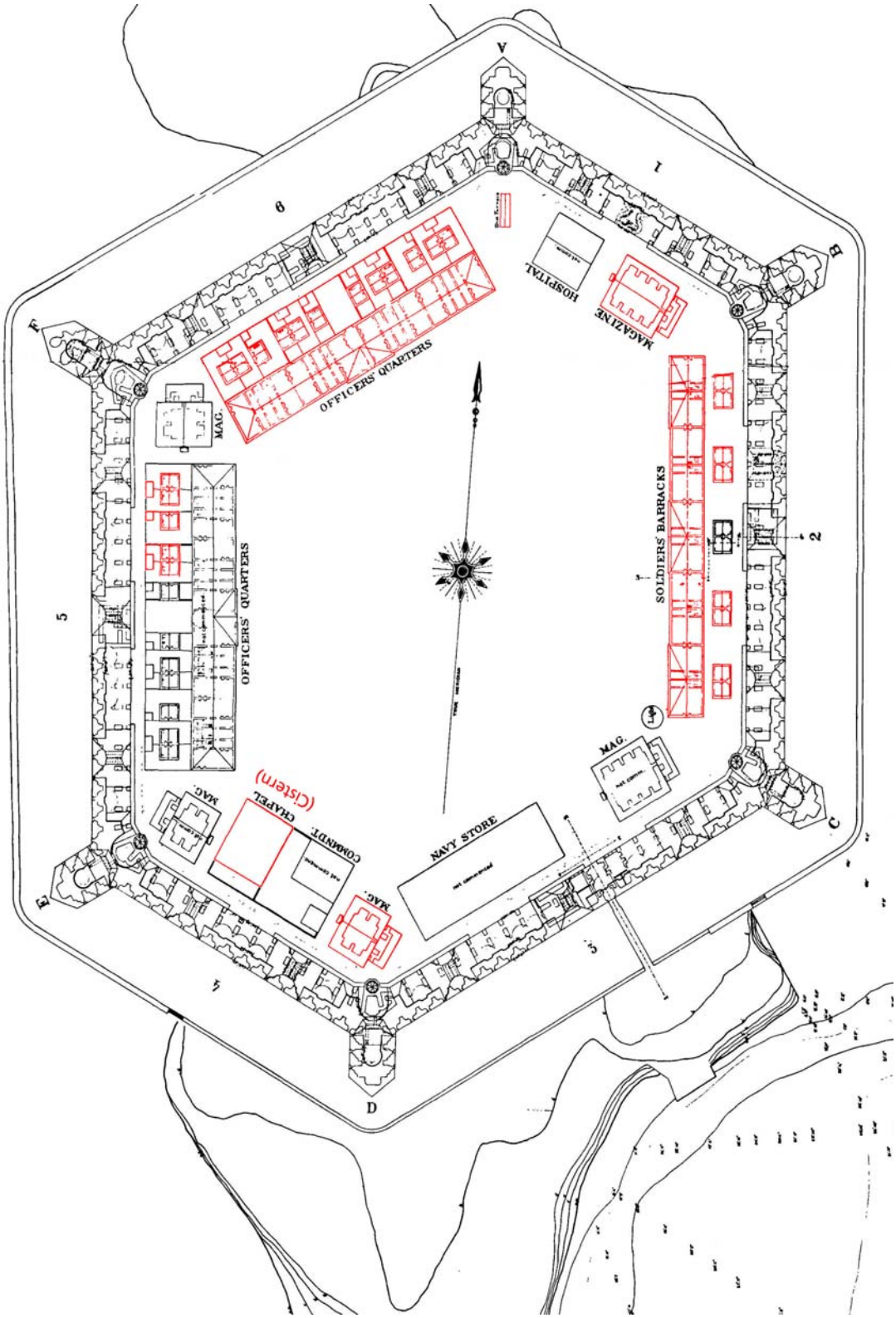

Figure 3. Plans for the parade and first tier of Fort Jefferson, as designed by the Board of Engineers in 1887. These plans are little changed but more detailed than those originally approved in 1846. Structures highlighted in red were eventually constructed on the parade ground.

frequent Yellow Fever outbreaks (Bearss 1983), indicating that these structures remained on site for some time.

With the original temporary structures completed and the workforce in place (initially mostly slaves hired from white owners in Key West and white laborers; later the Army employed civilian carpenters, blacksmiths, machinists, masons, and eventually the resident military prisoner population), work began on the counterscarp seawall and the original officer's quarters. The officer's quarters was the first permanent building erected on the site by the Army, though only a 69-foot section of the structure, located on the east end of what is now the ruins of the officer's quarters and its kitchens, was built. This original portion of the structure and two of its kitchens were completed in 1848, but the foundation of the expanded building we see in ruins today was not laid until 1862. After completing the majority of the counterscarp wall in 1855 (Vinson 1992), efforts focused on raising the six bastions and then the casemated tiers of the fort. Construction activity on the parade ground moved at a slower pace than that of the fort itself, though the grounds were significantly altered by the movement of material for the construction of the bastions and casemates and the addition of vast quantities of fill sand necessary to increase the land mass of Garden Key. Only necessities were built within the parade ground before the fort was brought to its full height. A large concrete cistern for collecting rainwater was placed on the site of the proposed chapel and offices in 1852; it was needed because the temporary wooden cisterns that were brought to the island with the first temporary structures were failing. The surface of the concrete cistern was intended to serve as the foundation of a chapel that was never built. Modernly retrofitted, this cistern is still in use for rainwater collection at the fort today. A second masonry cistern was also installed in 1852 on the east side of the existing officer's quarters, where its ruins can still be seen on the ground surface today. The engineer officer's quarters were completed in 1855 (Bearss 1983). They were originally intended to function as the northern outbuildings of a never built complex comparable to the ruined officer's quarters to their northeast. Instead, this small section was completed and pressed into service as housing to accommodate the engineering officer's need for living space separate from the soldiers and work crews.

By 1862, the fort had reached its full height and had been partially armed in anticipation of capture attempts by Confederate forces (Anderson 1988). The fort was never captured, however, and because it stayed in Union hands construction was able to continue throughout the war. With the majority of the fortifications completed, construction goals shifted to the parade ground and the permanent structures visible today began to take shape. Foundations for the enlisted men's barracks, the officer's quarters, and the two detached magazines were laid in 1862 (Vinson 1992). Construction of the hotshot furnace began in 1861 and was completed in 1862 (Bearss 1983). By 1865, the arched roof of the large magazine in the northeast quadrant of the parade ground was completed and the small magazine was near completion. Construction of the full-sized officer's quarters, the soldier's barracks, and both buildings associated their kitchens and latrines continued throughout the war and after. They were substantially complete by the end of 1874, though neither building was ever completely finished and both were regularly damaged by hurricanes, necessitating reconstruction efforts almost continuously.

In the years following the Civil War, low congressional funding and a series of Yellow Fever outbreaks among the military prisoners and other residents slowed construction efforts at the fort. In 1875, the Army finally abandoned the nearly complete fort and left it's stewardship in the hands of the lighthouse keeper and several caretakers. In 1889, the U.S. Department of the Treasury utilized the fort and Tortugas harbor for the establishment of a quarantine hospital and as a quarantine station for isolating ships before allowing them into U.S. ports. The Spanish American War encouraged the Army to re-occupy the fort in

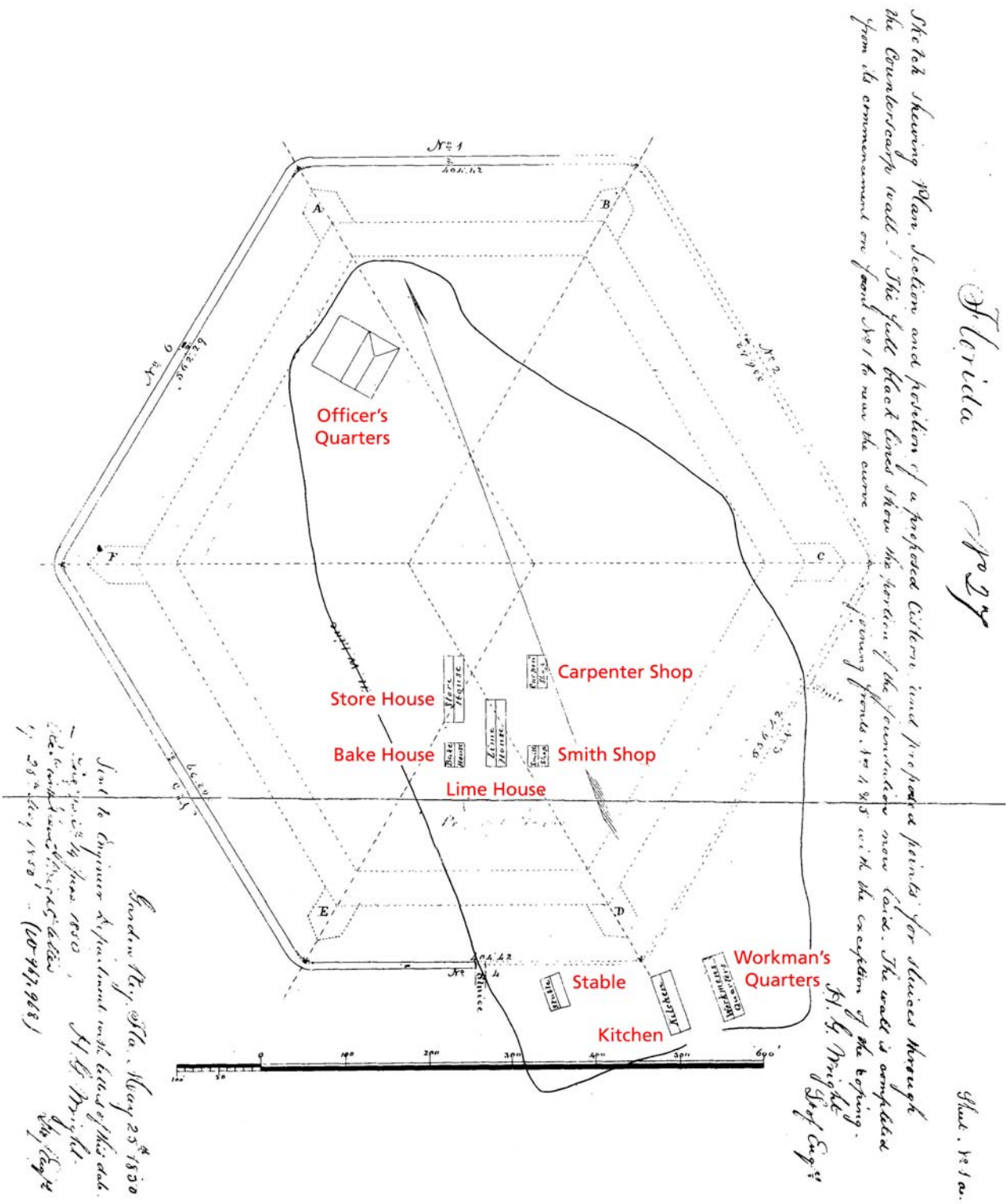

Figure 4. Portion of an 1850 map of Garden Key showing completed and pending construction and the location of temporary structures (labeled in red) at Fort Jefferson.

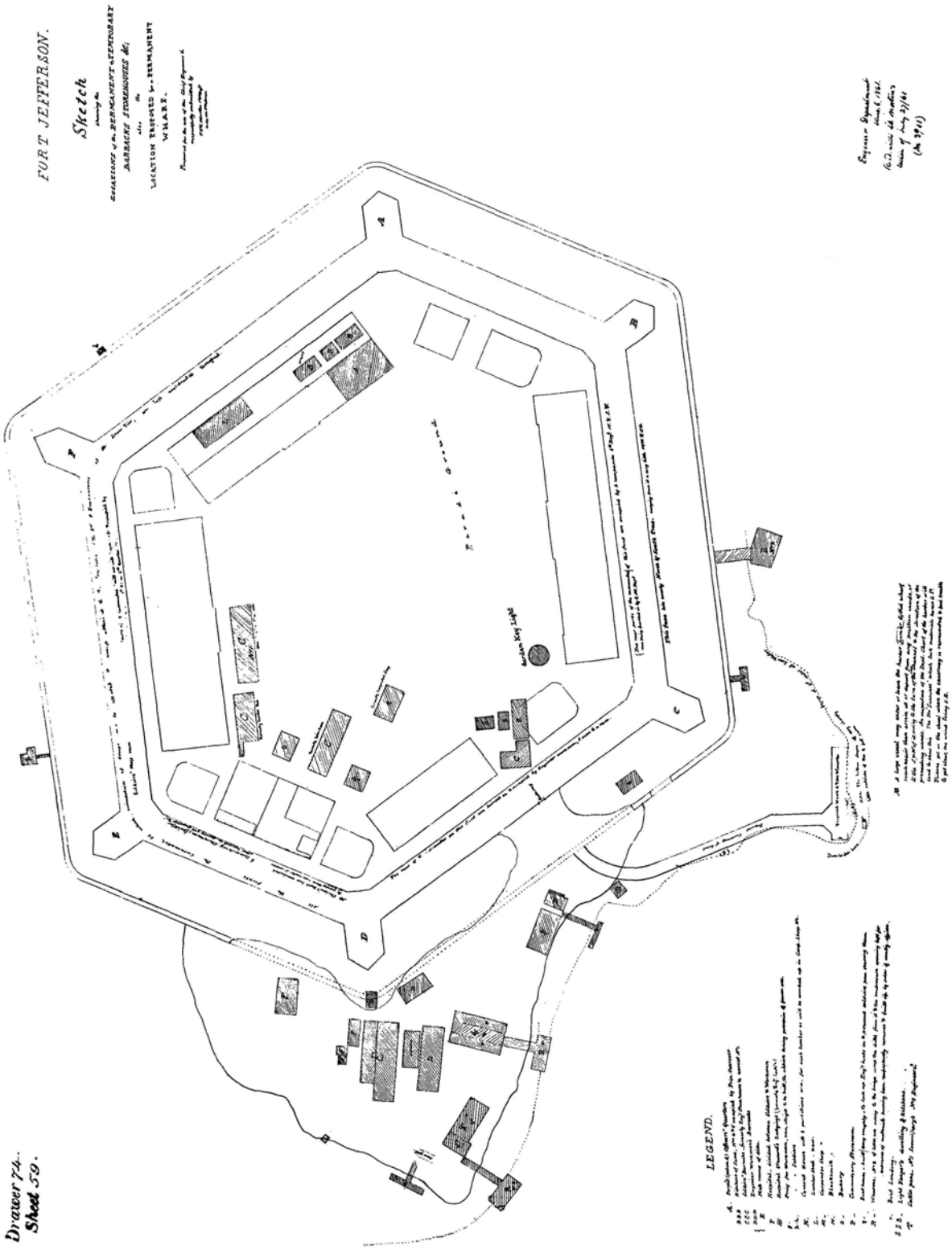

Figure 5. Map of Garden Key conditions in 1861. It shows the then current state of construction efforts at the fort as well as the planned locations of permanent structures and existing temporary structures (including the original lighthouse keeper's quarters) at the fort in 1861.

1898 and to lay a submarine telegraph cable from Key West to Garden Key in 1899. In 1900, the fort was formally turned over to the Navy who then proceeded to dredge the harbor and install a large coal refueling station outside the walls of the fort. Use as a coaling station continued until 1908, at which time the Tortugas reservation was turned over to the Department of Agriculture for use as a bird preserve. In 1910, a hurricane destroyed what was left of the coaling station and damaged buildings on the fort's parade ground. In 1912, fire destroyed the lighthouse keeper's residence and the interior of the enlisted men's barracks, and in 1927 the interior of the officer's quarters also burned (Bethel 1979). After 1918, and until the fort was declared a National Monument in 1935, it was mostly neglected. The National Park Service assumed management of the fort in 1935 and over the next 70 years made modifications and additions to the fort's water, electrical, sewer, and communications systems; and retrofitted several of the casemates to serve as visitor service areas, residences for park staff, and facilities management workspaces. The burned ruins of the officer's quarters and soldier's barracks were razed to their foundations in 1962 out of concern for safety.

Chapter 3
Historic Map Analysis

Archeological geophysical survey is most productive when a combination of factors are in place. First, it is important to recognize what types of features may be buried in a project area and to determine a plan for recognizing these features within the noise generated from the natural geology of a site. Second, ground-truthing excavation following a survey can help to identify unexplained anomalies and confirm the identity of those that match expected patterns for the predicted archeological features. Ground-truthing can also provide additional information about a site that can guide recalibration of geophysical instruments, or modification of a survey technique, so that a re-survey of the project area may provide a more detailed picture of the subsurface. Unfortunately, excavation was not an option during this project so special attention was given to predicting the types of features that may be present in Fort Jefferson's parade ground prior to the start of the survey.

Using the Denver Service Center's electronic Technical Information Center (eTIC) and the DRTO archives at Everglades National Park (EVER), a collection of historic maps and photographs of Fort Jefferson in various stages of construction were obtained for examination. Maps included those drawn as early as 1849, displaying proposed locations for the fort and interior structures, and as late as the 1960s showing modifications made by the NPS. Further scrutiny was applied to any map that showed the location of temporary structures during the construction era between 1849 and 1875. Historic photographs of the parade ground were examined for evidence of extinct structures, footpaths, gardens, and smaller features that may not have been considered important enough to put on the official maps. Many of the photographs obtained were taken after 1875 because of the Army's prohibition on photography inside the Third System forts under construction (Bearss 1983).

The historic maps obtained from eTIC were either downloaded as .tiff (tag image file format) files or were converted to such so that they could be imported into a GIS. A modern USGS map showing the location of the fort was used as a base map and the historic images were stretched over the map using the locations of the bastion corners as reference points between the modern and historic maps. This is a process known as geo-rectification and allows a historic map to be scaled, positioned, and oriented to a modern map so that the location of relict features on the older map can be referenced on the new map. The rectified maps were then examined and the general locations of extinct structures and features were noted so that they could be sought in the GPR data during the survey. Features that were identified on the maps which were hoped to be relocated during the survey included: 1) remains of the temporary buildings (lime house, blacksmith shop, carpenter's shop, log barn, storehouse, and bake house); 2) the original lighthouse, keeper's quarters house and outbuildings, the second keeper's quarters home and outbuildings, and the Italy grave (belonging to the wife of one of the lighthouse keepers); and 3) evidence of the original distribution routes for construction material. Upon completion of the survey, and after a detailed map of the project area was constructed using GPS and total station data, the historic maps were re-rectified using the more accurate project map. These maps were then used to help interpret the final results of the GPR survey. The final rectified maps and modern feature shapefiles are provided in a digital format in Appendix 1.

The Temporary Structures

Several maps were drawn in the early years of construction at Fort Jefferson that show both the progress of construction of the permanent features of the fort and the locations of temporary wooden frame buildings. The original temporary buildings show up on the early maps because they were specifically requested by the military engineers and constructed at government expense. Later temporary structures were put up as needed and were not subject to oversight; therefore they usually did not appear in the project engineer's maps that were prepared to document progress to Washington. The earliest map of Garden Key showing the locations of the original frame structures built was drawn on July 24, 1848 (10 months after the structures were built) (Figure 6). This map shows the existing temporary structures, the original lighthouse and lighthouse keeper's quarters, as well as all of the proposed construction at the fort. The map also shows the extent of Garden Key's 1848 land mass at mean high and low tides.

As work progressed on the island more maps were drawn showing progress and future plans. An 1851 map displays a clearer view of the original temporary structures, as well as the location of the first permanent part of the fort, the east end of the officer's quarters (Figure 7). The map also shows Garden Key's 1851 high tide line and the extent of progress on the counterscarp wall. Figure 8 shows the construction progress up to 1854. The temporary structures are still present and so is the original lighthouse keeper's quarters, but changes since 1851 include the construction of the masonry parade ground cisterns (in 1852) and the addition of massive amounts of sand that raised the parade ground and increased the overall size of the island. In 1861, the last map displaying locations of temporary structures was drawn (Figure 9). It shows all of the frame buildings that were present on the island in 1861 and includes all of the original temporary structures except the storehouse, which burned in 1857. Two new frame buildings replaced the storehouse on the parade ground and additional outbuildings are also shown in association with the original lighthouse keeper's quarters (these may represent new structures or they may have not been included on the earlier maps because the keeper's quarters was pre-existing on the island and not an Army construction). The 1861 map also shows significant growth of the camp outside the fort, indicative of the increased labor force and amplified construction efforts in the years leading up to the Civil War.

The Lighthouse Station

The first structures built on Garden Key, the original lighthouse and keeper's residence, were constructed in 1825 and remained present on the island throughout the construction of the fort. The original lighthouse was a masonry tower that stood just off the southwest corner of the ruined soldier's barracks. It was damaged in 1876 by a hurricane and was then removed and replaced with the iron harbor light present today above Bastion 6. The original keeper's residence was a frame structure that was not the property nor the responsibility of the U.S. Army, but nevertheless showed up occasionally on the construction maps of the fort (see Figure 6, Figure 8, and Figure 9). The building was a two story frame house that was fenced by the Army to protect it from construction activities. It was located only a few meters to the northeast of the sally port entrance to the fort (Figure 10). According to the 1861 conditions map of the fort (Figure 9) the original residence was associated with at least three outbuildings located immediately to its north. In 1872 a new wooden frame keeper's residence was built slightly closer to the original lighthouse and further from the entrance to the fort. The new structure was larger, had full covered porches and was associated with a chicken house, a privy and a circular brick cistern (Figure 11 and Figure 12). The 1872 structure was removed after it burned in a fire in 1912.

Associated with the lighthouse station is the one grave known to exist on the parade ground of Fort Jefferson. The "Italy" grave is believed to be the resting place of the wife of one of the last lighthouse keepers before the harbor light was

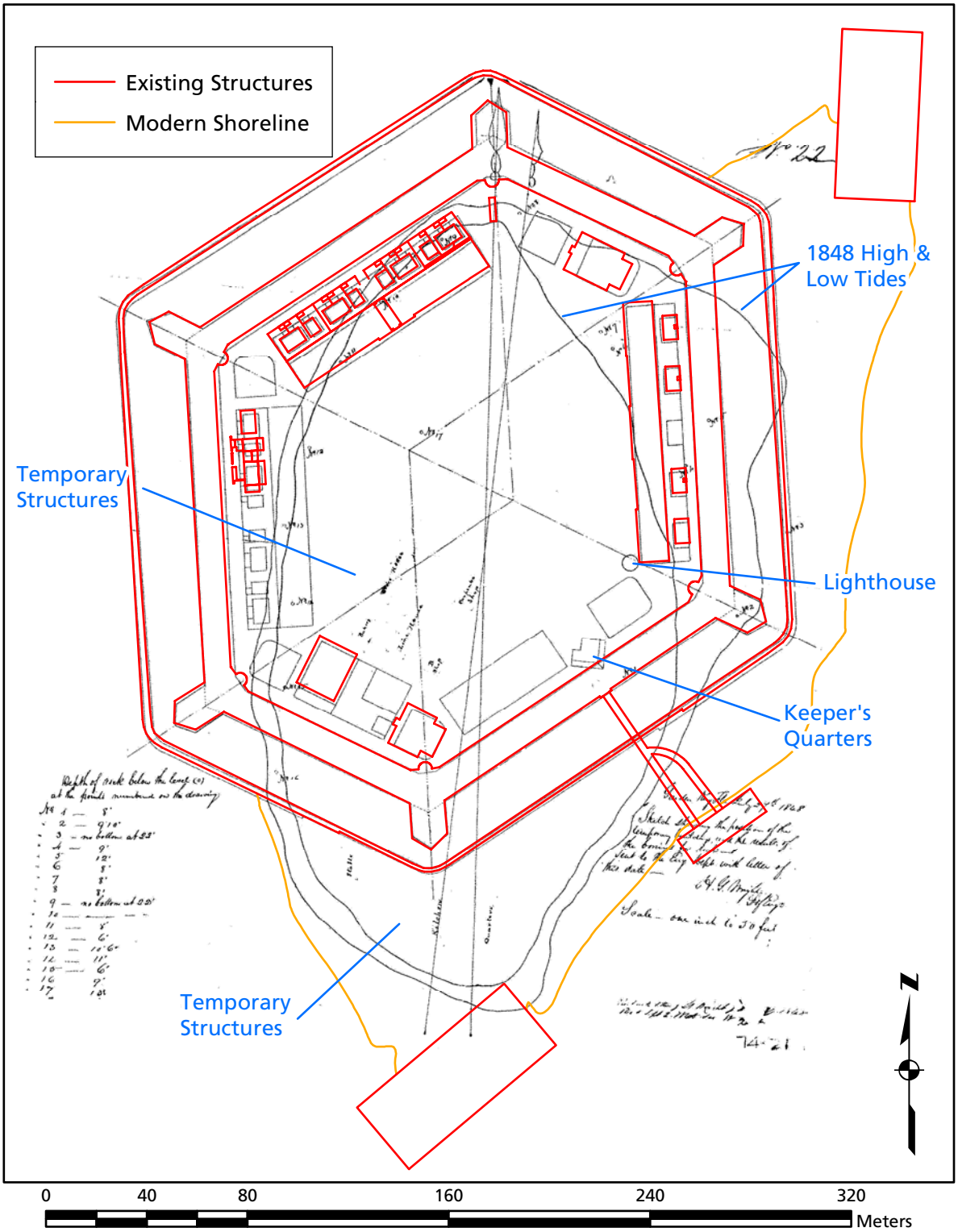

Figure 6. July, 1848 conditions on Garden Key. Showing the first temporary structures built on the island, the original lighthouse and keeper's quarters, mean high and low tides, and proposed construction not yet initiated. The historic map is displayed in association with the modern shoreline and currently existing features at the fort.

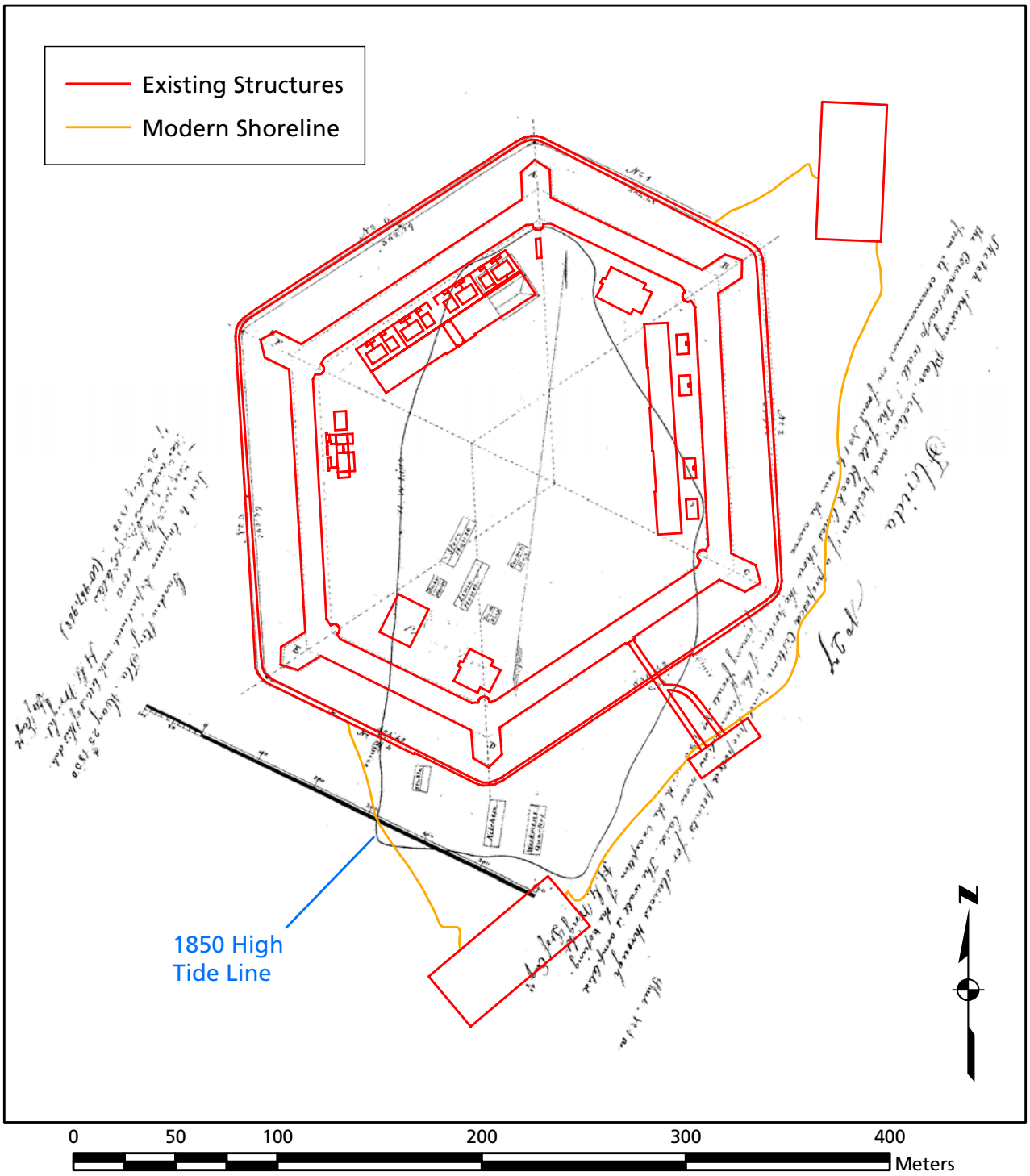

Figure 7. Geo-rectified version of a map depicting the conditions on Garden Key in 1850 (unmodified version shown in Figure 4). This map provides sound positional information for relocating the temporary structures on the modern landscape.

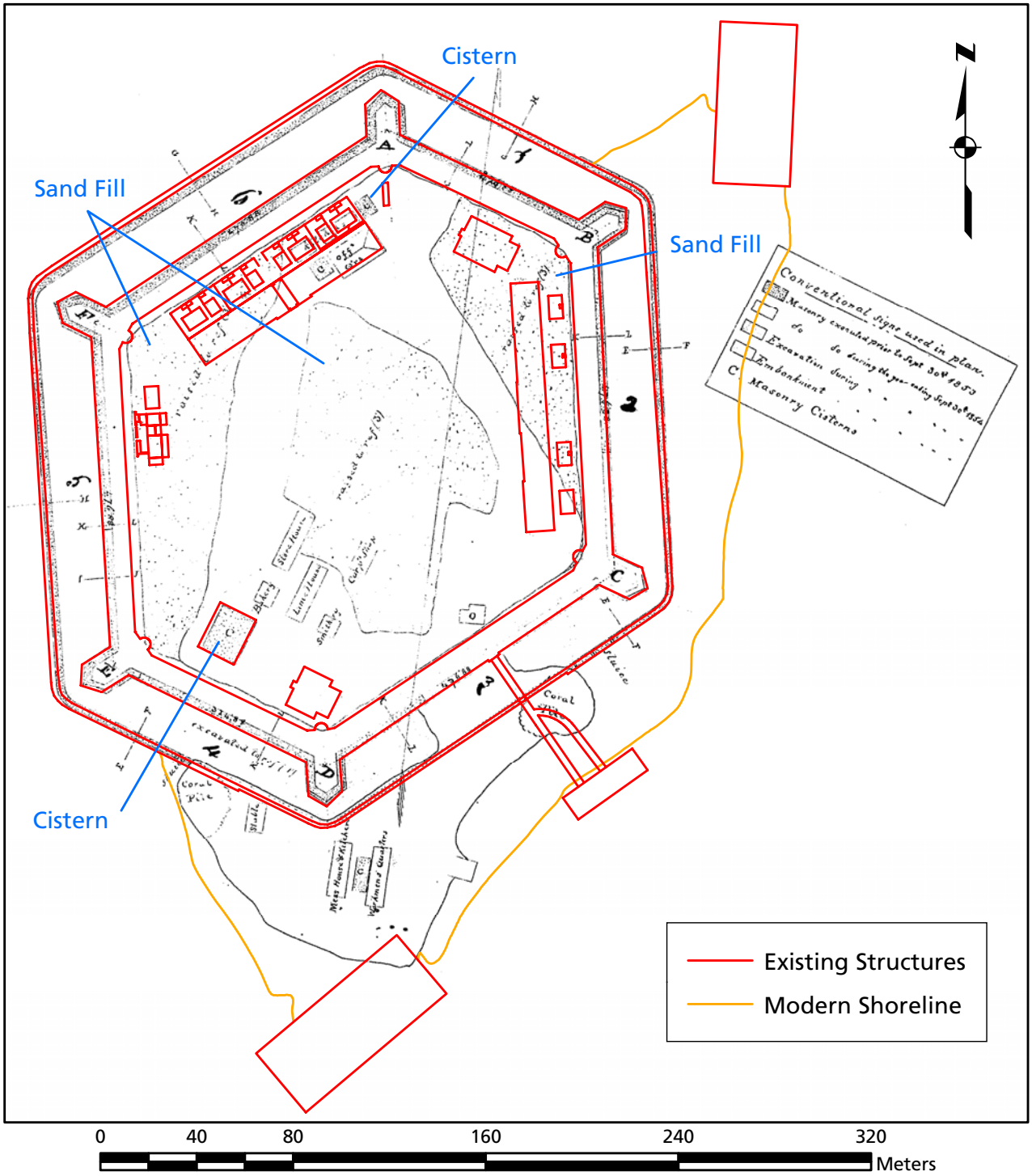

Figure 8. Geo-rectified version of a map depicting the conditions on Garden Key in 1854. Shows the progression of construction on the counterscarp and scarp walls, the permanent cisterns, and the extent of sand filling that produced the full parade ground. The historic map is displayed in association with modern features of the island.

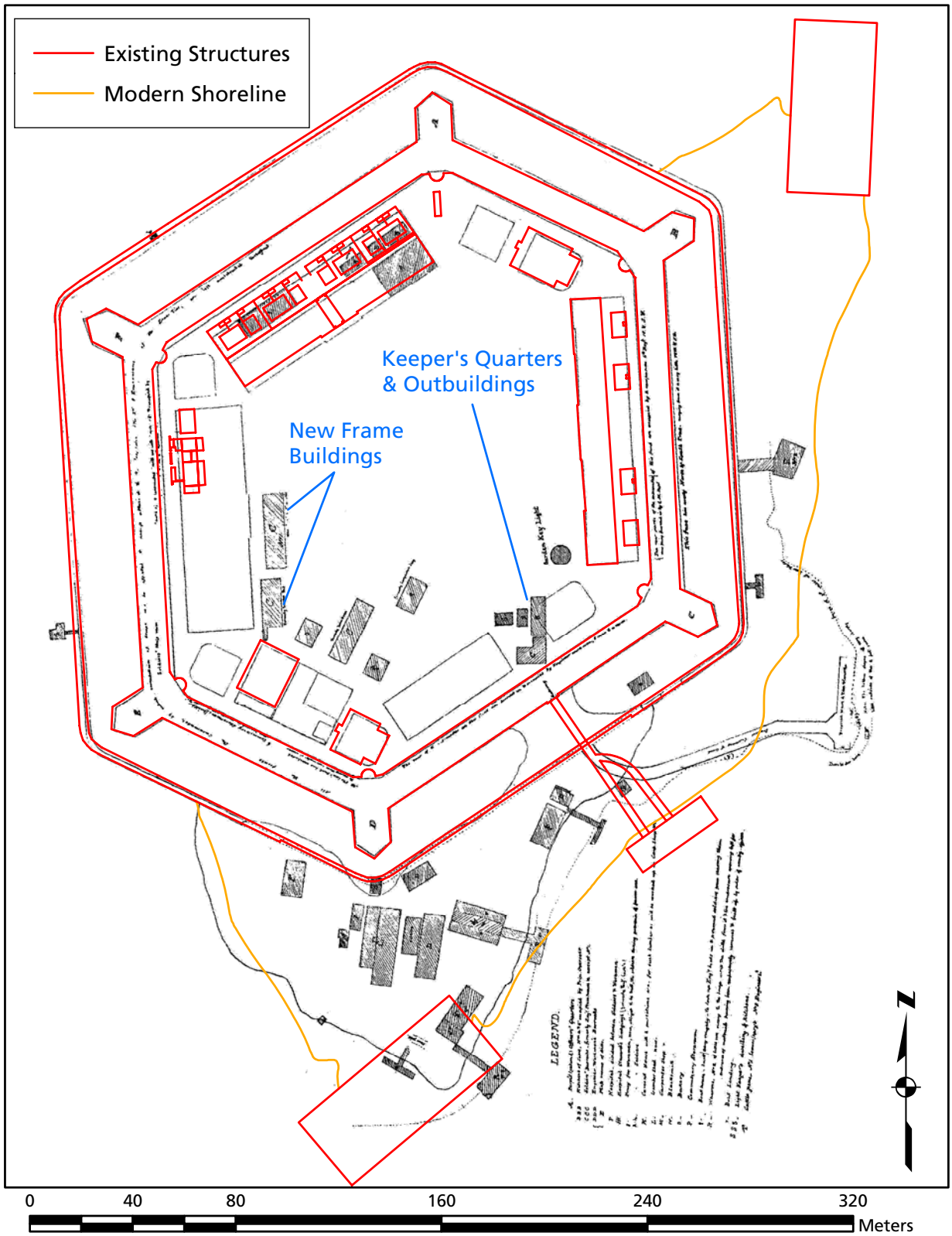

Figure 9. Geo-rectified version of a map depicting the progress of work at Fort Jefferson in 1861 (the unmodified version is shown in Figure 5).

Figure 10. Pre-1872 image of the sally port entrance to Fort Jefferson's parade ground. The original lighthouse keeper's residence is partially visible on the left hand side of the image.

automated in 1912. The grave is located north of the keeper's residence and southeast of the Major Smith Monument (Figure 13). It was well marked in 1937 when the National Park Service took over management of the island and was therefore included in the architectural drawings made of the fort in 1938. The wooden marker present in 1937 listed the year 1930, but that date likely refers to the year in which Cuban fisherman erected the wooden cross for the unmarked burial, rather than the date of the actual interment. The grave continues to be displayed on more recent maps, which are built off of earlier drawings, but it is no longer visible on the ground surface.

Construction Distribution Routes

One additional map was located that was pertinent to the GPR survey. In 1861, a map was drawn highlighting the planned distribution routes for construction material at the fort. The map shows the route of entrance to the fort as well as the route of distribution around the parade ground to each of the large permanent structures (Figure 14). The map indicates that a well used road may have surrounded the parade ground just inside the casemate walls.

Summary

There are a number of high-quality historic maps and photographs of construction activities and historic conditions at Fort Jefferson, several of which proved valuable in predicting the location or relict archeological and structural remains. The number of maps available speak both to the long construction period at the fort as well as to the remoteness of the project. The maps used in the analysis above were all prepared by on-site military engineers for the benefit of Congress and their superiors in Washington, who were not likely to ever visit the construction site, as they could at some of the more easily accessible Third System forts under construction elsewhere. Once coordinated with the modern ground surface using a GIS, the historic maps were used in an attempt to identify relict structures in the GPR data from the parade ground. As will be seen in the next chapter, this was accomplished with varying degrees of success.

Unfortunately, that engineer's maps do not document the vast majority of historic impacts to the parade ground. EVER's library of historic photos attest to this fact as they display numerous walking paths and unidentified frame structures, as well as fenced livestock pens and gardens throughout the parade ground. The GPR survey was well served by the identification of several possible target anomalies generated from examination of the historic maps, but prior to the survey it was clear that a wide variety of unexpected targets were also likely to be encountered.

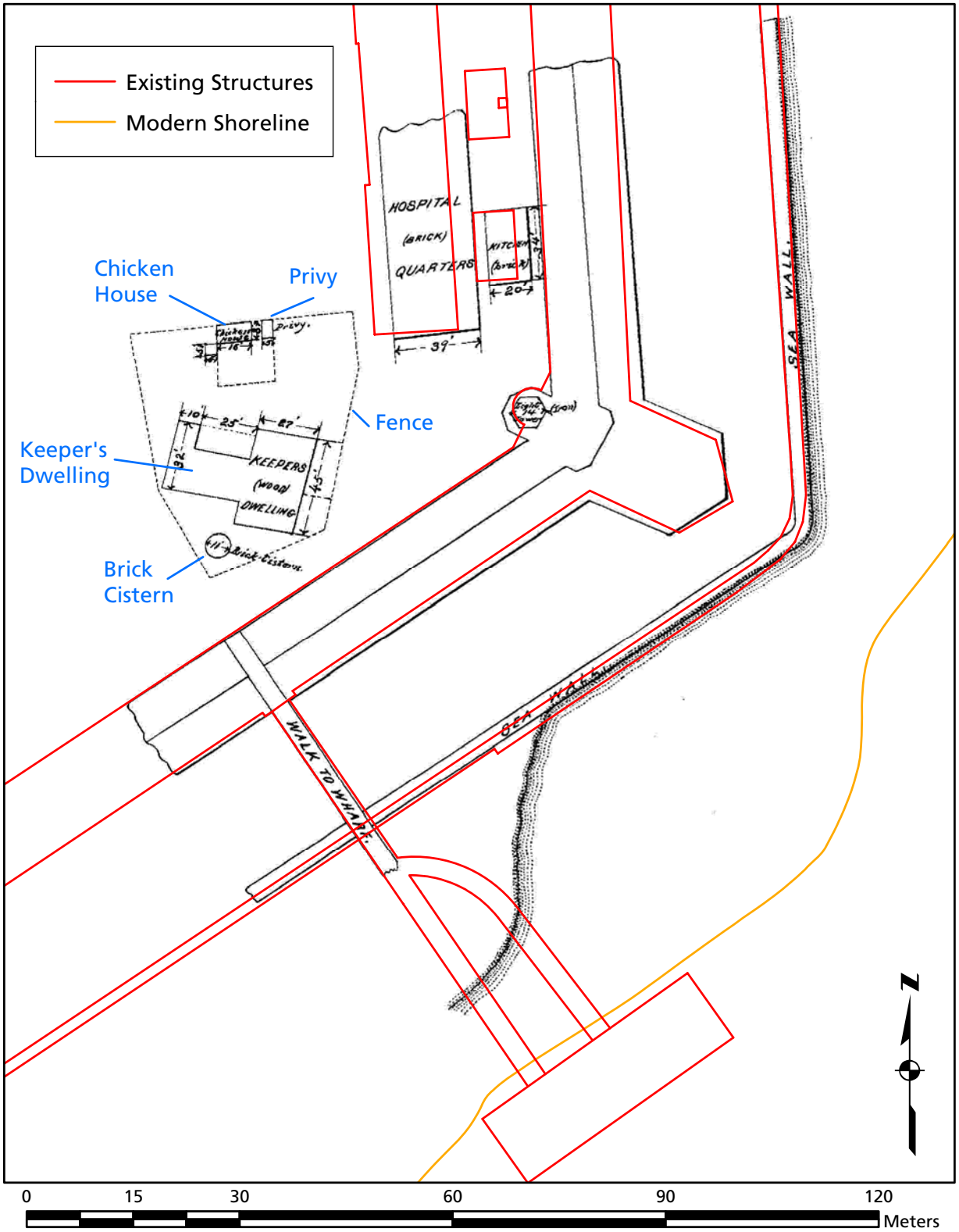

Figure 11. Geo-rectified version of an 1887 map of the second (1872-1912) lighthouse keeper's residence. Modern features including the dock, fort entrance, and the ruins of the soldier's barracks are visible as an overlay.

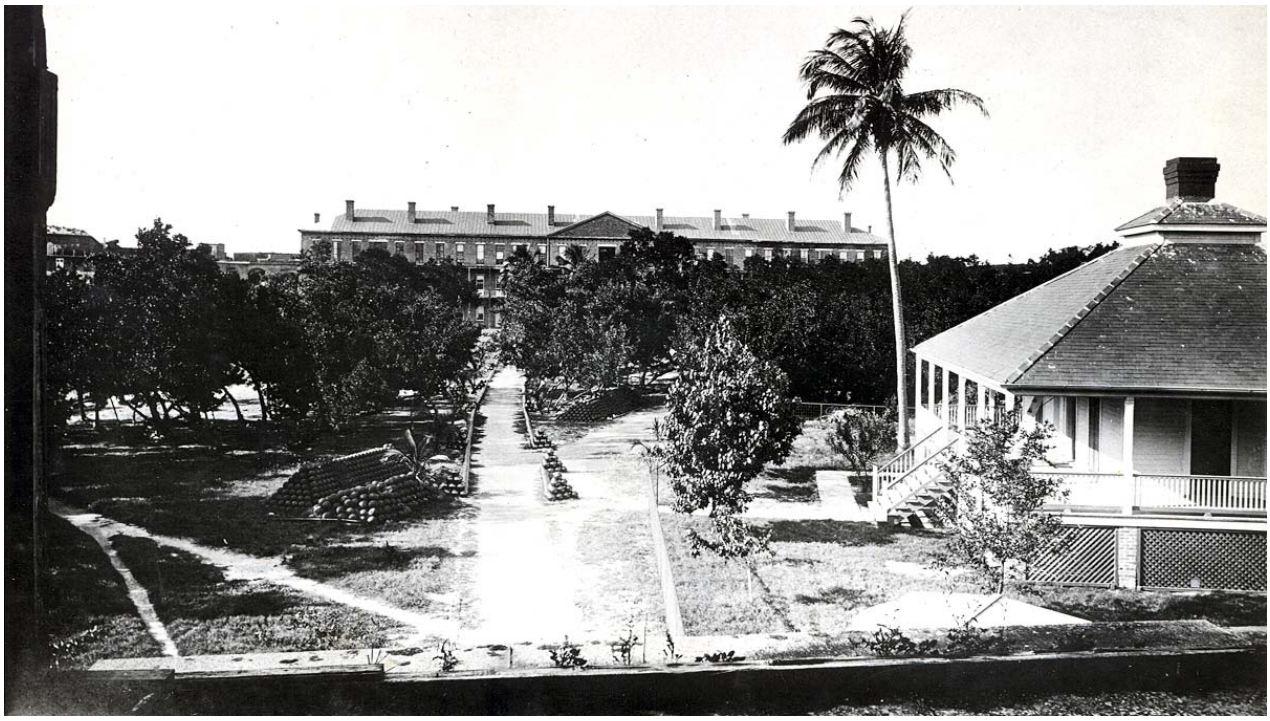

Figure 12. Image of the west side of the 1872-1912 lighthouse keeper's quarters. Cannonball lined trails can be seen running from the sally port (below frame of the image) to the officer's quarters on the north side of the parade ground.

Figure 13. The Italy grave and Major Smith Monument in 1937. The grave is marked with a wooden cross on the right hand side of the image.

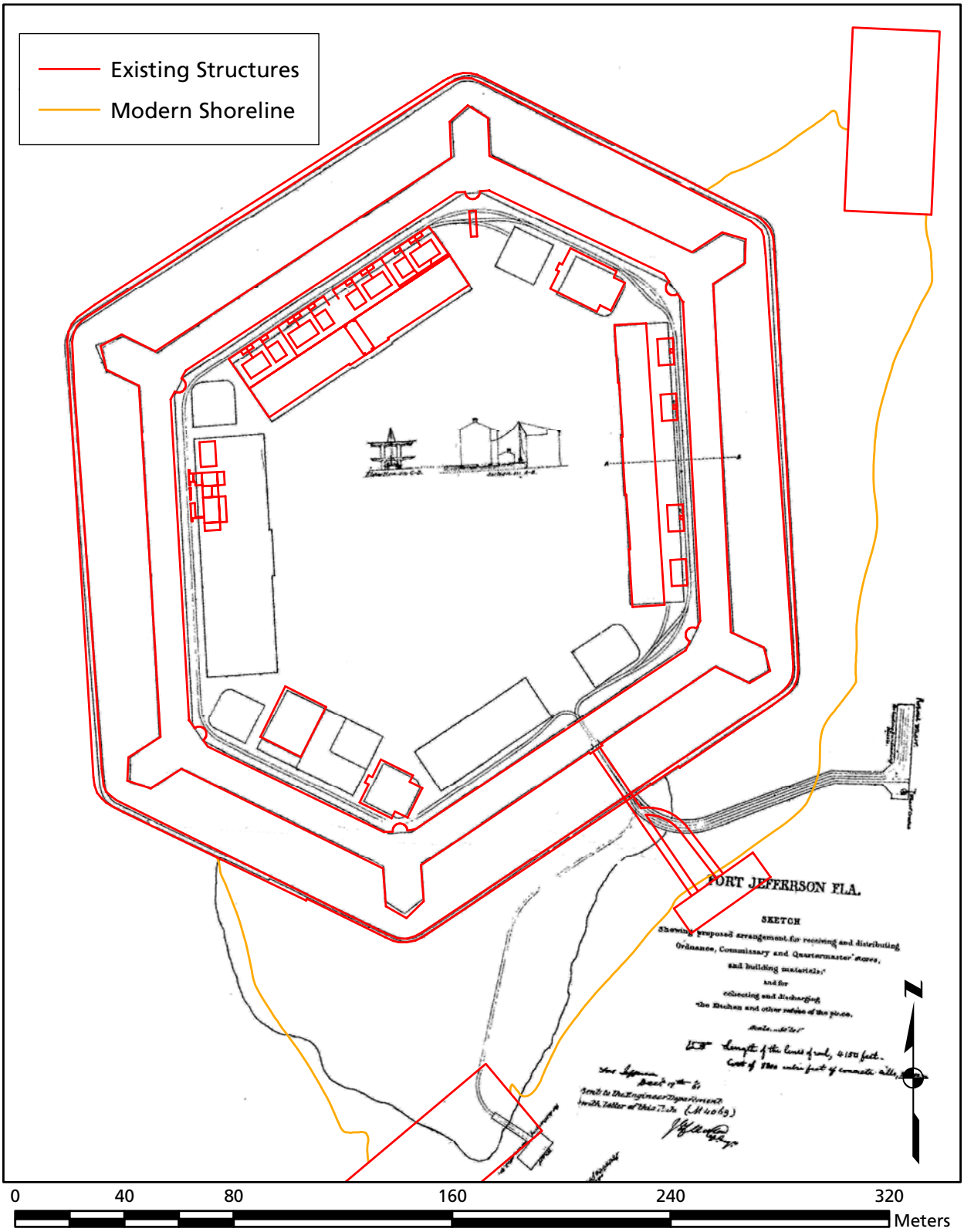

Figure 14. Geo-rectified map of the construction distribution routes at Fort Jefferson in 1861. Currently existing structural features are overlaid in red.

Chapter 4
Ground Penetrating Radar Survey

Traditional archeological spade and earth excavation is a time consuming, expensive, and destructive process, and unlike the early years of the science, today's standards of cultural resource management lean toward preservation of archeological patrimony in place rather than removal via excavation. This evolution of thinking, and annual advances in computer processing power, have led an ever increasing number of archeologists toward geophysical survey techniques for conducting research at known archeological sites, and, more recently, for general site identification (Johnson 2006). The first use of archeological geophysics dates to the early 1950s when English archeologists began utilizing magnetometers to identify Roman pottery kilns (Aitken 1961). Magnetometer use increased in Europe upon the discovery that the thermoremanent magnetism of burnt structures and naturally filled in ditches could be easily detected by the instruments (Clark 1990). Resistance meters, which can be used to map underground features with varying moisture contents, were also utilized early in the history of archeological geophysics. Resistance meters are particularly well suited to the mapping of underground walls, tombs, and cavities; which made them of great use when searching for buried Roman settlements (Aitken 1961). Magnetic and resistivity surveys continued to gain popularity in northern Europe throughout the 1960s and 70s and their success inspired experimentation with other geophysical prospecting techniques for archeology, such as magnetic susceptibility (Tite 1972, Tite and Mullins 1971), thermal imaging (Scollar 1990), and ground penetrating radar (Bevan 1998).

Although the birth of archeological geophysics coincided perfectly with the early careers of the American "New Archeologists," who were interested in hardening the science behind archeological investigation, the popularity of geophysical survey in Europe did not immediately translate to North American archeologists. In Europe, the successes of geophysical prospecting were associated with monumental architecture, such as buried Roman villas, and comparable archeological features in North America are infrequent. As a result, many American archeologists experimented with geophysics and received little useful results, leading them to abandon the science decades ago. However, the practice grew in Europe and additional instruments and computer software packages were developed for dealing with the large amounts of data generated during geophysical surveys. These further developments have spurred a resurgence in archeological geophysics in the United States over the past 20 years. This has been particularly true in the case of ground penetrating radar, especially since several North American companies have begun to market GPR systems and software specifically to the needs of archeologists and forensic anthropologists.

For all of the successes and advancements in archeological geophysics over the past half century, imaging of buried features can still be a difficult task. In order for archeological features (or anomalies) to be detected, and be recognizable as archeological features and not natural disturbances, they must contrast in some way with the surrounding soil matrix. Unfortunately, geophysical instruments respond to archeological and natural anomalies and, therefore, interpretation of geophysical survey results depends greatly on the recognition of patterns in the data that correspond to the expected form of an archeological feature. Often, if there is significant "noise" in the form of chemical or physical variations

in the surrounding soil matrix, archeological features can be lost (Nickel 2003). In the case of GPR, ground conditions that are most conducive (though not necessarily required) for successful anomaly recognition include dry, homogeneous, non-electrically conductive soils (Conyers and Goodman 1997) – much like the sandy soil that makes up Garden Key. Though the sand under Fort Jefferson and its parade ground is particularly well suited for GPR survey, difficulty sorting historic anomalies, natural tree roots, modern intrusions, and overlapping historic disturbances proved to be the challenge to this survey.

GPR units operate by transmitting distinct pulses of radio energy from a surface antenna which are reflected off buried objects, features, or soil structures and then detected back at the surface by a second receiving antenna. GPR systems are capable of producing reliable three-dimensional images of the subsurface because feature depth can be determined by measuring the round-trip travel time (in nanoseconds) of the radar pulse before it is recorded at the surface (Conyers 2006). GPR antennae operate on a variety of frequencies between 10 and 1600 megahertz (MHz), though frequencies in the range of 250 to 400 MHz are most commonly utilized in archeological prospecting. Generally, the lower the antenna frequency, the greater the depth into the soil that features can be resolved. However, lower frequency antennae can only resolve very large objects and there is therefore a trade-off between depth of penetration and detail of anomaly resolution. The survey at Fort Jefferson utilized a 400 MHz antenna capable of resolving features measuring a minimum of 50 centimeters in diameter to a depth of four meters in ideal situations. In practice, depth of penetration with a 400 MHz antenna is usually limited to about two meters because of varying physical and electrical properties of the natural soil deposits. During the Fort Jefferson survey the depth of penetration was limited approximately two meters.

GPR surveys are conducted by moving the radar antennas along the ground surface in a series of linear transects making up a larger grid. Two dimensional profiles that display radar reflections from the ground surface to the lowest level of radar penetration are recorded for each of the linear transects. After all of the adjacent transect profiles within a grid are collected, computerized software can be used to combine the profiles and correlate the features, allowing for the production of a three-dimensional cube displaying images of buried features and soil stratigraphy under the grid (Conyers 2006). That block can then be horizontally sliced at different depths (or times in nanoseconds) to produce "time slice" maps displaying subsurface anomalies present at any depth below the ground surface (see Figure 15 and Figure 16).

During the Fort Jefferson survey an arbitrary grid was laid out in the fort's parade ground with grid north oriented at 3.4 degrees west of true north. Grid north was established based upon the orientation of the western wall of the ruined soldier's barracks. A total of 36 GPR grids were established within the parade ground project area grid, but they were of varying sizes (Table 1) chosen to avoid obstacles such as trees, utilities, the Smith Monument and existing buildings. Some areas could not be surveyed because of the presence of such obstacles. Four additional grids were placed outside of the fort on the sandy land now encompassing the campground and picnic area. These four grids were oriented with their north edge along the brick seawall that makes up the southern wall of the moat. A final grid was also placed in the fort's first tier above the cisterns located west of the park office (see Figure 2). The five grids not located on the parade ground were laid out on a new project area grid with a coordinate system not correlated to the parade ground grid. The new project area grid was positioned so that grid east and west were oriented with the seawall outside the fort's sally port and an arbitrary point located at the northeast corner of Grid 37 was selected as N 1000, E 1000 (Table 2). In all of the grids, except the one placed in the first tier, the transect spacing was one-half meter. Transect spacing in the first tier grid was one-quarter meter.

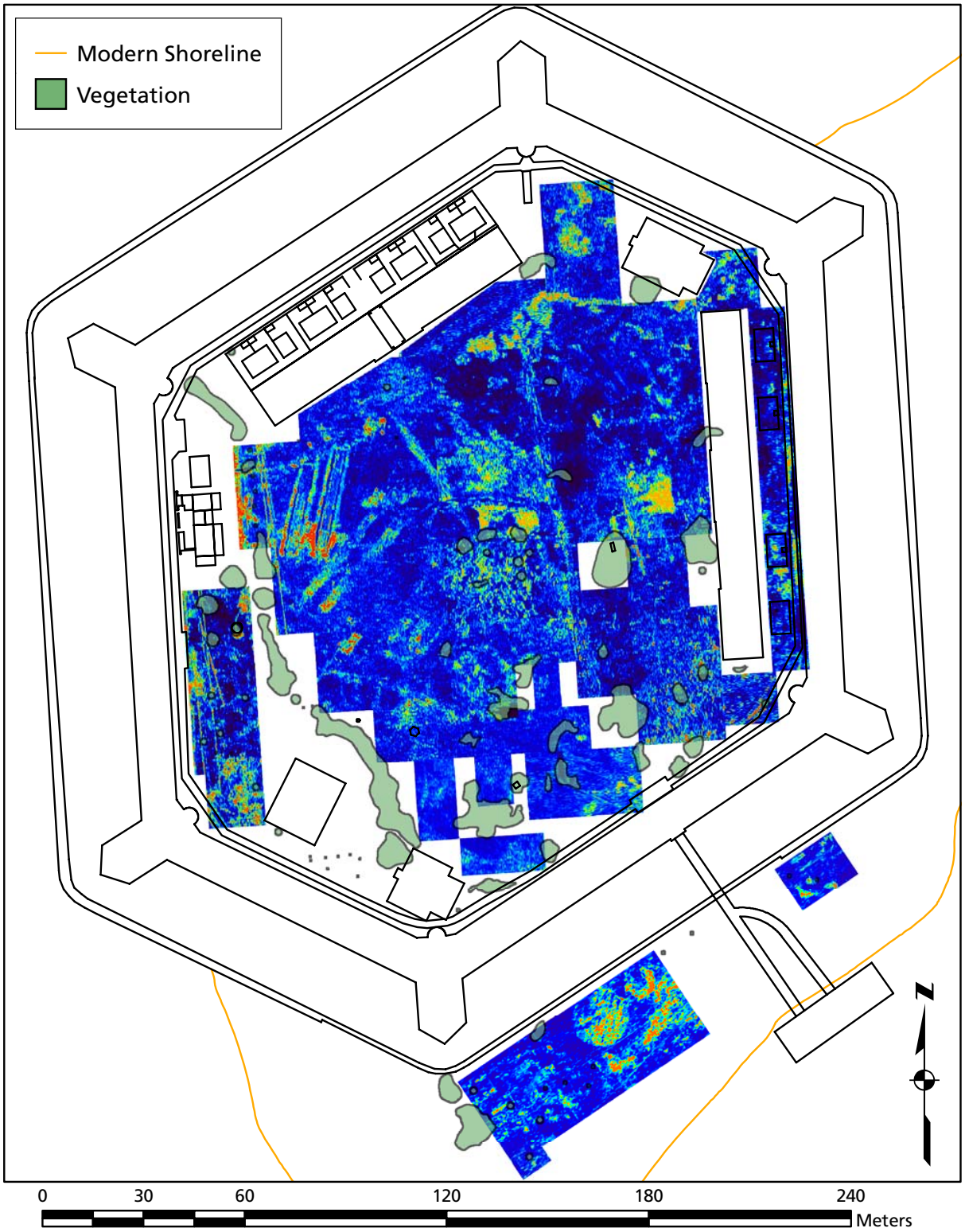

Figure 15. GPR results from the complete survey inside and outside of the fort. This image represents radar results from a time slice averaged between 5.5 and 9.5 nanoseconds or approximately 30 to 50 centimeters below the surface. The full scope of the project can be visualized, but detail is lost because of the image scale.

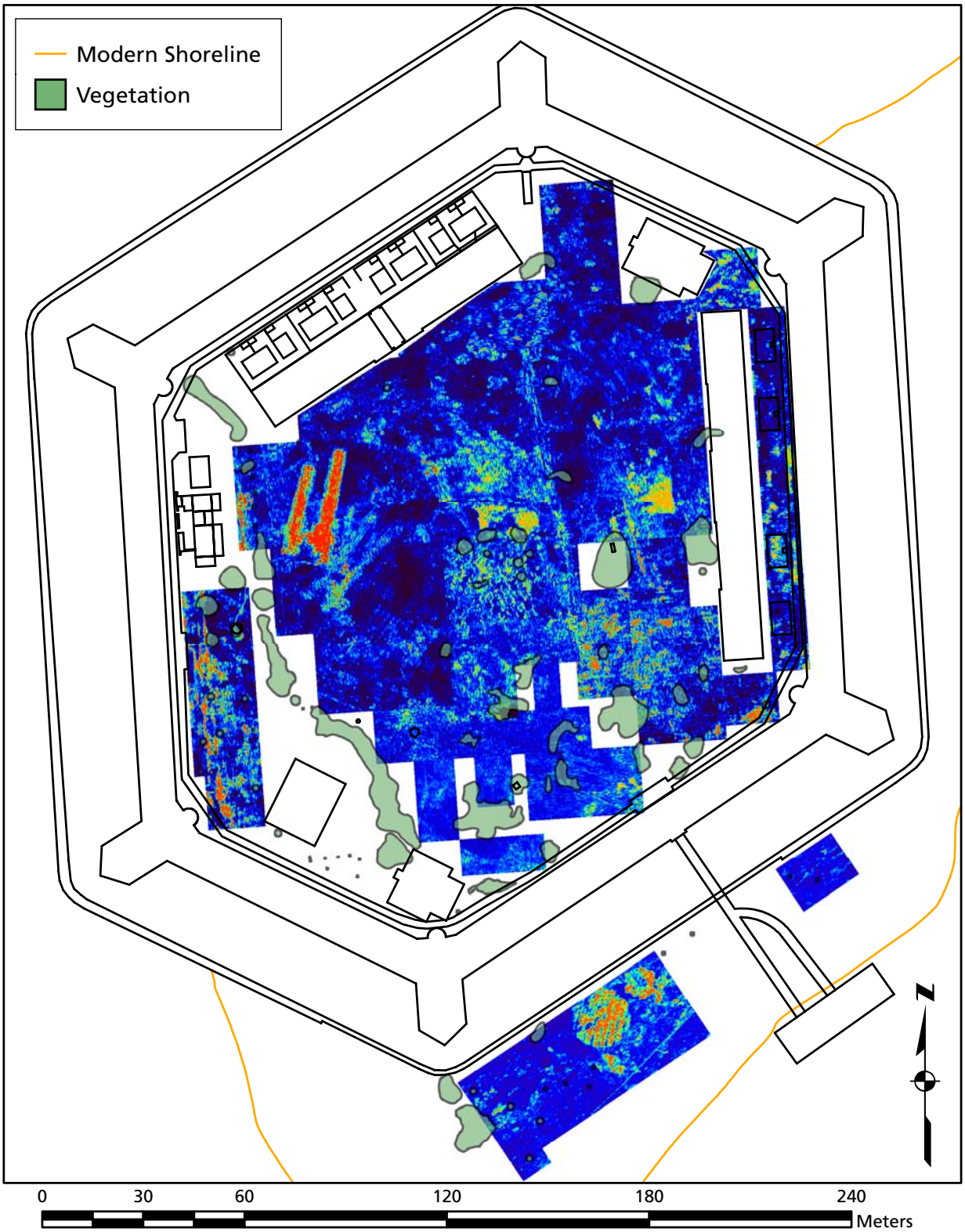

Figure 16. GPR results from the complete survey inside and outside of the fort. This image represents radar results from a time slice averaged between 9.5 and 17 nanoseconds or approximately 50 to 90 centimeters below the surface.

Table 1. Fort Jefferson Parade Ground GPR Grid Locations and Sizes. Corner locations of the ruined soldier's barracks are also provided to allow for relocation of the grids in the future.

GPR Grid	*SW Corner Coordinates*		*Grid Size (Meters)*	
	Northing	*Easting*	*North*	*East*
1	1080	960	40	40
2	1120	956	48	22
3	1120	911	20	45
4	1080	920	40	40
5	1120	978	11	22
6	1127	1000	18	19
7	1100	1015	27	11
8	1073	1015	27	11
9	1046	1015	27	11
10	1019	1015	27	11
11	1004	1000	15	16
12	1061	960	19	40
13	1000	974	40	26
14	1015	957	32	17
15	1040	974	21	18
16	1040	920	40	40
17	1080	880	23	40
18	1103	880	17	40
19	1066	860	31	20
20	1040	880	40	40
21	1016	880	24	40
22	1000	896	16	24
23	1040	869	26	11
24	1000	842	40	20
25	1040	842	15	20
26	984	845	16	17
27	976	907	24	12
28	985	925	15	11
29	965	919	11	25
30	980	940	20	34
31	1026	920	14	40
32	1015	920	11	19
33	1010	920	5	19
34	1000	920	10	40
35	1010	939	3	21
36	1013	944	13	8
	SW Corner	*NW Corner*	*SE Corner*	*NE Corner*
Soldier's Barracks	N 1023.163	N 1126.568	N 1023.195	N 1126.545
	E 1002.336	E 1001.864	E 1014.110	E 1013.445

Table 2. GPR Grid Locations and Sizes of the Five Grids Established off of the Parade Ground.

GPR Grid	SW Corner Coordinates		Grid Size (Meters)	
	Northing	Easting	North	East
37	970	970	30	30
38	970	940	30	30
39	1027	954	3.5	50
40	985	1043	15	20
41	965	930	35	10

Following data collection, each grid was subjected to a series of post processing steps using the software package Radan. These processing steps are intended to improve feature resolution, remove background noise, and accurately identify feature depth and size. The data was then exported to the contour mapping software program Surfer, in which additional refinement could be made to further resolve some features and produce quality graphics.

Because the survey area was exceedingly large (see Figure 2, Figure 15, and Figure 16), collections of several individual grids were combined into eight larger units referred to as *quadrants* to aid in the identification of anomalies that stretched across multiple survey grids. Seven of the quadrants were inside the parade ground, the eighth was made up of the grids placed outside the fort. The first tier grid was examined alone. After data processing, the results of the survey were examined and geophysical anomalies were identified; some of these anomalies remain unidentified and others are presumed to be modern features, several of them have been tentatively identified based upon their correlation with projected historic features gleaned from rectified maps produced in the GIS exercise described in Chapter 2.

GPR Quadrant 1: Grids 1, 4, 16, & 12

GPR Quadrant 1 is made up of three 40-by-40-meter grids (Grids 1, 4, and 16) and one 19-by-40-meter grid (Grid 12). It is located to the west of the north half of the ruins of the soldier's barracks, and south of the large magazine and east end of the officer's quarters ruins (Figure 17). The examination of historic maps did not reveal specific features expected to be present in Quadrant 1, but historic photographs indicated that evidence of extinct walking paths leading to the existing buildings could be identified. It was also speculated that buried remnants of frame structures utilized during the construction of the soldier's barracks may be located.

The GPR data from the near surface reflection in Quadrant 1 shows a series of walking paths, three of which run in a northeast direction toward the officer's quarters (one of these three splits into two for a portion of the route), with another running west toward the soldier's barracks. Two square shaped anomalies are present in the surface reflection associated with the paths. The clearer of the two is located east of the path leading to the east end of the officer's quarters. It measures approximately five meters square, is centered on N 1108, E 954 on the project grid, and is directly attached to the path (Figure 18). The anomaly's function is unknown, but it may be the foundation of a small pavilion or storage platform. It is located immediately below the grass on the parade ground but is not apparent on the surface. The second anomaly associated with the paths is located in the center of the trail leading to the soldier's barracks. It is also approximately 5 meters square and is centered on N 1097, E 970. This anomaly is somewhat more difficult to distinguish in the near surface reflection but becomes more apparent in the deeper time slices (see Figure 19 and Figure 21). It too has the appearance of a pavilion of some sort and is associated by with the soldier's barracks by way of contact via the walkway, but its actual identity is unknown. In addition to the paths

Figure 17. Location of GPR Quadrant 1.

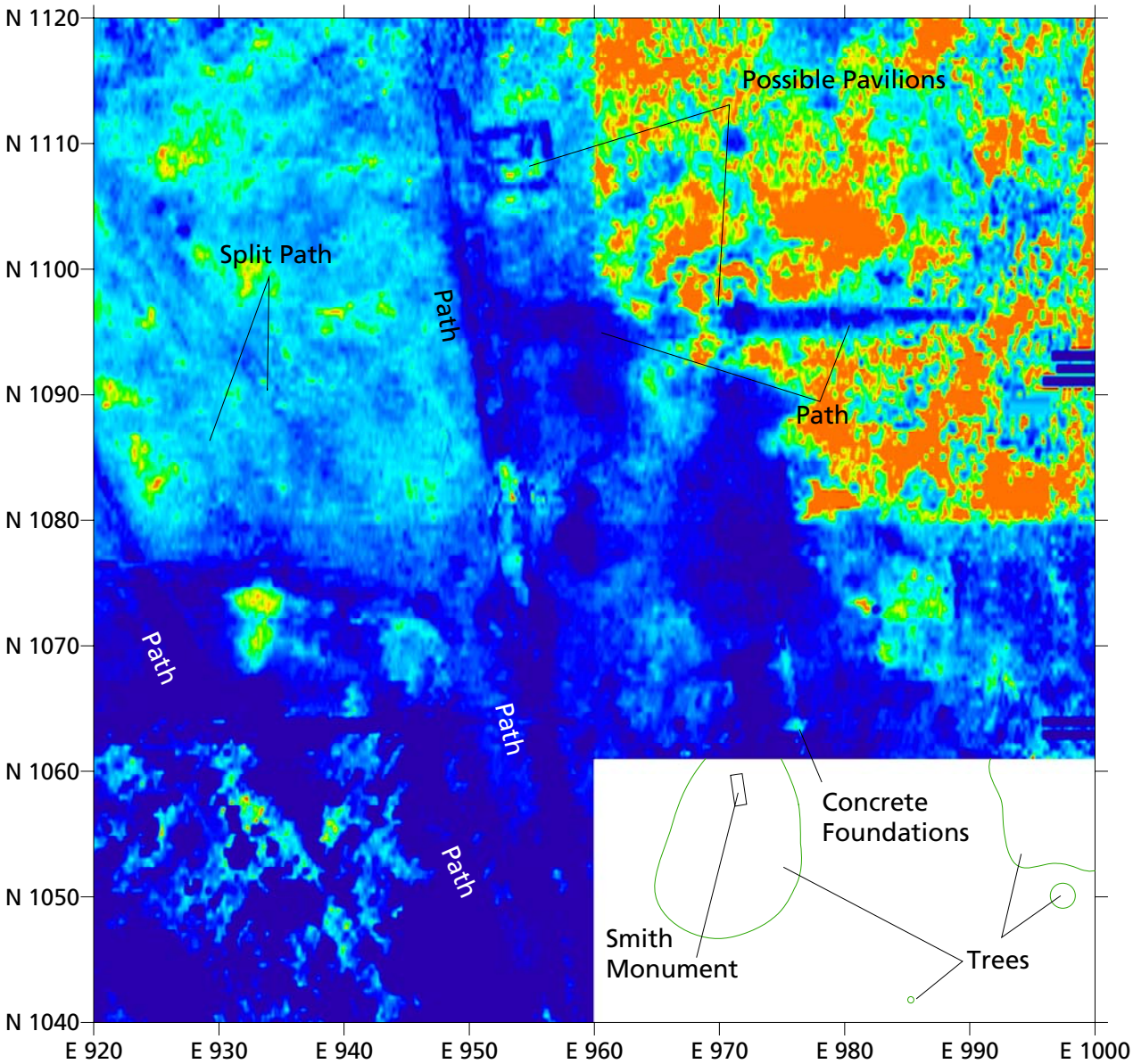

Figure 18. GPR time slice of Quadrant 1 from the near surface reflections. Short dark lines in the central eastern edge of the quadrant represent missing data where collection was hindered by the presence of vegetation.

and their associated features, part of a concrete foundation is visible in the southwest portion of Grid 12. This feature is part of a series of poured concrete foundations surrounding the Major Smith monument, they are partially exposed on the surface but also appear more clearly in the lower GPR time slices.

As we move deeper below the parade ground and examine the radar data from 10 centimeters below the ground surface, previously identified anomalies become more clear and new features are identified (Figure 19). At this depth, some segments of the trails identified in the near surface reflection are still visible and a portion of the possible pavilion associated with the trail to the soldier's barracks is made clear. There is also clear evidence of a PVC waterline that was recently buried across the parade ground, running from the maintenance area in the southwest corner of the fort to the large magazine. Also visible is more of the surface-exposed concrete foundations in

the southern half of Grid 12. In the southwest corner of Quadrant 1, a large square-shaped anomaly is partially visible, extending into Quadrants 3 and 7, it appears to be a large modified surface in the center of the parade ground. Evidence of a hard packed clay and sand surface associated with this anomaly is occasionally visible on the modern ground surface, as are small fragments of iron scrap and brick. The squared off edges of this anomaly seem to indicate a constructed feature, as opposed to a surface that was naturally created through heavy foot and material traffic in the parade ground. There is no historic documentation to support the previous existence of a parade ground structure large enough to have created this anomaly, but it may be associated with the gardens (built using soil brought from the mainland) and livestock pens known to have existed on the parade ground throughout the construction of the fort (Figure 20), or perhaps with a prepared muster area for soldiers stationed at the fort.

GPR data from a time slice of Quadrant 1 at 48 centimeters below the surface is presented in Figure 21. Several new anomalies appeared

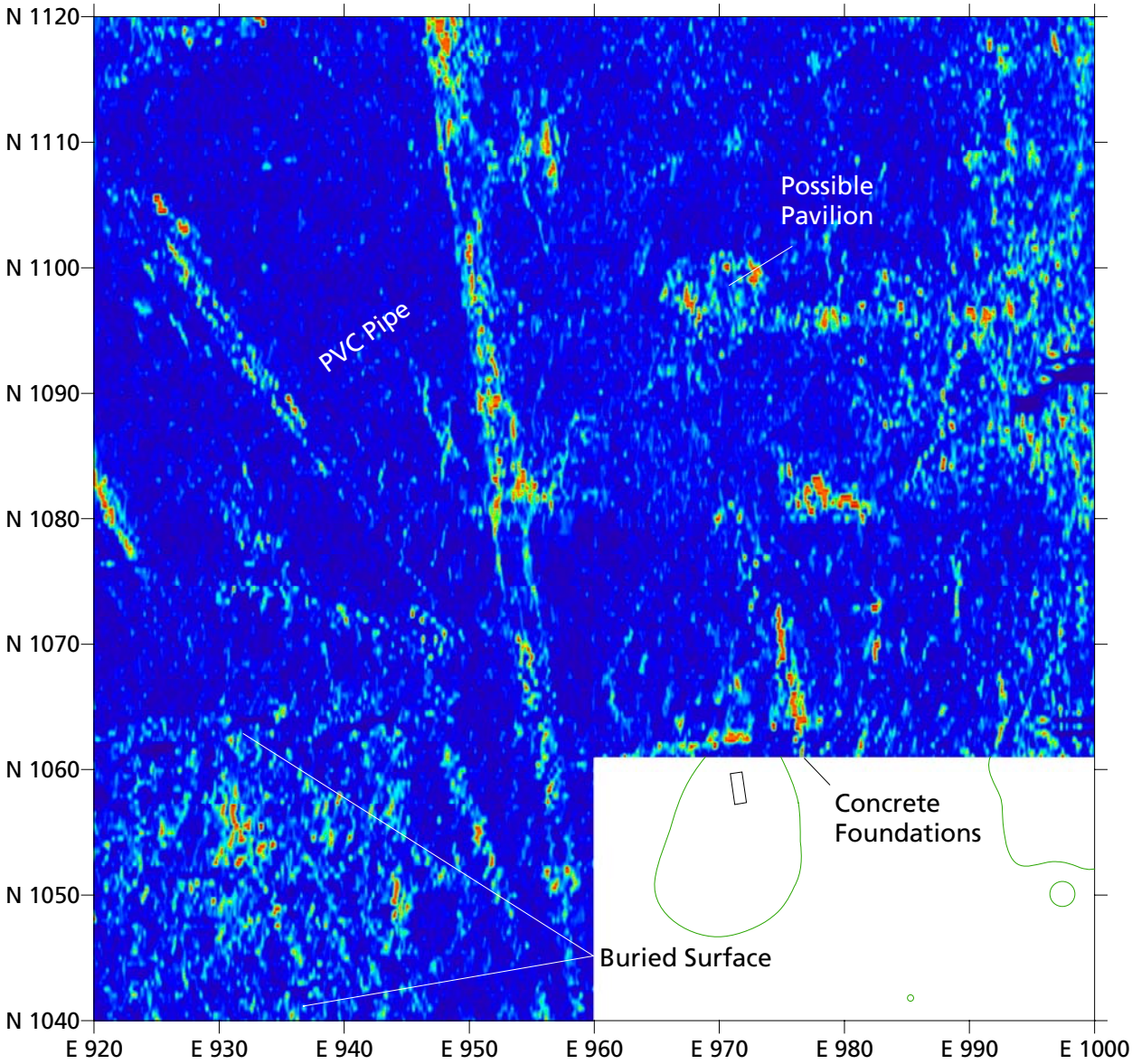

Figure 19. GPR time slice of Quadrant 1 from 10 centimeters below the surface.

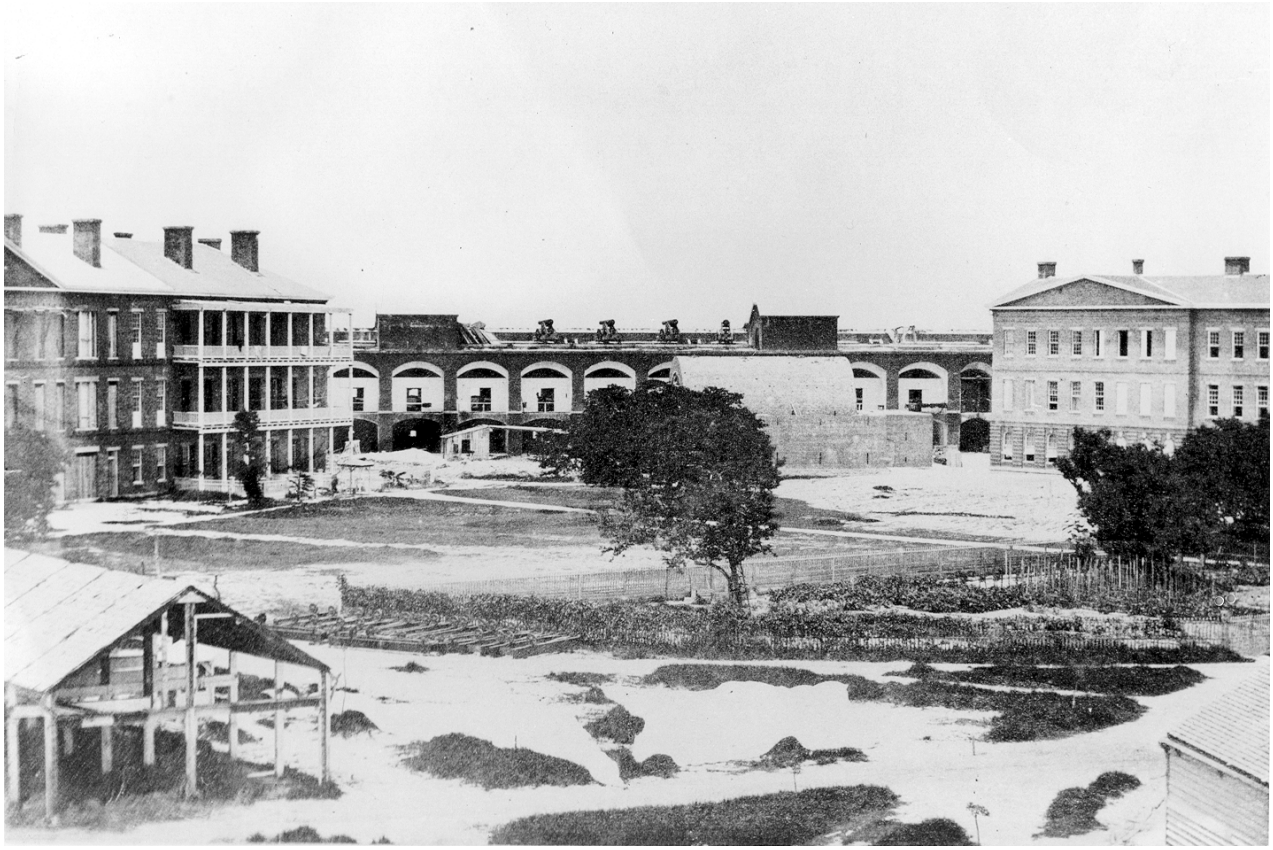

Figure 20. Historic view of the parade ground facing northeast circa 1875. A fenced garden that may be the source of the large prepared surface anomaly in Quadrants 1, 3, and 7 is visible.

at this depth. In the northwest corner of the quadrant, three roughly circular anomalies are visible, one of which partially extends into Quadrant 2. These anomalies appear to be pit features and are probably filled with refuse and debris produced during the construction of the officer's quarters. In the southeast corner of the quadrant, in Grid 12, the full extent of the concrete foundations partially exposed on the ground surface is visible, as well as a rectangular area of high amplitude reflection that may represent the floor of a temporary structure that was in use during the construction of the barracks (Figure 22), or a disturbance created during the staging of materials for this building. These two anomalies may be associated, or their adjacent locations may be a coincidence. Two other large amorphous areas of high amplitude reflection are evident in the southwest portion of Quadrant 1, just off the northeast corner of the large square-shaped anomaly identified at 10 centimeters below the surface. The identity of these large anomalies is unknown. Other areas of high amplitude reflection in the northern half of the quadrant may reflect buried items, or physical variation in the subsurface soils. The small reflections in the northeast portion of the quadrant, for example, may indicate buried metal objects, and the more diffuse reflections in the northwest portion of the quadrant suggest variation in soil compaction.

The last time slice provided for Quadrant 1 is from 1.6 meters below the surface (Figure 23). In this image, a different view of the large rectangular anomaly first identified at 10 centimeters below the surface is visible. This buried surface, interpreted as either gardens, a livestock pen, or a muster area, is most likely not present at 1.6 meters below the surface, rather this is a reflection produced after the radar signal has bounced back and forth from

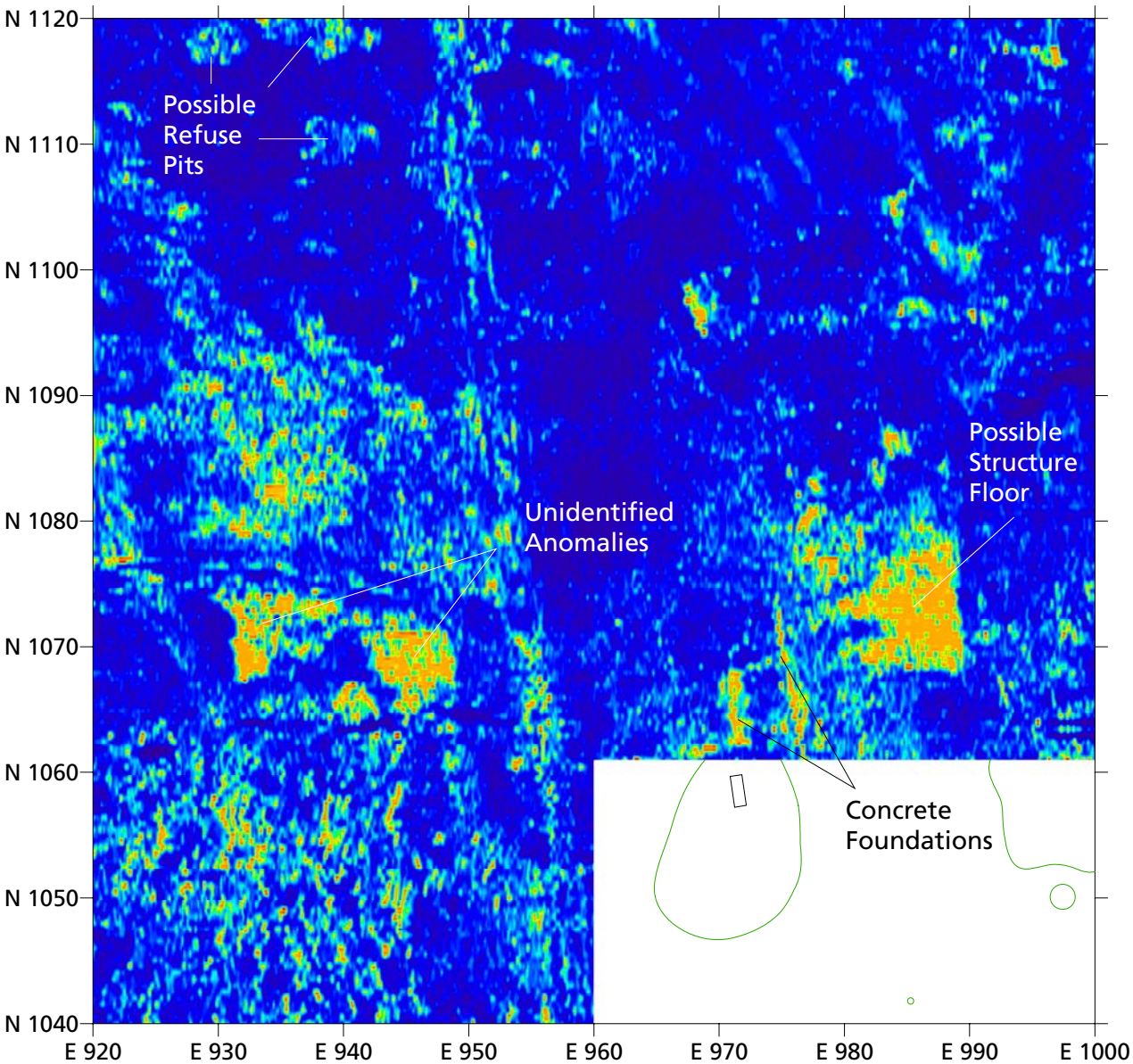

Figure 21. GPR time slice of Quadrant 1 from 48 centimeters below the surface.

the surface to the top of the anomaly several times before being recorded (when this occurs the instrument records the additional signal travel time as increased depth). The graphic is only presented because it provides a clear image of the dimensions of the large rectangular feature.

GPR Quadrant 2: Grids 2, 3, & 5

GPR Quadrant 2 is made up of three individual grids located north of Quadrant 1 and south and west of the large magazine (Figure 24). Quadrant 2 comprises GPR Grids 2, 3, and 5, measuring 48 meters north by 22 meters east, 20 meters north by 45 meters east, and 11 meters north by 22 meters east respectively. GPR data collection in Grid 3 stopped along the southern wall of the ruins of the officer's quarters, resulting in no data collection from the northwest corner of Grid 3. Prior to the radar survey, it was expected that features associated with walking paths in front of the officer's quarters and large magazine would be encountered. It

was also hoped that evidence of the balconies and porches in front of the officer's quarters would be revealed.

The GPR data from the near surface reflection in Quadrant 2 showed no historic features of note (Figure 25). The modern (1963) brick path that circles the interior of the fort walls, is visible in the northeast corner of Grid 2 and evidence of shallow surface depressions are visible throughout the quadrant.

Figure 26 displays the radar data from a time slice cut at 45 centimeters below the ground surface. At that depth, it is possible to discern a relict path that ran in front of the officer's quarters and then east across the south side of the powder magazine. It also appears possible that a smaller path forked southeast off of the main route in the direction of the soldier's barracks. What used to be the balconies and front porch of the officer's quarters is clearly visible in the data as an area of low amplitude (dark blue) data extending approximately nine meters from the southern wall of the ruined building. There is a great deal of apparent disturbance adjacent to the path south of the officer's quarters in the southwest corner of Grid 3. These reflections are likely the result of ground disturbance associated with the construction of the building or day to day activities after the building was completed and occupied. In the northern portion of the quadrant, between the hot shot furnace and the large powder magazine, there are several large high amplitude reflections, the nature of which are unknown. The anomalies may, however, represent activity areas or dumps of construction debris.

Moving deeper in Quadrant 2, most of the reflections associated with the possible activity areas have disappeared by the time 91 centimeters of depth is reached (Figure 27), but several new anomalies have become visible. Two circular features are visible in the center of Grid 2 which may represent pits, though their contents are unknown. A variety of other anomalies are

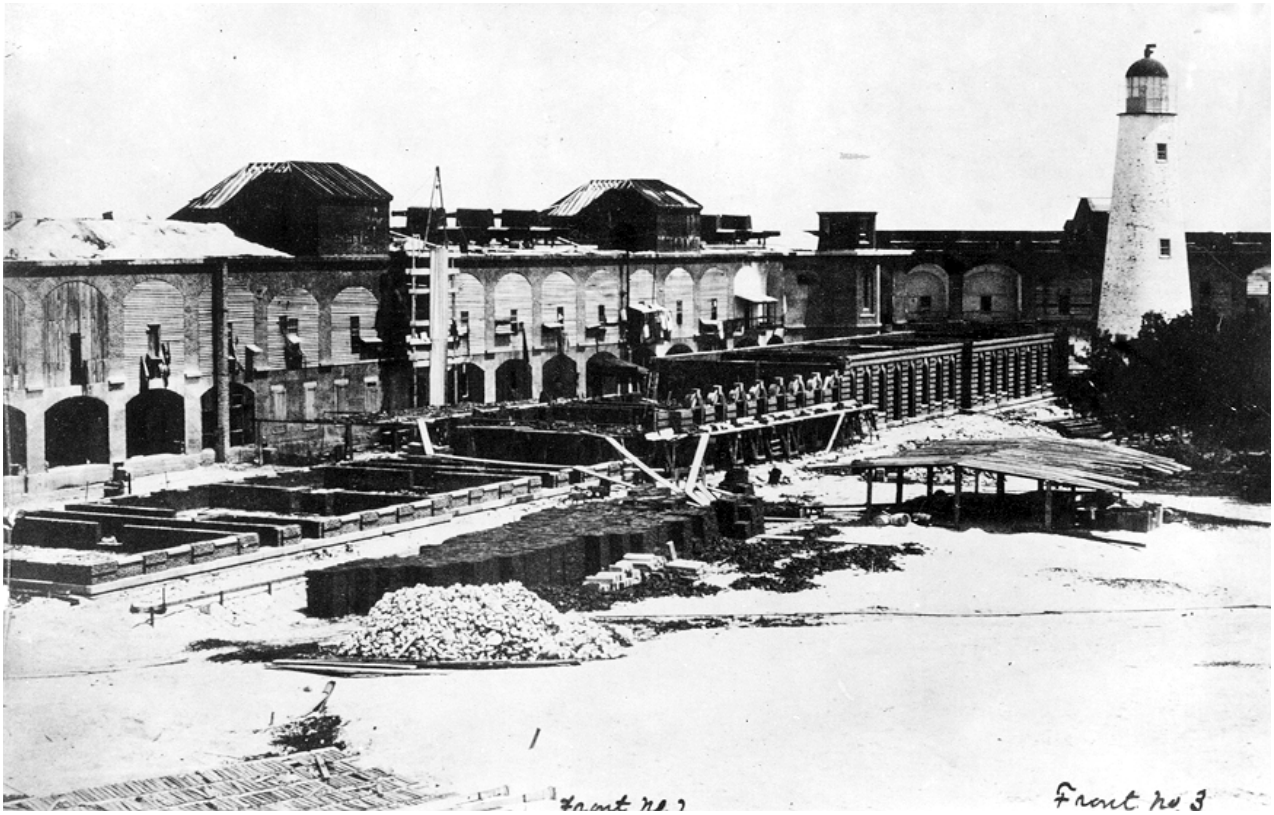

Figure 22. Photo taken during the construction of the soldier's barracks (circa 1862), facing southeast. Note the presence of the roofed structure and staged building materials.

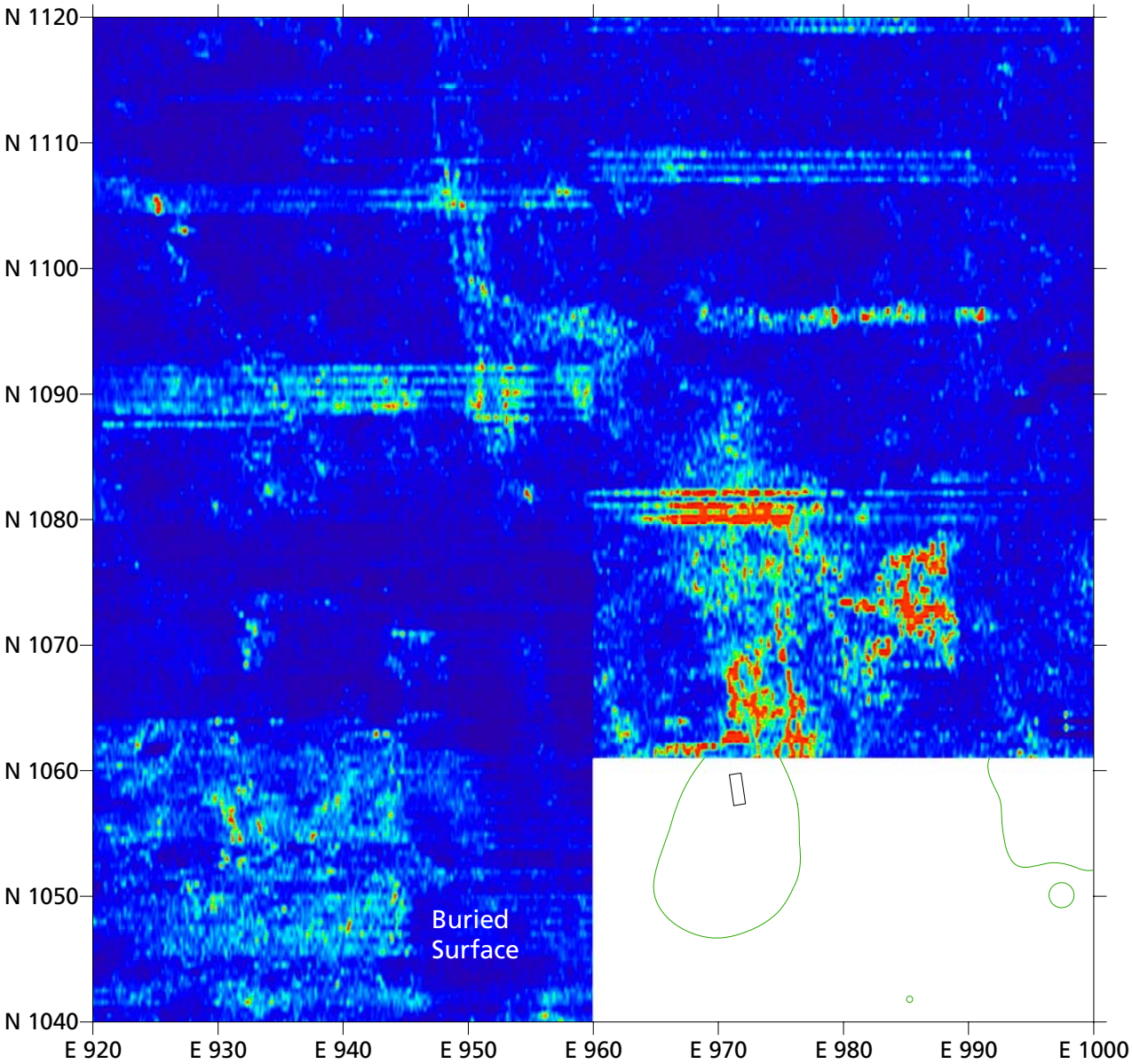

Figure 23. GPR time slice of Quadrant 1 from 1.6 meters below the surface. The linear banding present in the data is a result of interference from the park's radio telephone system. This interference only effected the lower levels of the GPR's penetration.

also present adjacent to the hot shot furnace, south of the officer's quarters, and south of the large magazine. The source of these anomalies is unknown, but they likely represent buried construction debris.

The final view presented of the GPR data from Quadrant 2 is from a depth of 1.13 meters below the ground surface (Figure 28). This graphic displays small remnants of the possible pit features originally identified at 45 centimeters below the surface, as well as a continuation of some of the larger scattered anomalies from west of the hot shot furnace, south of the officer's quarters, and south of the large magazine. Any or all of these anomalies may be interesting historic features, particularly the anomalous area in the northeast corner of Grid 3, but they are unidentifiable from the radar data alone. Of particular interest at the 1.13 meter depth is a linear anomaly running about two meters away

Figure 24. Location of GPR Quadrant 2.

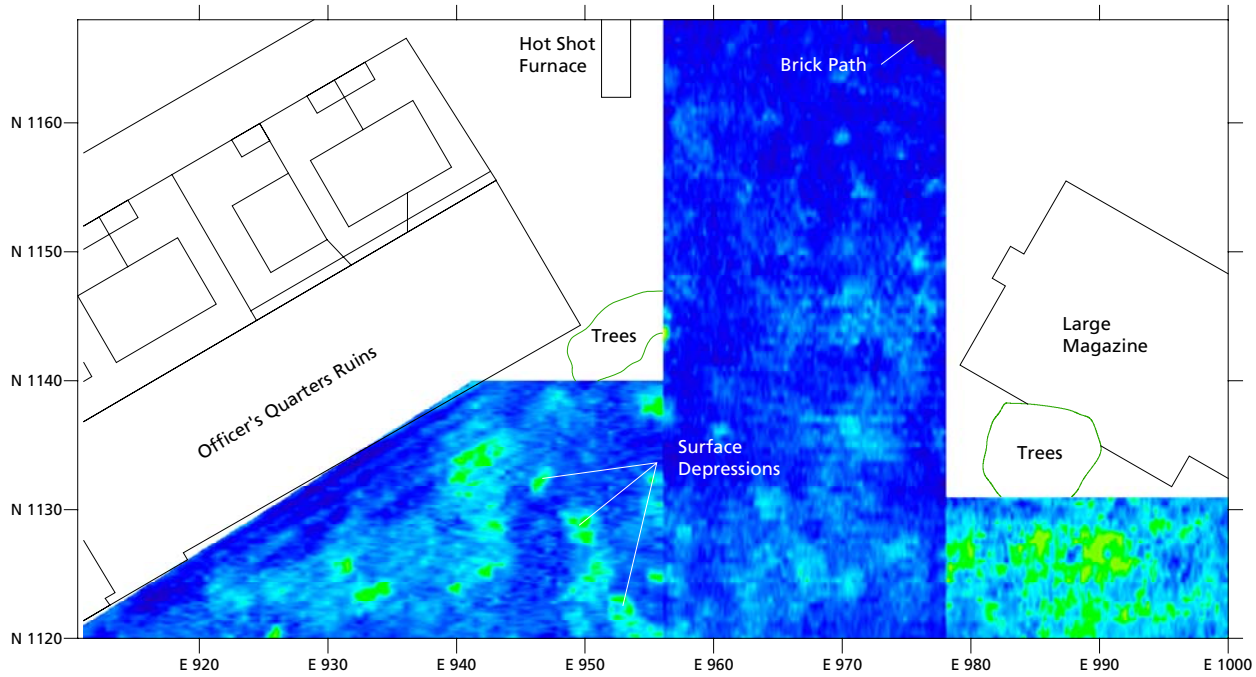

Figure 25. GPR time slice of Quadrant 2 from the near surface reflections.

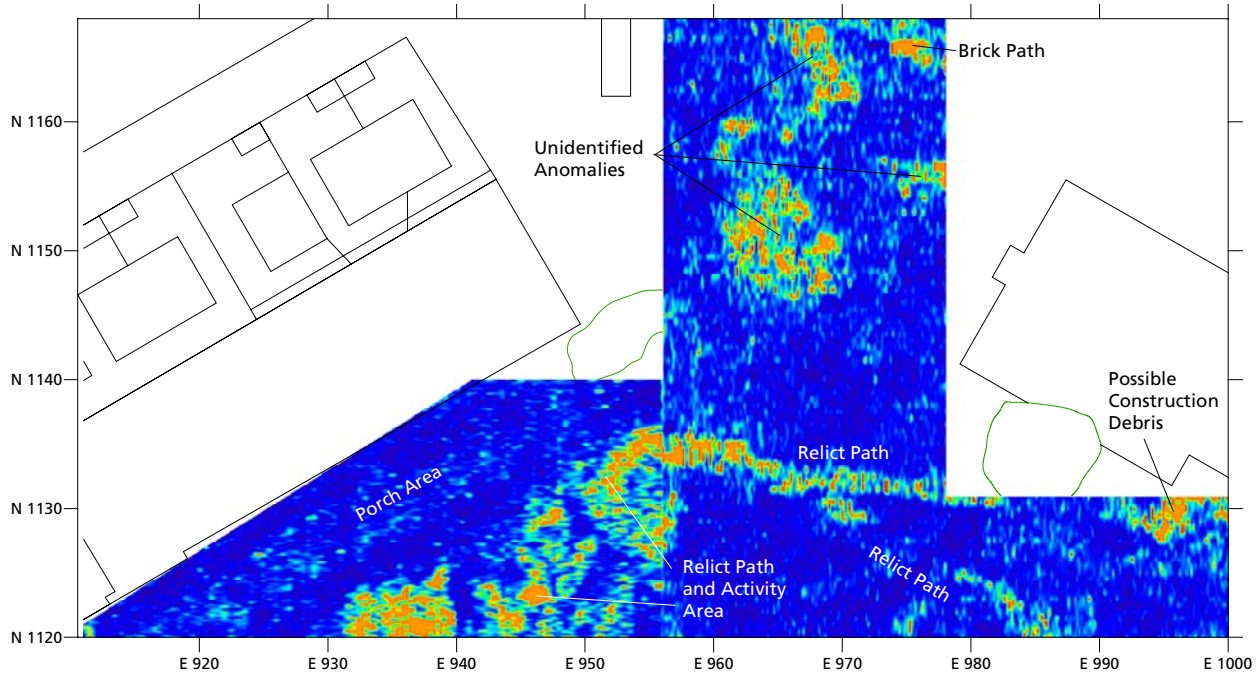

Figure 26. GPR time slice of Quadrant 2 from 45 centimeters below the surface.

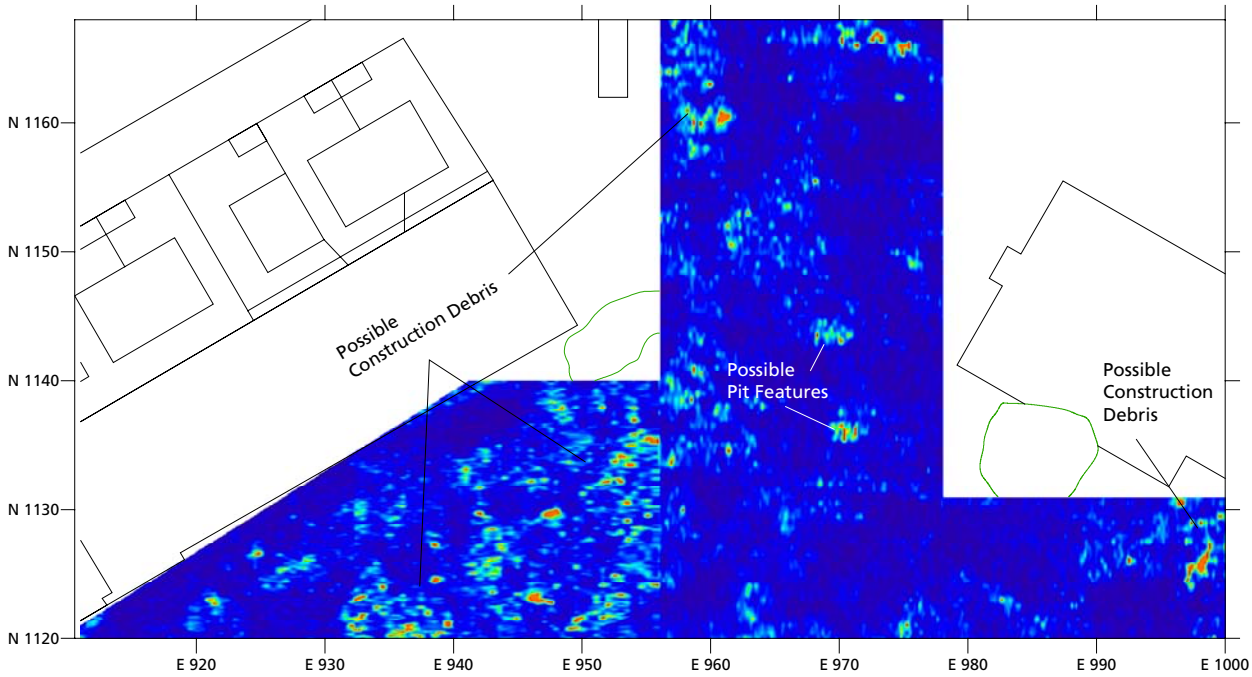

Figure 27. GPR time slice of Quadrant 2 from 91 centimeters below the surface.

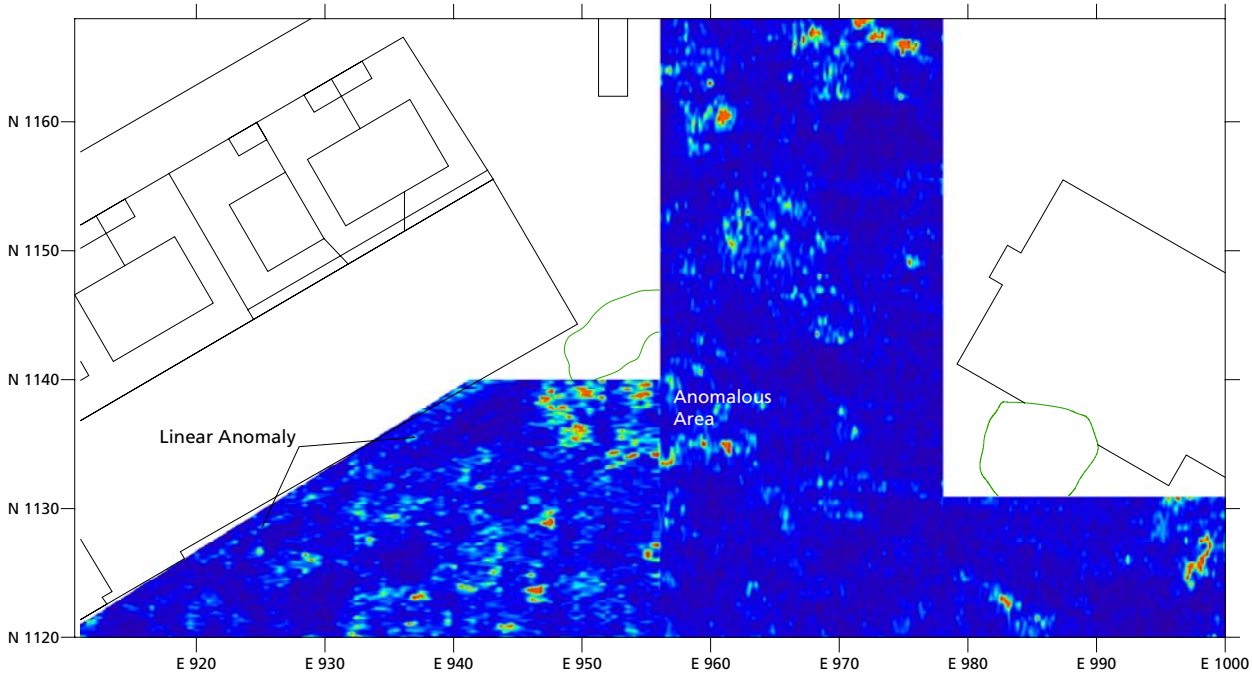

Figure 28. GPR time slice of Quadrant 2 from 1.13 meters below the surface.

from, and parallel with, the southern wall of the officer's quarters. This feature is no doubt a foundation component of the building's original ground floor veranda/patio. At N 1125, E 920 meters on the project grid the linear anomaly can be seen to turn into the wall of the officer's quarters ruins. This indicates that the linear anomaly is associated with the veranda and balconies of the original building (Figure 29), which was completed in 1848, and not expanded to the size seen today until 1862.

Figure 29. Historic view of the parade ground facing northeast. Image includes the original extent of the officer's quarters before it was expanded in 1862.

GPR Quadrant 3: Grids 17, 18, 19, 20, 21, & 23

GPR Quadrant 3 is made up of GPR grids 17 through 21 and 23 (see Table 1) on the western side of the parade ground (Figure 30). The quadrant includes a variety of modern features including two raised septic leach fields and several utility covers visible on the ground surface. In addition to the surface features, a pair of buried leach fields were known to be in the project area before the survey was begun. Historic features that were expected to be encountered during the survey included evidence of one of the original temporary structures, the storehouse that burned in 1857, and possibly other temporary structures built at later dates (see Figure 5).

Figure 31 displays the GPR results from the near surface reflections in Quadrant 3. Several buried features are displayed as well as a number of features that are visible on the ground surface. The most prominent features displayed are the two sets of oval shaped septic leach fields in the center of the quadrant. The northern-most set are a recent construction in raised mounds on the parade ground, the southern set are a buried feature that cannot be seen on the surface. It is possible to see the utility covers associated with each of the interior pipes of the leach fields on the north end of the raised beds. Besides the leach fields, three relict walkways can also be distinguished. The southernmost of the three paths identified in Figure 31 is possibly a modern feature associated with traffic in and out of the NPS maintenance area. The other two paths marked in the northern portion of the quadrant are historic walkways which lead from the front porch of the engineering officer's quarters to the officer's quarters, and from the officer's quarters toward the sally port of the fort (connecting to the westernmost path displayed in the surface data from Quadrant 1). A portion of the path leading from the engineering officer's quarters can be seen coming into contact with the northern edge of the raised leach field beds. This path was archeologically investigated in 2003 by SEAC after construction of the leach field inadvertently exposed a portion of it (personal communication, Margo Schwadron 2007, SEAC Accession 1842). The 2003 archeological investigations uncovered a portion of the path and determined that it was lined with brick and plastered across its surface (Figure 32). Also visible in the near surface reflection is a

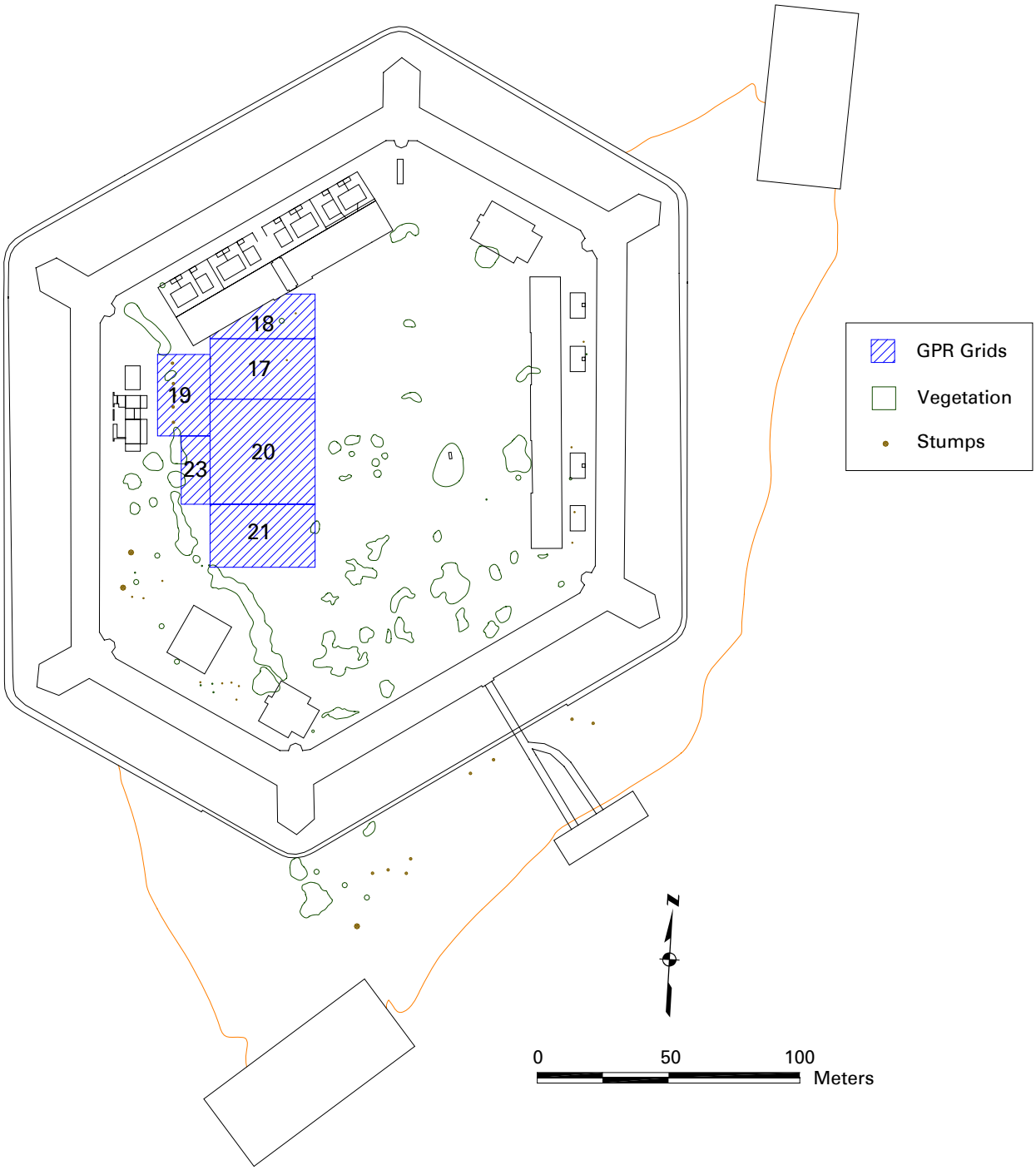

Figure 30. Location of GPR Quadrant 3.

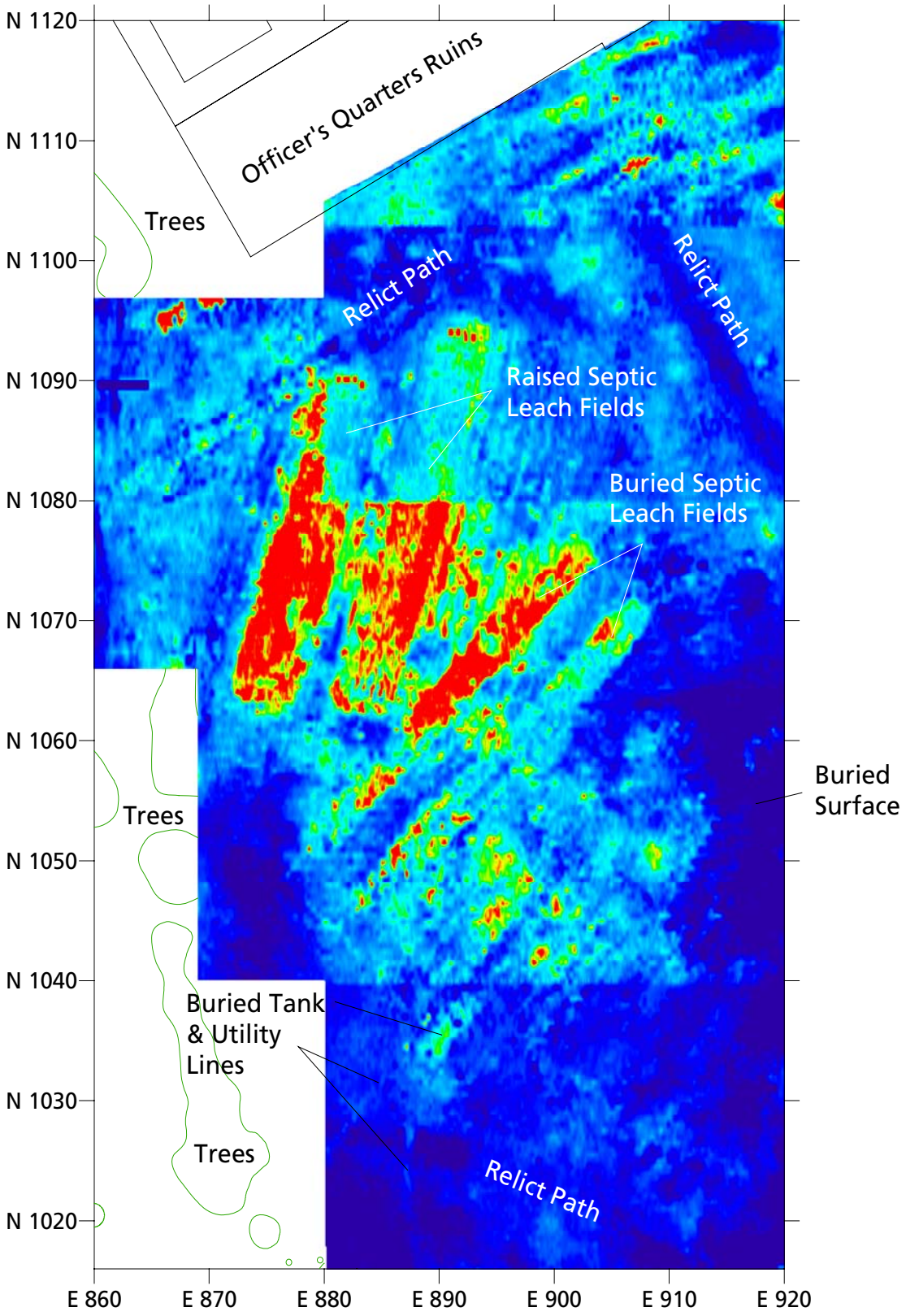

Figure 31. GPR time slice of Quadrant 3 from the near surface reflections.

dark, low amplitude area on the west side of Grid 20 and the northwest corner of Grid 21 that corresponds with the large rectangular anomaly from Quadrant 1 that was interpreted as a buried surface associated with gardens, livestock pens, or a muster area. Finally, a buried septic tank with two utility lines leading away from it can also be seen in the southern portion of the quadrant.

The time slice from 30 centimeters below the surface of Quadrant 3 (Figure 33) clarifies some of the surface features and exposes several new anomalies. The dominant features are still the two sets of leach fields, and it is now possible to identify the individual pipes within the two raised beds. A roughly rectangular shaped anomaly measuring three meters by four meters is centered on N 1079, E 901, just northeast of the northern buried leach field. This anomaly may be a modern utility feature associated with the leach field, or a potential historic feature of unknown origin. A similar, slightly larger (six by five meters), anomaly is centered on N 1100, E 902. This anomaly may also be either a modern utility associated with the septic fields, or an unidentified historic feature. The PVC water pipe first identified in Quadrant 1 can also be seen in Figure 33 extending to the northeast from the northeast corner of the southernmost leach field. The western portion of Quadrant 3 is dominated by north/south running utility lines, three of which are easily identifiable (probably iron pipes) at 30 centimeters below the surface. On the far western edge of the quadrant a band of high amplitude reflection is indicative of a trench, or series of adjacent trenches, that holds additional utilities that will become visible at a lower depth. A southeast oriented spur off of this trench feature appears to represent disturbance associated with more linear utilities running to the new, northern set, of leach beds. In the southern portion of the quadrant the buried tank identified in the near surface reflection has become more clearly visible, though the two utility lines running to its southwest corner are less apparent.

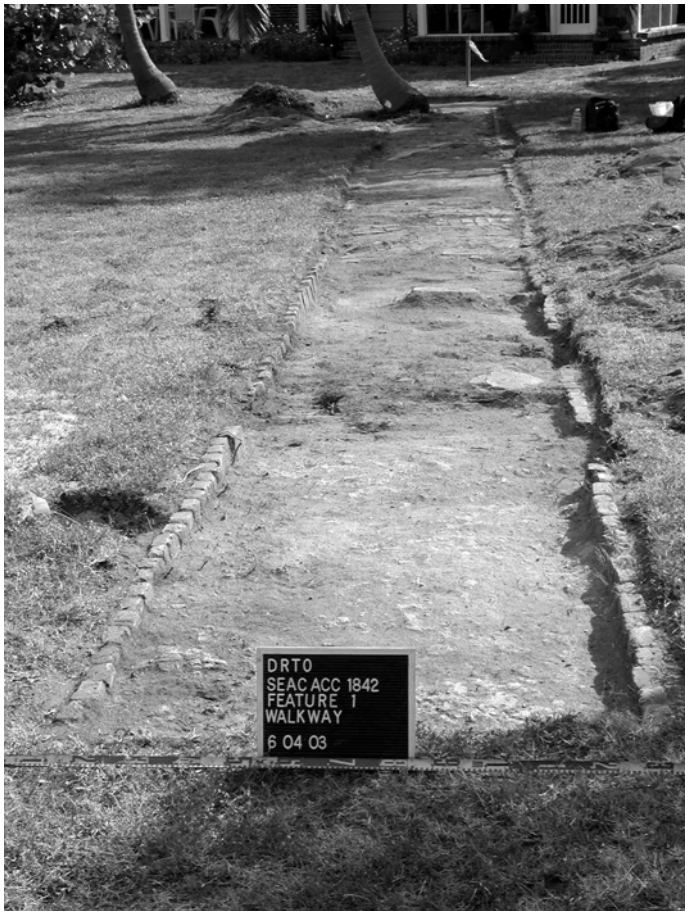

Figure 32. An excavated (2003) portion of the brick lined path running from the engineering officer's quarters to the officer's quarters. Photo facing west.

The final anomaly identified in Quadrant 3 at 30 centimeters below the surface is centered on N 1036, E 912 and is the most historically promising feature in the data set. It is roughly rectangular and corresponds in general size and orientation to the expected form of the temporary storehouse that burned in 1857. This particular anomaly is better visualized at a slightly deeper depth (Figure 34).

There are several anomalies in the GPR data from 67 centimeters below the ground surface of Quadrant 3 (Figure 34). At this depth it is possible to see the moisture associated with the newer, active, leach fields. The leaching water is visible as a high amplitude reflection under the raised beds' pipes, and it is possible that either the beds are not distributing the water equally, as the wettest area is in the southern half of the western bed, or some variation in the soil

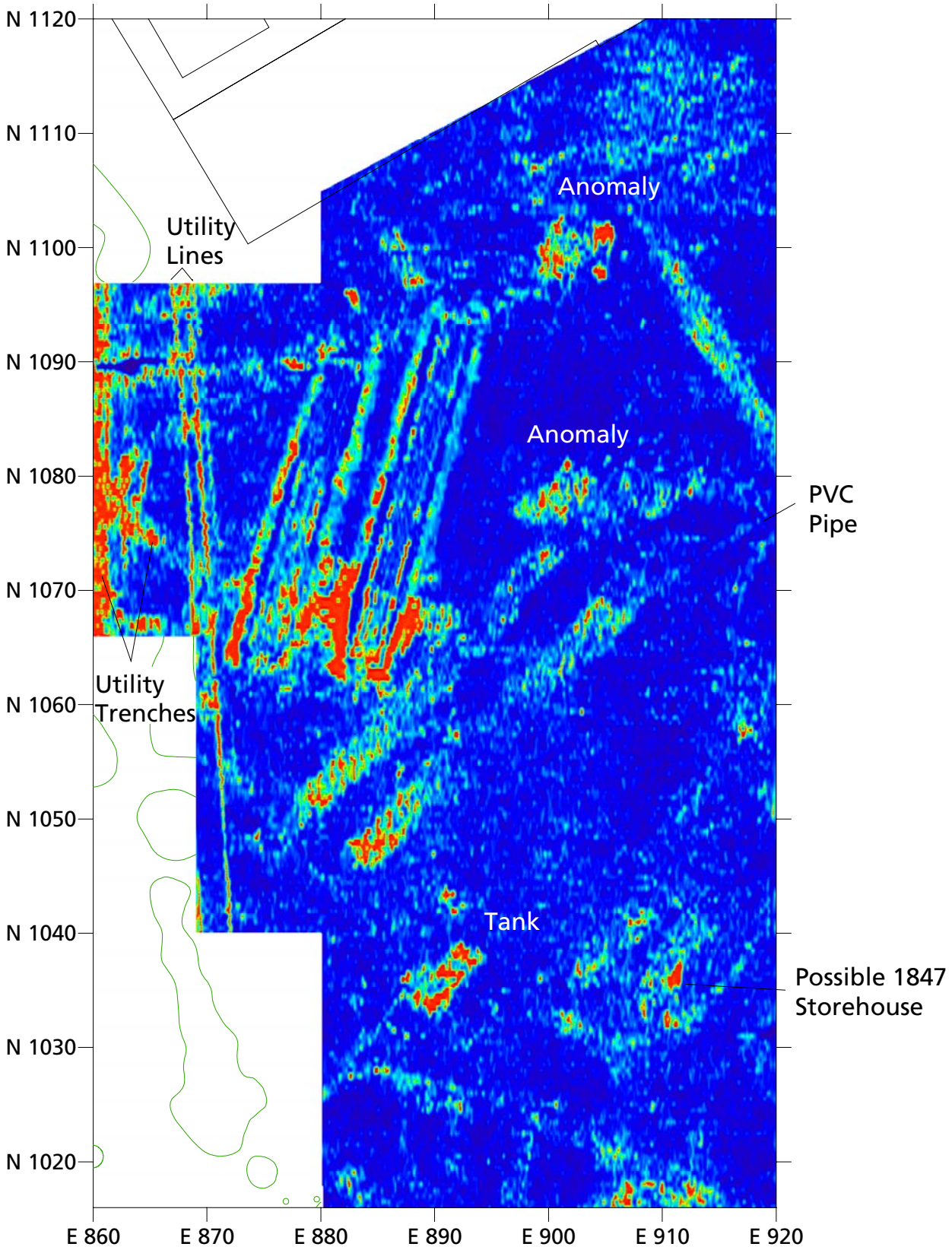

Figure 33. GPR time slice of Quadrant 3 from 30 centimeters below the surface.

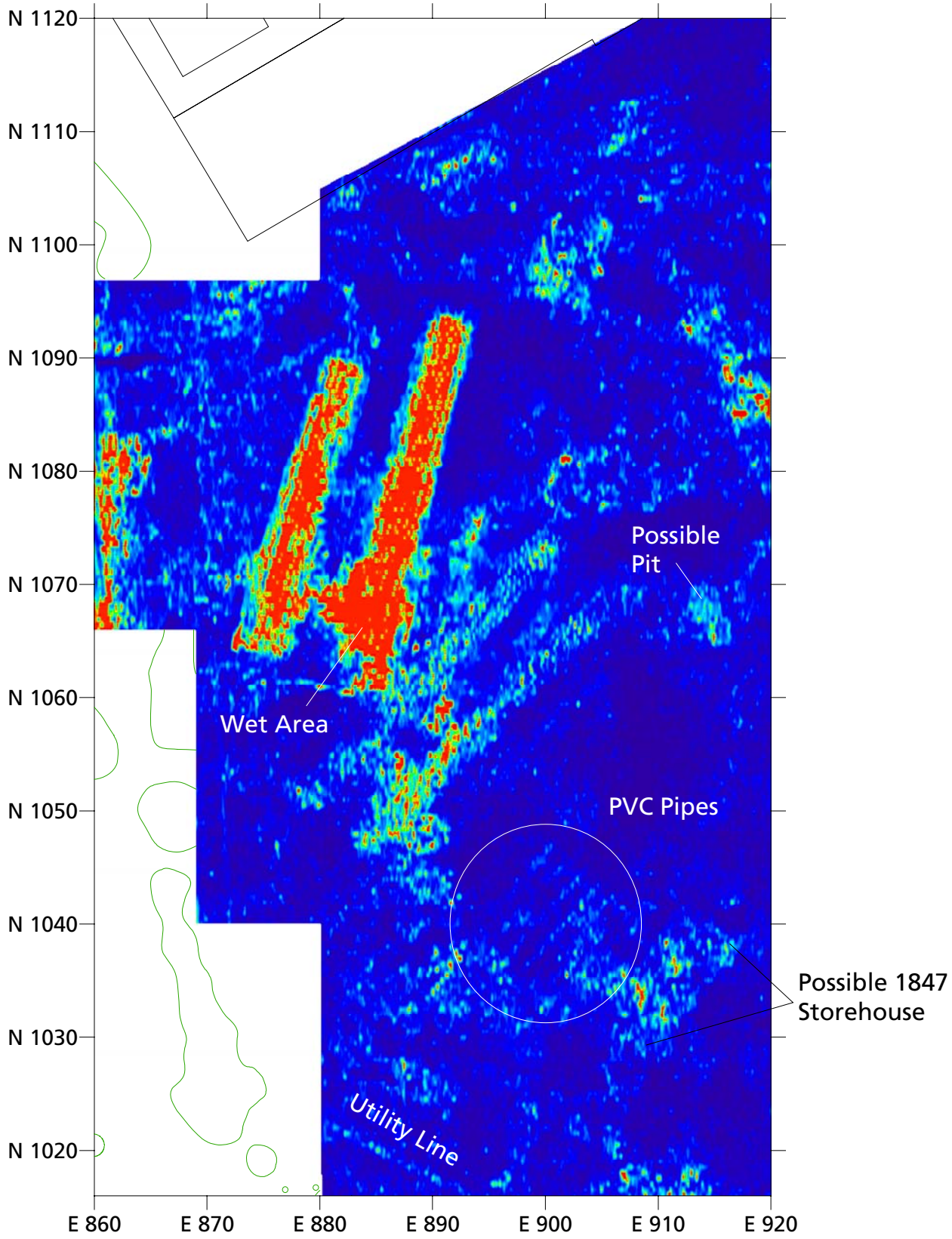

Figure 34. GPR time slice of Quadrant 3 from 67 centimeters below the surface.

around that part of the leach field allows it to hold more moisture than the surrounding area. Another modern linear utility is visible at this depth in the southwest corner of Grid 21 running in a southeast direction from E 880 to E 885. In the west central portion of the quadrant there is an unknown anomaly that appears to be roughly circular in shape and may be a shallow pit feature. The primary feature of interest at this depth is the rectangular anomaly in the in the southeast corner of the quadrant. This is the same anomaly identified at 30 centimeters below the ground surface, but at this increased depth its shape is more clear. It appears to be a buried surface and may represent the partial floor of the temporary frame storehouse. Immediately adjacent to the rectangular feature are five parallel linear anomalies generated by perforated PVC pipes attached to the septic tank visible in Figure 33. These pipes and the tank are part of a now defunct sanitary sewer system installed in the early 1980s.

The final data view presented for Quadrant 3 is from 1.27 meters below the ground surface (Figure 35). At this depth, the bases of the two rectangular features (first identified at 30 centimeters) off the northeast corner of the northern leach field and the northwest corner of the southern leach field can be seen. Some of the north/south running linear utilities in the trench on the western edge of the quadrant are also visible. Lastly, an area of reverberated high amplitude reflection associated with the large buried surface in the center of the parade ground was recorded at this depth.

GPR Quadrant 4: Grids 24, 25, & 26

GPR Quadrant 4 is made up of three GPR grids (24, 25, and 26) that are isolated from the rest of the parade ground survey, but still placed on the same overall project area grid (see Table 1). The quadrant is located south of the engineering officer's quarters and east of the NPS maintenance area occupying the first tier on the west side of the fort (Figure 36). By the late 1860s, at least one large temporary structure that was used as a lumber shed (Bethel 1979) had been built in Quadrant 4 (Figure 37), and other activities may have taken place in the area prior to that time. However, the area has been heavily impacted by the installation of buried utility systems since the National Park Service assumed management of the fort, and prior to the survey it was unknown if any portion of Quadrant 4 would be found free of modern impacts.

After processing the GPR data from Quadrant 4 it was clear that no portion of the quadrant was unimpacted by modern utilities. Figure 38 presents the near surface results and data from a slice cut at 30 centimeters below the surface. In the image, a number of utilities can be seen running north/south along with a rectangular tank serviced by a buried pipe running toward the northeast corner of the quadrant. The only features not attributable to modern utilities are the low amplitude reflections from the existing 1963 brick paved path in the southwest corner of the quadrant and the brick patio outside the entrance to the maintenance workshop on the west side (both visible in the surface reflection). Figure 39 shows two deeper time slices from Quadrant 4. In the 54 centimeter slice, more utilities become exposed in the east central portion of the quadrant. In the lowest slice presented, 71 centimeters below the ground surface, it is possible to see the deepest utility lines and reflections from the bases of several trenches that the other lines sit inside of. There were no anomalies identified in Quadrant 4 that resemble the expected form of a foundation for the lumber shed or any other historic feature. The number and pervasiveness of modern features buried in the quadrant suggests that if historic features had been present in this portion of the parade ground; little remains of them now.

GPR Quadrant 5: Grids 11, 13, 14, & 15

Quadrant 5 was made up of four individual GPR grids of various sizes (see Table 1) located in the southeast portion of the parade ground to the south and southeast of the soldier's barracks (Figure 40). It was hoped that surveying this portion of the parade ground would reveal archeological remains associated with the Italy

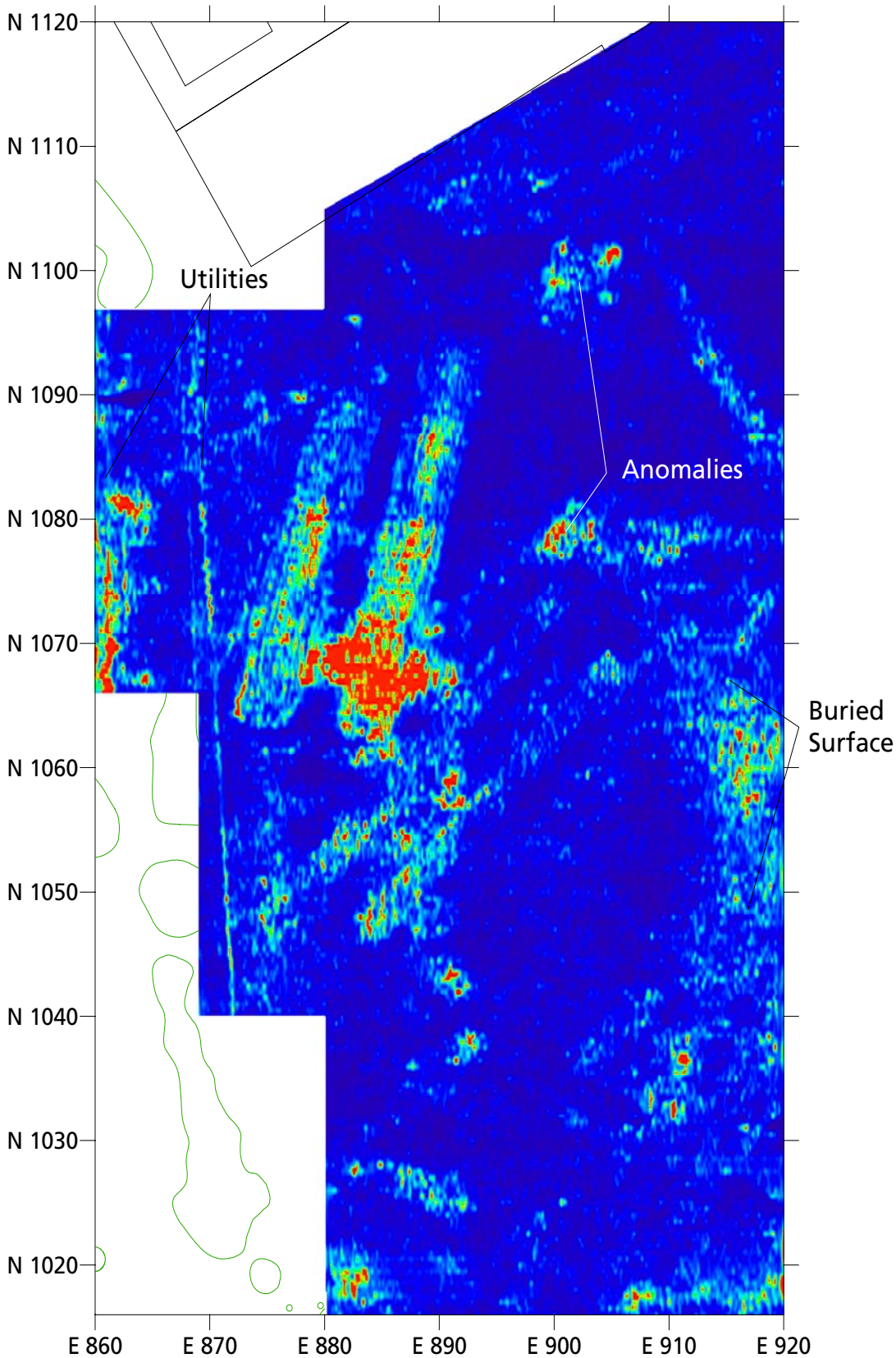

Figure 35. GPR time slice of Quadrant 3 from 1.27 meters below the surface.

Figure 36. Location of GPR Quadrant 4.

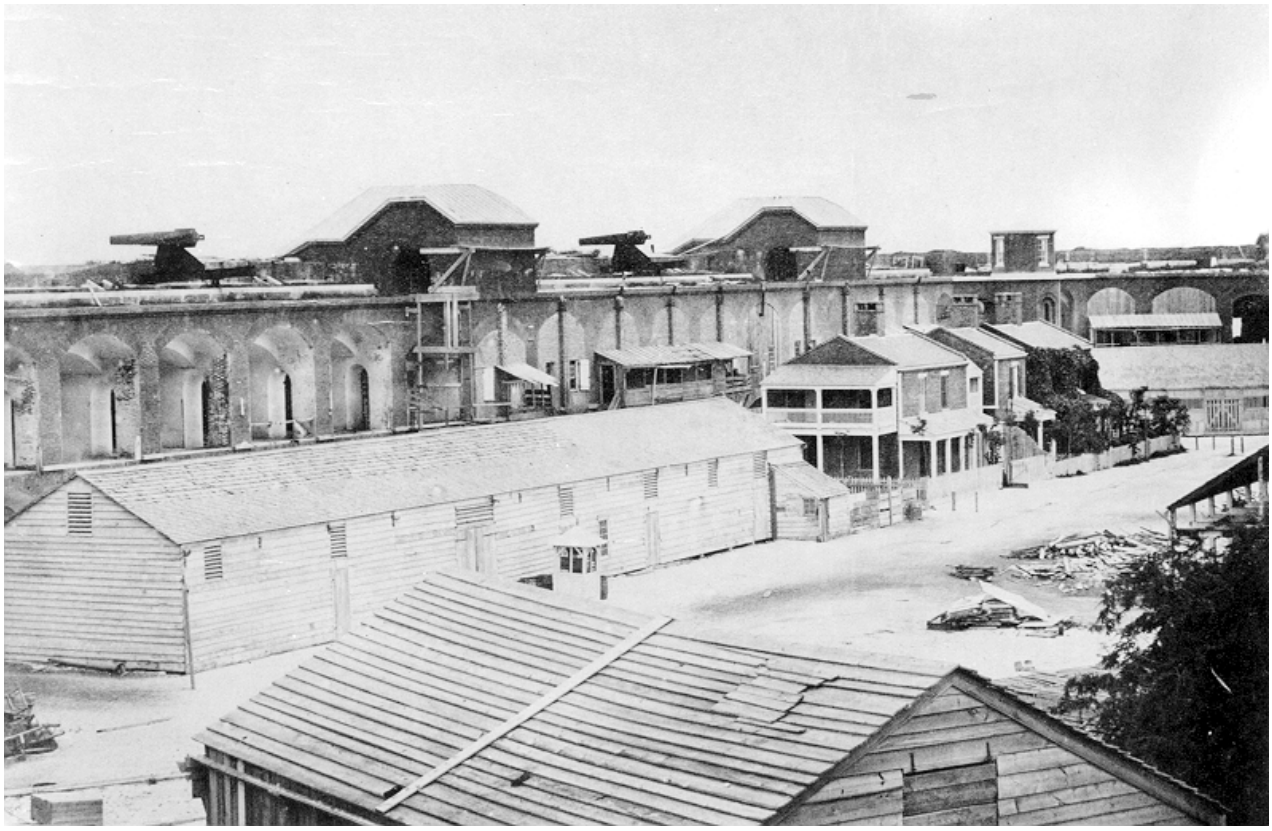

Figure 37. View of the southwest portion of the Fort Jefferson parade ground from the late 1860s. Image facing northeast. The brick engineering officer's quarters are in the background and the long frame building is a lumber shed.

grave, the foundation of the original lighthouse, the second lighthouse keeper's quarters and its associated outbuildings including a privy and chicken house, outbuildings associated with the first lighthouse keeper's quarters, and the possible material distribution road that partially circled the parade ground.

The near surface results of the GPR survey of Quadrant 5 are displayed in Figure 41. Several anomalies are readily apparent in the graphic. Three of the anomalies encountered are fully or partially visible on the modern ground surface, including the brick paved walkway in the southeast corner of the quadrant; the concrete foundation remains east of the Major Smith Monument; and a portion of the 1825 lighthouse foundation, the surface of which has been plastered with concrete and is partially exposed. The relict path leading to the officer's quarters and connecting with a walk identified in Quadrant 1, and the two circular anomalies in the west half of the quadrant are not visible on the modern ground surface. The northernmost of the two circular anomalies (at N 1045, E 977) is likely a reflection associated with the Italy grave, as it is a strong reflector positioned in the exact location indicated maps drawn of the fort when the grave was still marked on the surface. However, the deeper time slices do not continue to display an anomaly in this area, as would be expected if the grave had been dug to a reasonable depth (though if the body was not placed in a casket there may be very little variation in the soil matrix surrounding the grave and such a burial could be missed). The actual surface anomaly recorded for the grave may be associated with the remains of the above ground treatment applied to the grave site by Cuban fisherman who, in 1930, found the unmarked grave unacceptable and built wooden framing around the grave outline and placed a wooden marker above it. The second

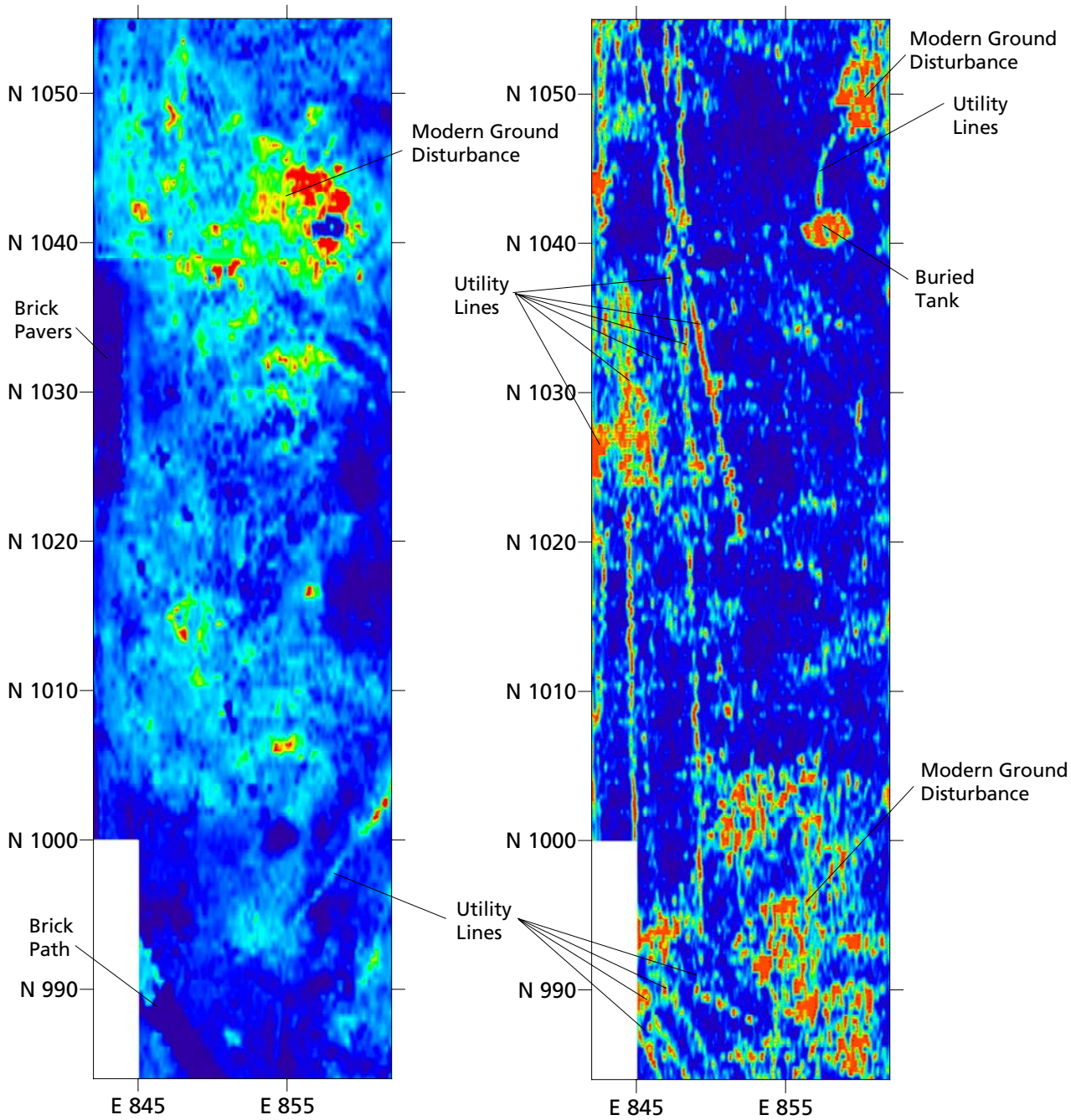

Figure 38. GPR time slices of Quadrant 4 from the near surface (left) and from 30 centimeters (right) below the surface.

circular anomaly; centered at N 1029, E 965; is of unknown origin but may represent a surface depression or be associated with tree roots from an adjacent bush. Also present in the data is a large area of high amplitude reflection surrounding the southern portion of the soldier's barracks and the 1825 lighthouse. This anomaly is probably a result of variation in compaction and content of the near surface soils associated with a high activity area around the lighthouse and barracks.

Moving to a depth only a few inches below the ground surface reveals quite a bit of variation in the radar results from Quadrant 5. Figure 42 shows the time slice from 15 centimeters below the ground surface and reveals

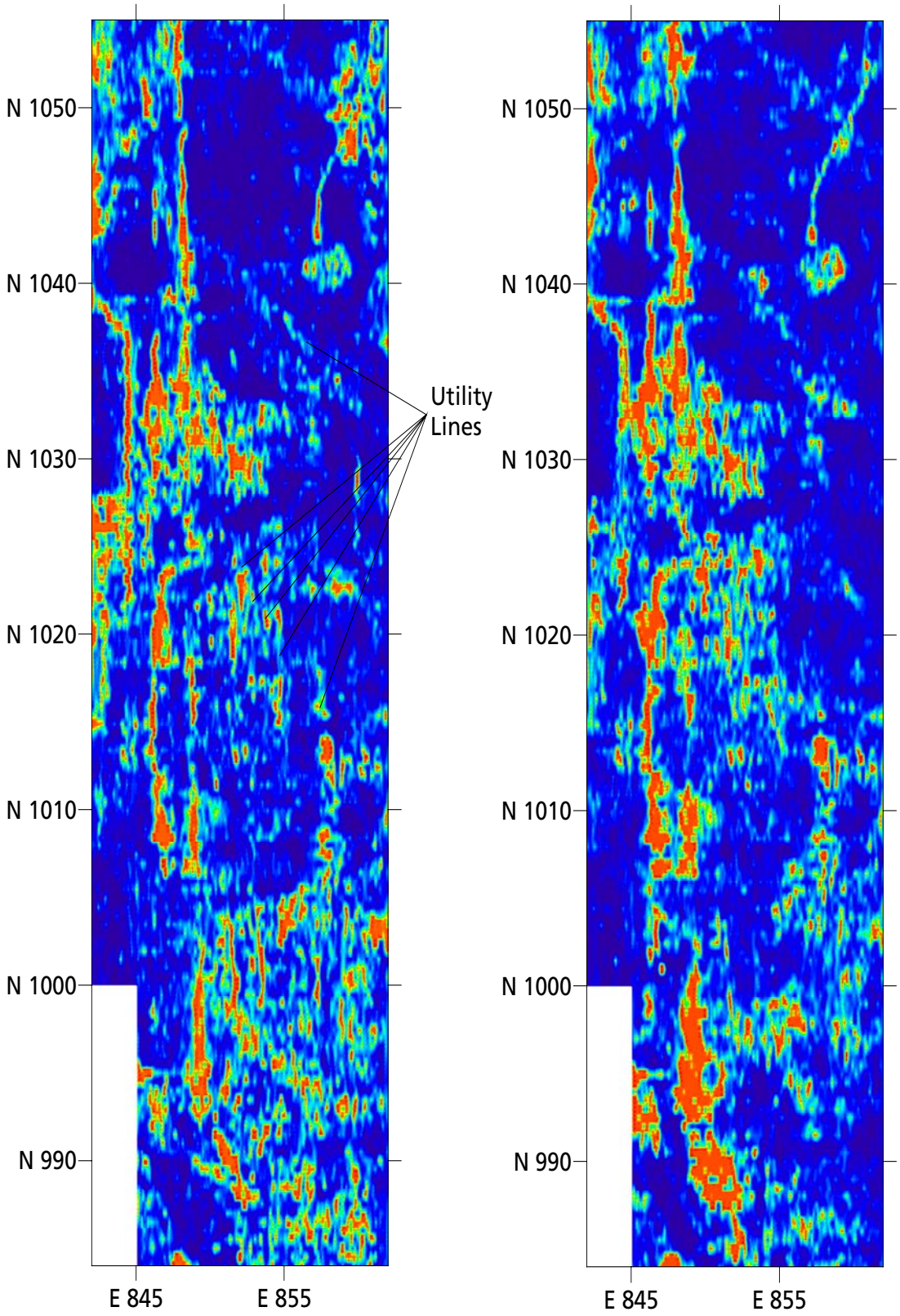

Figure 39. GPR time slices of Quadrant 4 from 54 centimeters (left) and 71 centimeters (right) below the surface.

Figure 40. Location of GPR Quadrant 5.

several new anomalies. In the southeast corner of the quadrant, south of the soldier's barracks, it is possible to see the remains of a relict road, presumably a portion of the material distribution route that brought building supplies from the sally port to the construction site of the soldier's barracks. The concrete foundations partially exposed on the surface east of the Smith monument are more clearly visible at this depth. There are also a number of small high amplitude reflections scattered throughout the center of the quadrant and around the foundation of Garden Key's original lighthouse; they are of unknown origin, but are presumably associated with the high activity area surrounding the structures in this corner of the parade ground. Along the southern edge of the quadrant there are two particularly large anomalies that may represent buried debris or some type of ground disturbance.

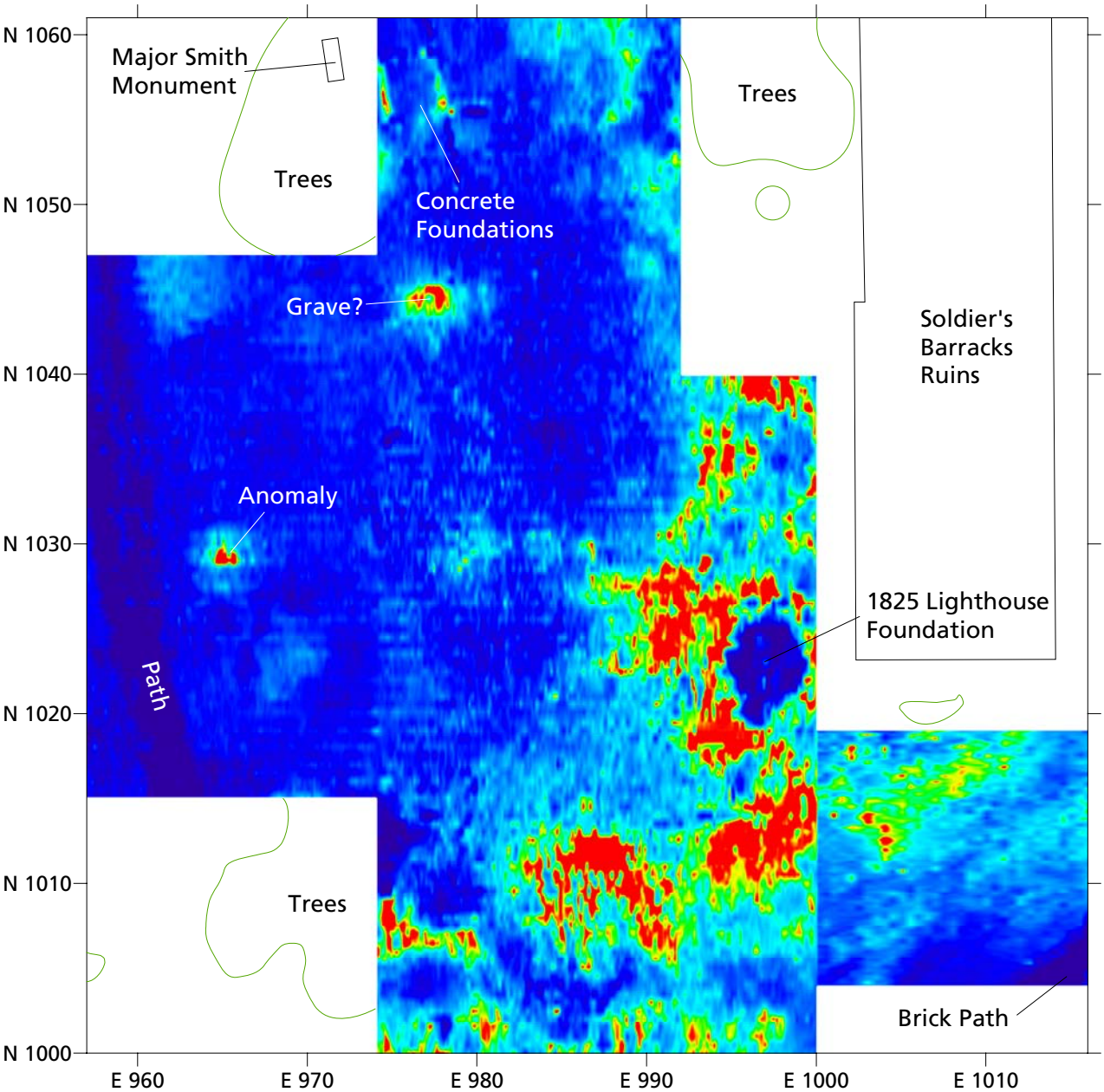

Figure 41. GPR time slice of Quadrant 5 from the near surface reflections.

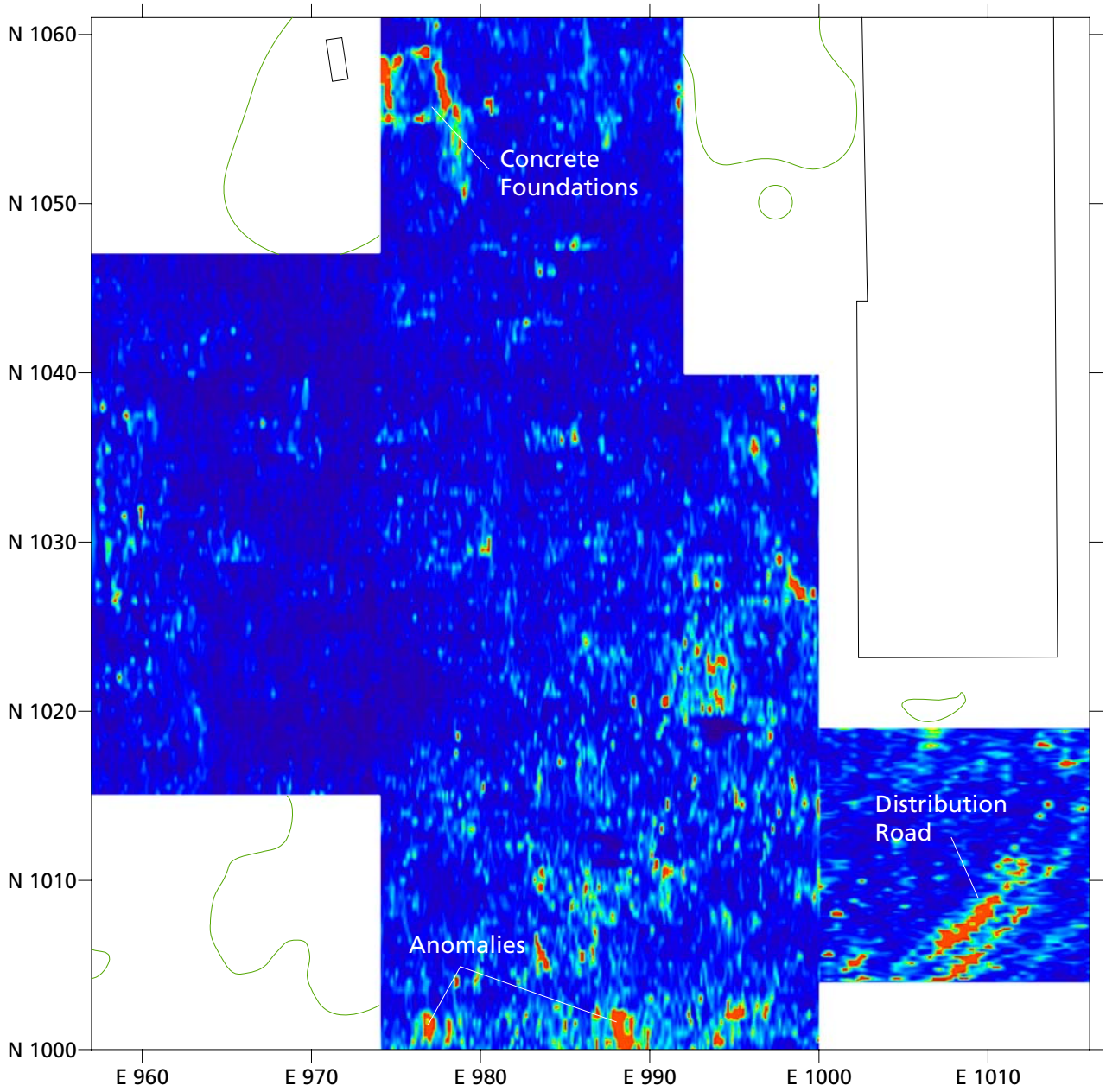

Figure 42. GPR time slice of Quadrant 5 from 15 centimeters below the surface.

At a depth of 50 centimeters below ground surface, some reflection associated with the distribution road is still present but most of the high amplitude reflectors scattered around the lighthouse foundation and the soldier's barracks are no longer apparent. In their place, two clear but amorphous anomalous areas are visible (Figure 43). These two regions of subtle reflection are located in the middle and northeast corner of Grid 13, and may be associated with prepared surfaces or may represent variations in soil compaction or chemistry resulting from previous positioning under or around historic structures. The anomaly in the center of Grid 13 is centered on N 1019, E 986 and measures approximately 10 meters square. This is roughly the size of the second lighthouse keepers quarters, though the GIS map geo-rectification exercise predicted this structure's location would be further south in

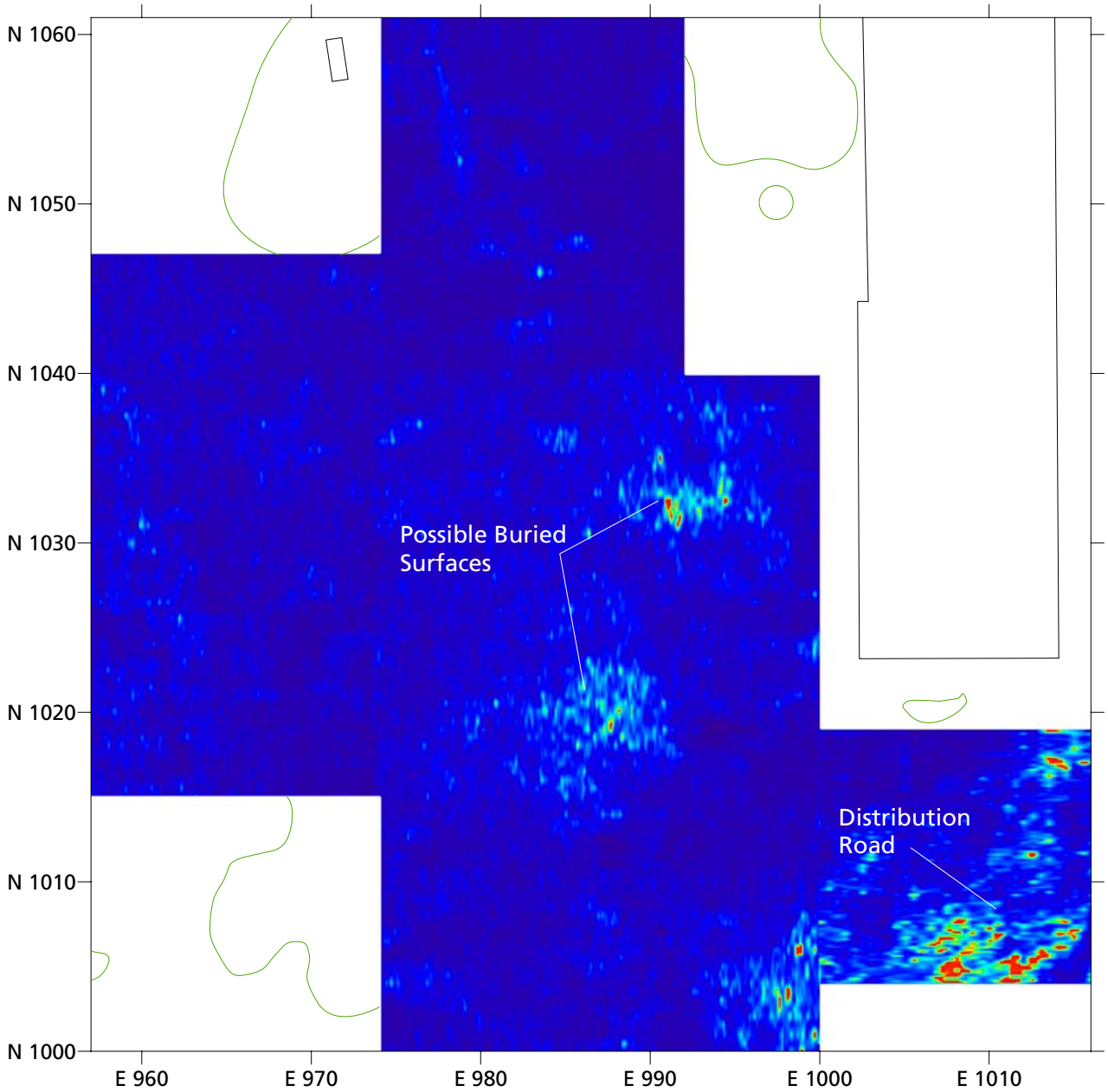

Figure 43. GPR time slice of Quadrant 5 from 50 centimeters below the surface.

Grid 13, with the fenced area surrounding the chicken house and privy instead appearing in this location (see Figure 11). The anomaly in the northeast corner of Grid 13 is centered at N 1034, E 992 and measures roughly five meters square. There was no expectation of a structure in this area, but if the central anomaly identifies the location of the second keeper's quarters, then this anomaly may be indicative of the fenced area and outbuildings.

Moving still deeper into the soil, another anomaly is revealed that may indicate a different location for lighthouse keeper's outbuildings. At 65 centimeters below the ground surface the reflection of a buried pit is revealed in the northern central portion of Grid 13 (Figure 44). Centered on N 1036, E 984.5 the pit feature measures two meters in diameter and may represent the remains of a shallow privy shaft. Other reflectors are present approximately 10

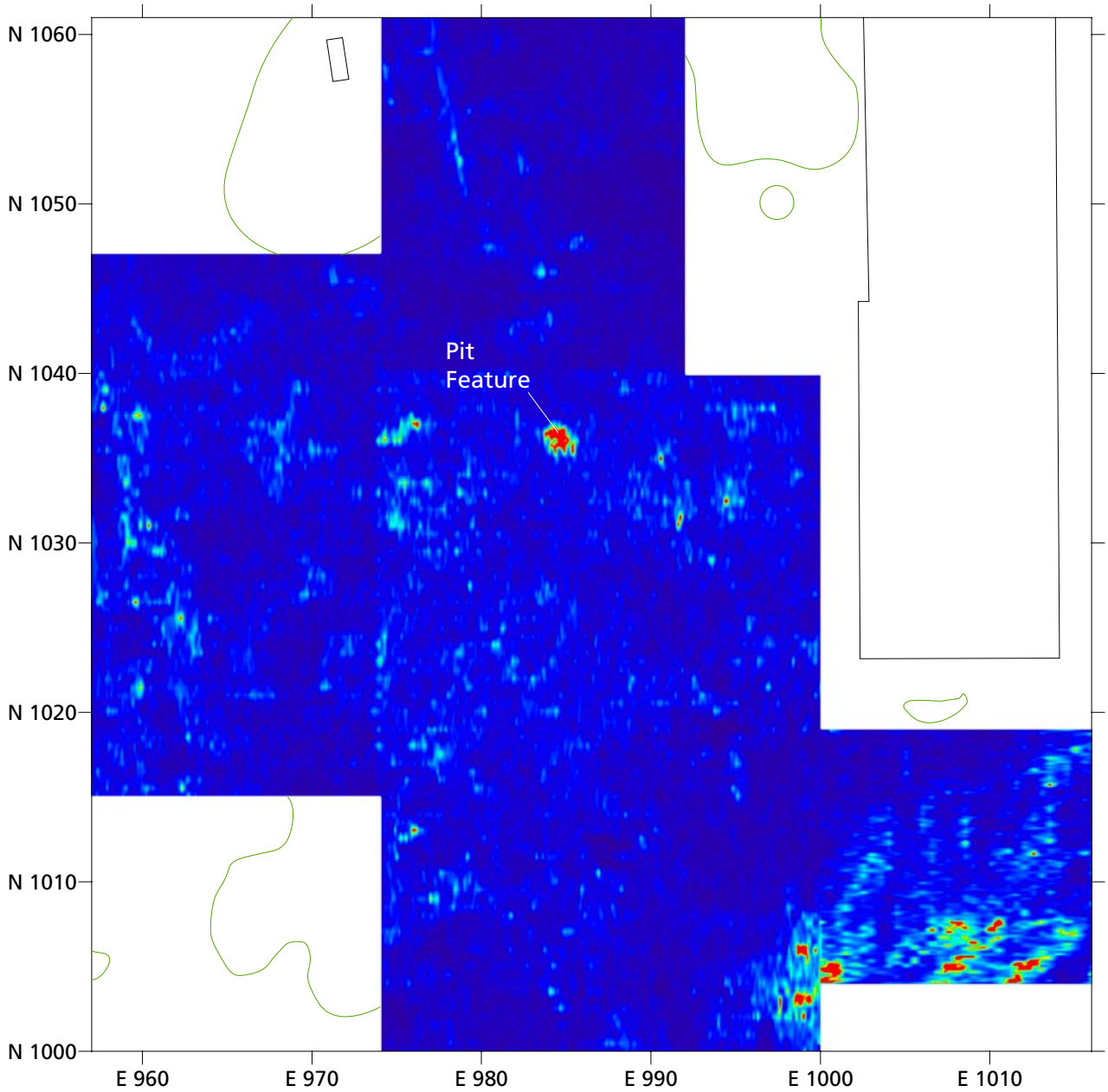

Figure 44. GPR time slice of Quadrant 5 from 65 centimeters below the surface.

meters west of the pit feature that could represent the remains of the other outbuildings associated with the second keeper's quarters. Unfortunately, since this pit does not correspond with either of the anomalies identified 15 centimeters higher, nor with the expected location of the privy based upon the historic map study, it is not possible to conclusively identify it as the privy without ground truthing through excavation.

One final view of the radar data from 1.34 meters below the surface is presented in Figure 45. The high amplitude reflections that cover much of this graphic are most likely associated with the interface of ground water. However, the figure is presented to illustrate the existence of a rectangular shaped low amplitude area in the southwest corner of the quadrant. This anomaly may be associated with the foundation or floor of one of the outbuildings north of the original keeper's quarters visible on the 1861 Garden Key conditions map (see Figure 9).

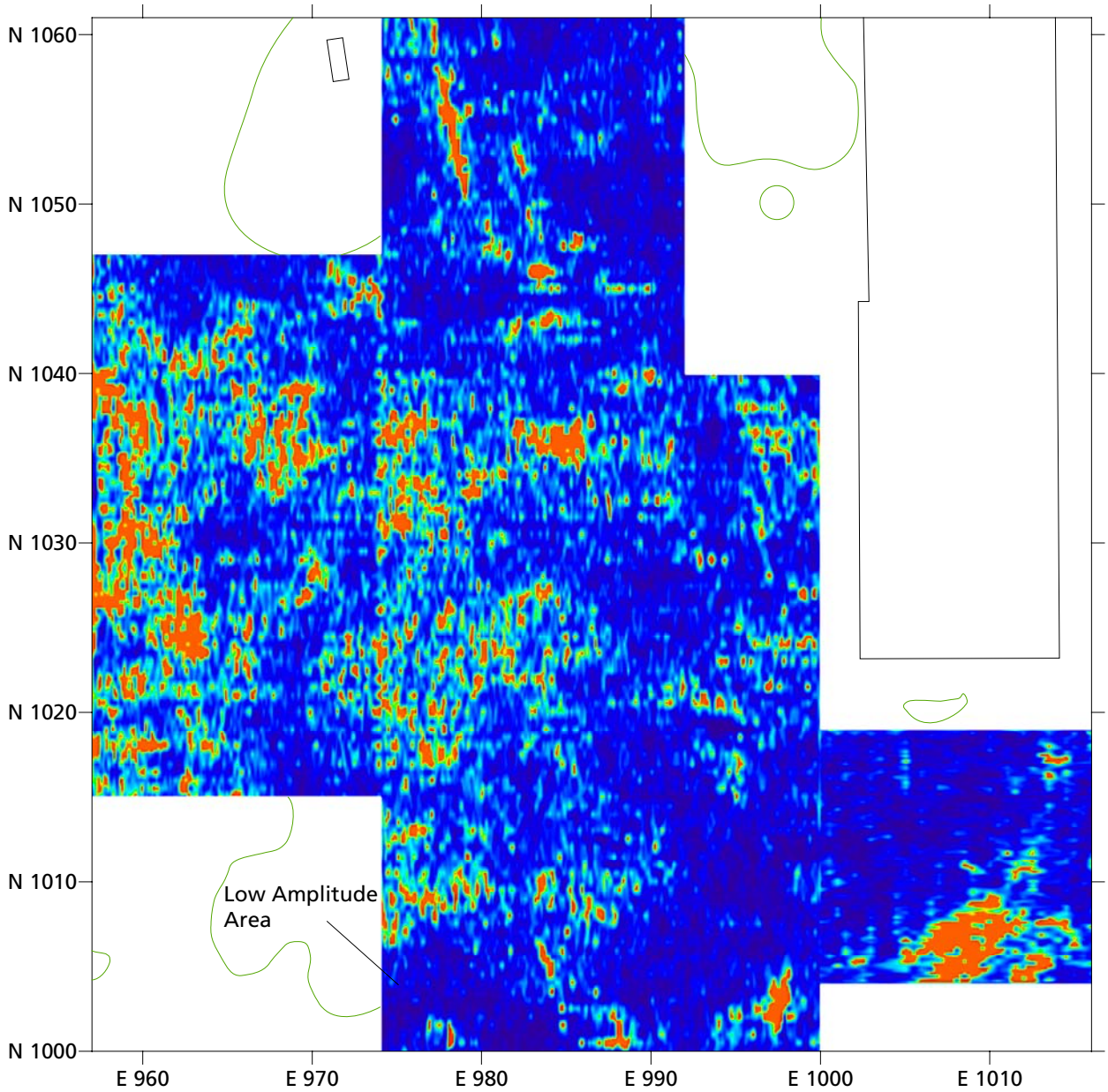

Figure 45. GPR time slice of Quadrant 5 from 1.34 meters below the surface.

GPR Quadrant 6: Grids 6, 7, 8, 9, & 10

Quadrant 6 (Figure 46) is made up of four GPR grids east of the soldier's barracks (Grids 7-10) and one grid north of the barracks and east of the large powder magazine (Grid 6). Table 1 lists the sizes and project grid locations of each of the individual grids in Quadrant 6. The only anomalies expected to be identified in Quadrant 6 were those associated with subsurface remains of the barrack's kitchens. The concrete foundation of the second kitchen from the south (in GPR Grid 9) remains on the ground surface along with bases of the brick chimneys from the northern two kitchens in Grids 7 and 8. No other kitchen remains are present above the ground.

Figure 47 presents the Quadrant 6 GPR results from the near surface and from a depth of 31 centimeters. In the near surface reflection, it is possible to see the modern brick paved path running north/south along the eastern side of

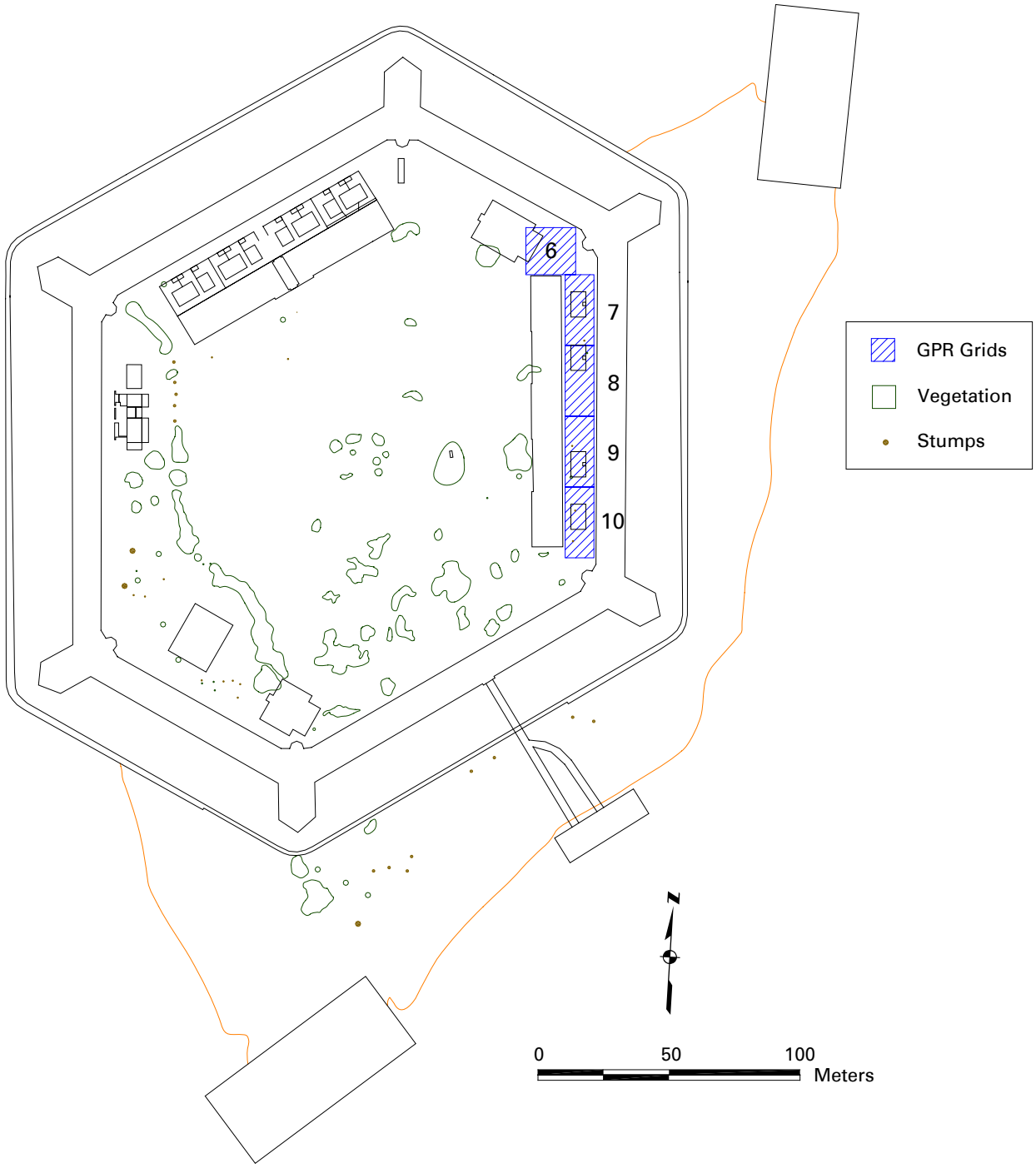

Figure 46. Location of GPR Quadrant 6.

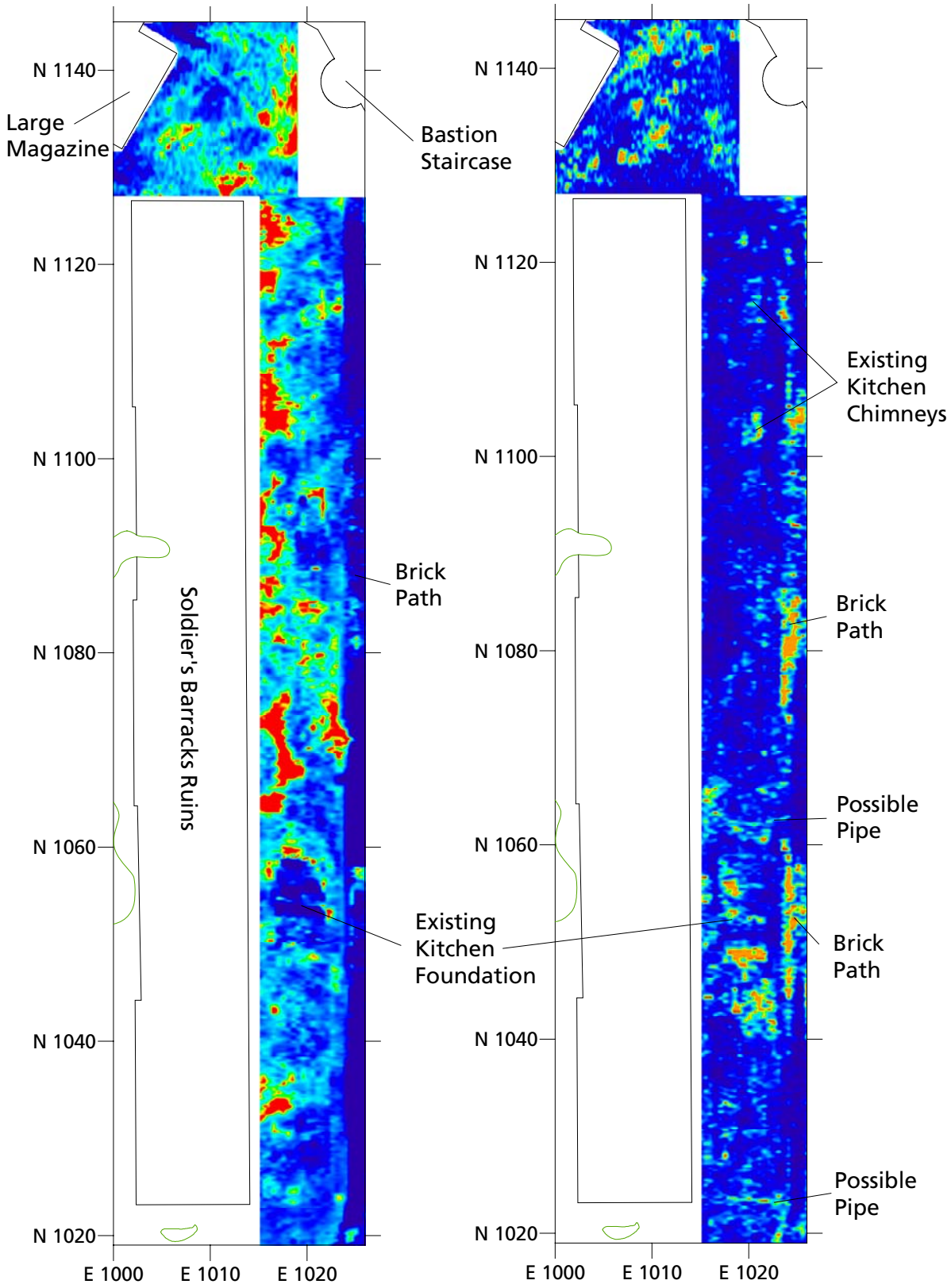

Figure 47. GPR time slices of Quadrant 6 from the near surface (left) and from 31 centimeters below the surface (right).

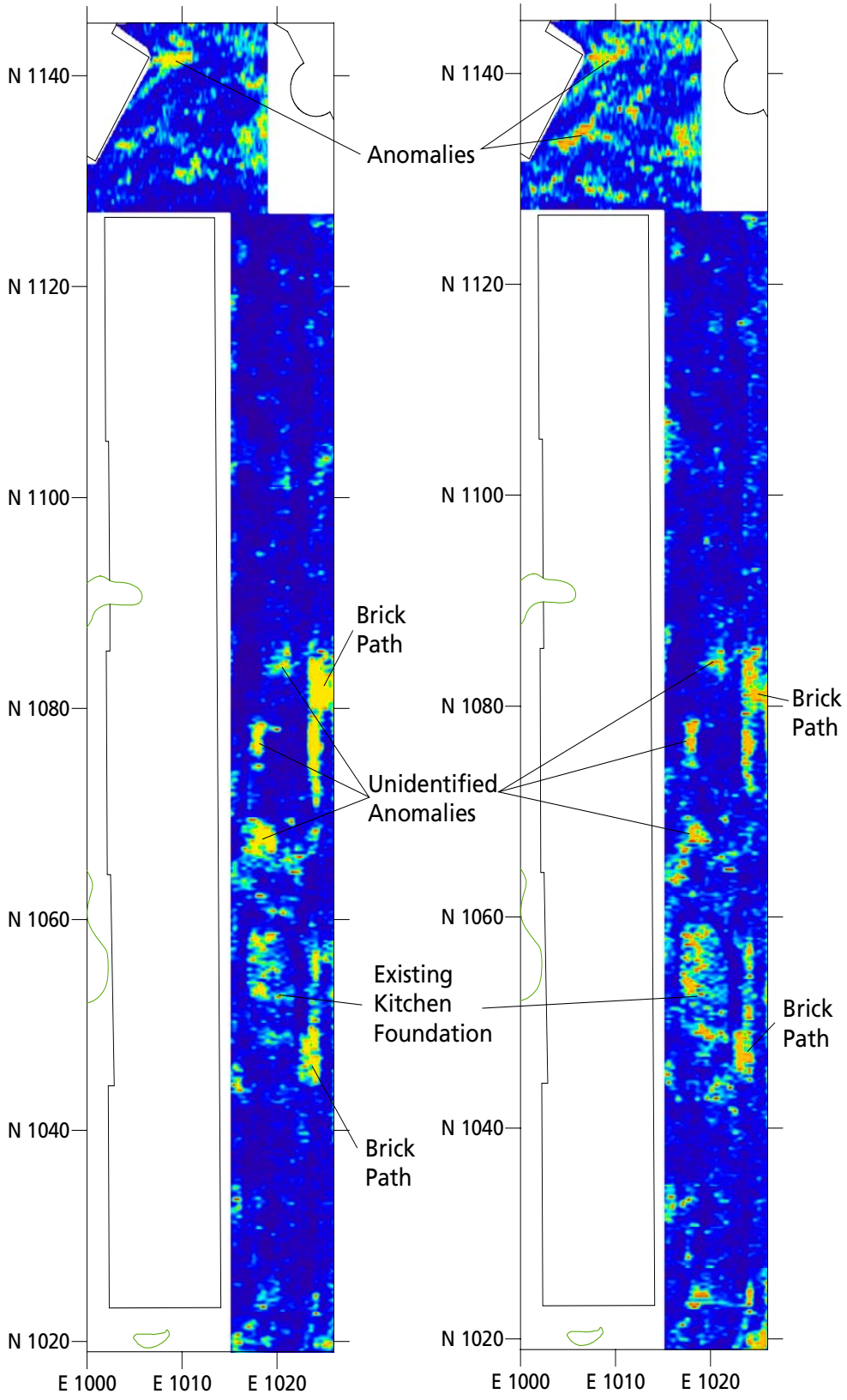

Figure 48. GPR time slices of Quadrant 6 from 54 centimeters (left) and from 65 centimeters (right) below the surface.

the quadrant, as well as a low amplitude reflection of the existing concrete kitchen foundation in Grid 9. Several areas of high amplitude reflection throughout the near surface time slice are most likely associated with slight depressions of the ground surface. At 31 centimeters below the ground surface the reflection of the brick-paved path, though broken, is still visible, and the one existing kitchen foundation still persists as well. Also present are reflections associated with the existing brick chimneys in Grids 7 and 8, and two possible pipes running from the barracks toward the casemates on the east side of the fort. However, no evidence of the completely demolished kitchens, other than the two existing chimneys, is present.

Moving deeper into the ground, Figure 48 displays the radar results from 54 and 65 centimeters below the ground surface. In both views, it is still possible to see portions of the brick path and a well defined reflection from the existing kitchen foundation, but there is no sign of remains associated with the other three kitchens. What has appeared are three roughly rectangular shaped anomalies in the central portion of the quadrant in the area between the two sets of kitchens. There are no known historic features or structures to explain these anomalies; they remain unidentified pending ground truthing excavation. Figure 48 also displays several amorphous high amplitude anomalies on the east side of the large powder magazine. These features may be evidence of a disturbed buried ground surface associated with activity around the magazine, or they could represent buried debris associated with the construction of the magazine.

GPR Quadrant 7: Grids 21, 22, 27, 28, 29, 30, 31, 32, 33, 34, 35, & 36

The final GPR quadrant from the fort's parade ground includes 12 individual GPR grids of various sizes (see Table 1). Most of these grids are small because they were designed and placed in order to cover as much ground surface between trees and other obstacles as possible (Figure 49). The trees and vegetation are also responsible for the missing data gaps in the quadrant. One of the GPR grids in Quadrant 7, Grid 21, was also displayed as a part of Quadrant 3. It is unfortunate that Quadrant 7 had to be collected piecemeal and that there were areas that could not be surveyed, because several interesting historic features dating to the early construction period at the fort may be present in the area, including the carpenter's shop, the lime house, the blacksmith shop, the first storehouse, and the original lighthouse keeper's quarters.

The first time slice presented for Quadrant 7 is the near surface data (Figure 50). In this figure, a path can be seen leading from the sally port toward the maintenance area in the western casemates of the fort. This may evidence a relict path or it may be a soil compaction feature associated with modern vehicle movement. Portions of a second path can also be seen running north from the sally port toward the officer's quarters; this path connects with one originally identified in Quadrant 1. A portion of the expanded brick pavement can be seen around the interior of the sally port in the southeast corner of the quadrant; the pavement is surrounded by an area of moderate amplitude reflection associated with foot traffic from visitors entering the fort. Modern utility lines leading to a buried tank are also visible in the northwest corner of the quadrant.

Two anomalies are present in Figure 50 that may be associated with historic features. The first is a high amplitude reflection measuring approximately five meters square and centered on N 988, E 918 on the project grid. This anomaly shares the predicted location, orientation, and approximate size of the blacksmith shop that was built in 1847 and remained in use until its removal in 1870. The second anomaly of interest is a circular feature measuring two meters in diameter centered on N 1003.5, E 957.5. The identity of this anomaly is unknown, but it may be related to the outbuildings that surrounded the first lighthouse keeper's quarters. It has the appearance of a privy or cistern, but no such features were identified on any of the historic maps.

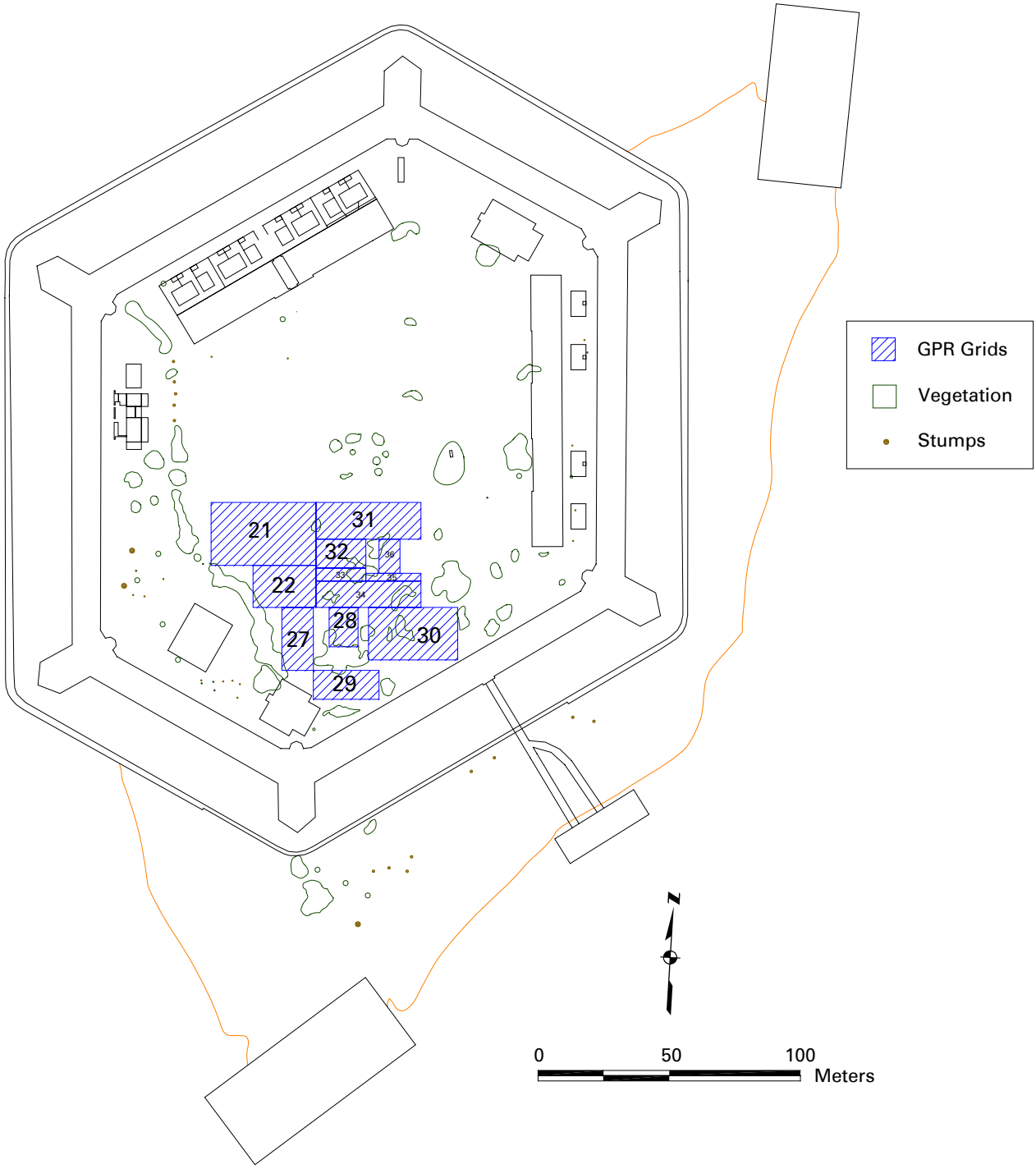

Figure 49. Location of GPR Quadrant 7.

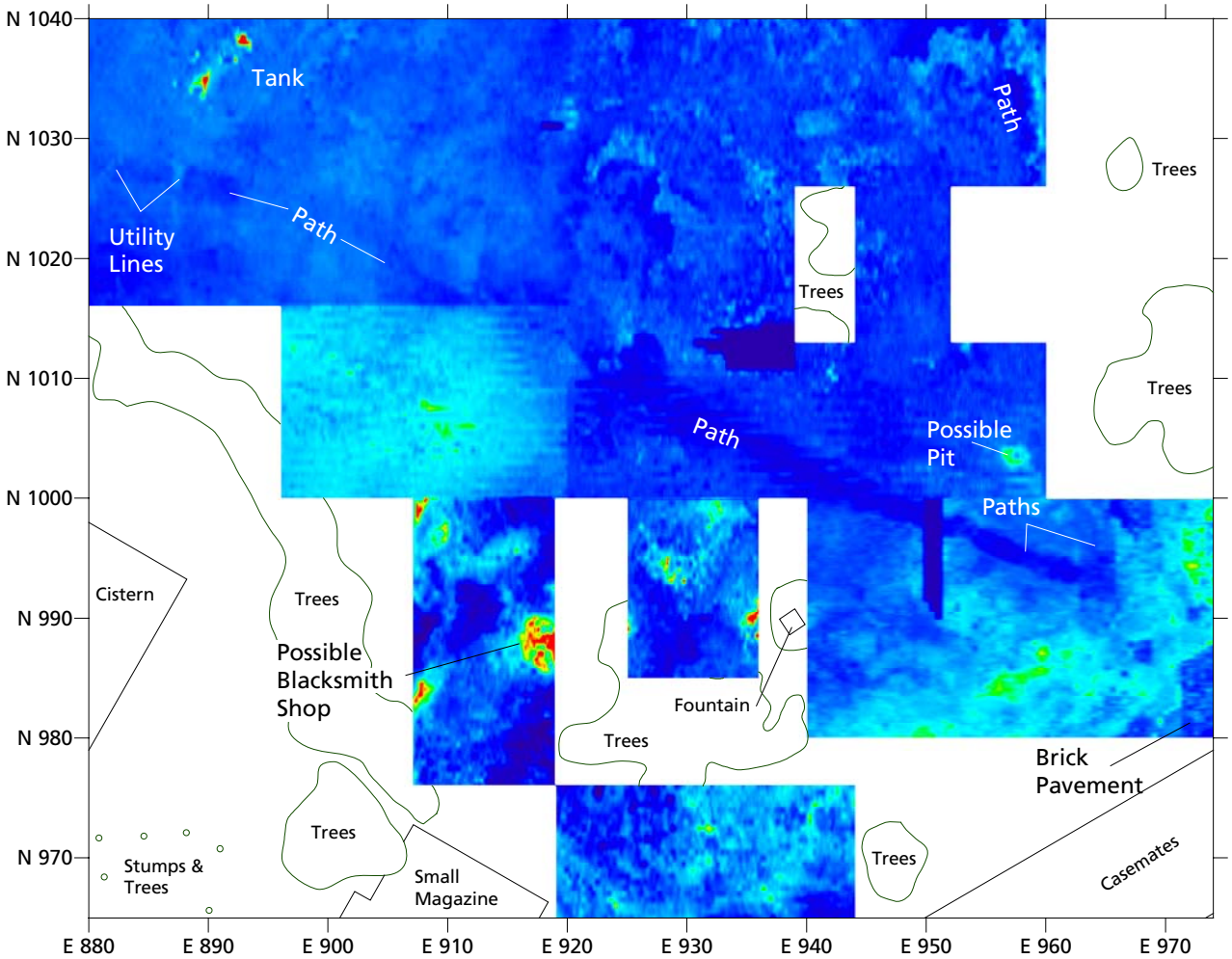

Figure 50. GPR time slice of Quadrant 7 from the near surface reflections. The dark bands in GPR Grids 30 and 33 represent missing data where collection was hindered by the presence of vegetation.

In Figure 51, the radar data from 25 centimeters below the ground surface of Quadrant 7 are displayed. Two buried utility lines are present, one in the southeast corner of the quadrant that runs from under the park office casemate toward the Audubon Fountain and a less distinct one in the southwest corner running north/south. A clearer view of the buried tank in the northwest corner of the quadrant is also visible at this depth. The possible pit feature identified in the surface reflection at N 1003.5, E 957.5 is still present at 25 centimeters of depth, but the high amplitude reflection noted in the expected location of the blacksmith shop has vanished. In the southwest and northwest corners of the quadrant there is high amplitude noise associated with modern foot traffic from park visitors and historic foot traffic on the path to the officer's quarters, respectively. In the north central portion of the quadrant (between N 1010 and 1030, and E 900 to 945) there are some amorphous reflections that may be associated with historic features. The historic maps indicate that the carpenter's shop and a portion of the lime house and storehouse would be present in this area. There are no patterns in the reflections that would indicate intact foundations of these buildings at this level, but the amorphous reflections could be indicative of activities associated with these buildings. The final anomaly of note in Figure 51 is a rectangular shaped low amplitude area in the southwest corner of the quadrant spanning GPR grids 27 and 29. This anomaly may

be associated with soil chemistry or moisture content and could represent either a modern or historic ground disturbance.

The final view of the GPR data from Quadrant 7 is from 50 centimeters below the surface and is presented in Figure 52. Reverberated reflections of the near surface walking paths and a continuation from the levels above of the possible pit feature and the utility line running to the Audubon Fountain can be seen at this depth. There is a new anomaly present in the southwest corner of Grid 21 at N 1019, E 882; its identity is unknown, but it is located below two utility lines running to the buried tank and may be a modern disturbance. The most obvious feature in the 50 centimeter time slice is a strong high amplitude area on the west side of the quadrant in opposition to the low amplitude areas on the east and south sides. There do not appear to be any discernible features or patterns within either the low or the high amplitude areas, but the variation is likely attributable to the activities around the temporary structures and the material left behind by such activities, such as lime and metallic debris.

GPR Quadrant 8: Outside the Parade Ground, Grids 37, 38, 39, 40, & 41

In addition to the GPR data collected within Fort Jefferson's parade ground, four grids (Grids 37, 38, 40, and 41) were laid out in the picnic and camping area outside the fort, south of the sally port. A single grid (Grid 39) was also placed inside of the first tier casemates west of the park office and east of Bastion 1 (Figure 53)

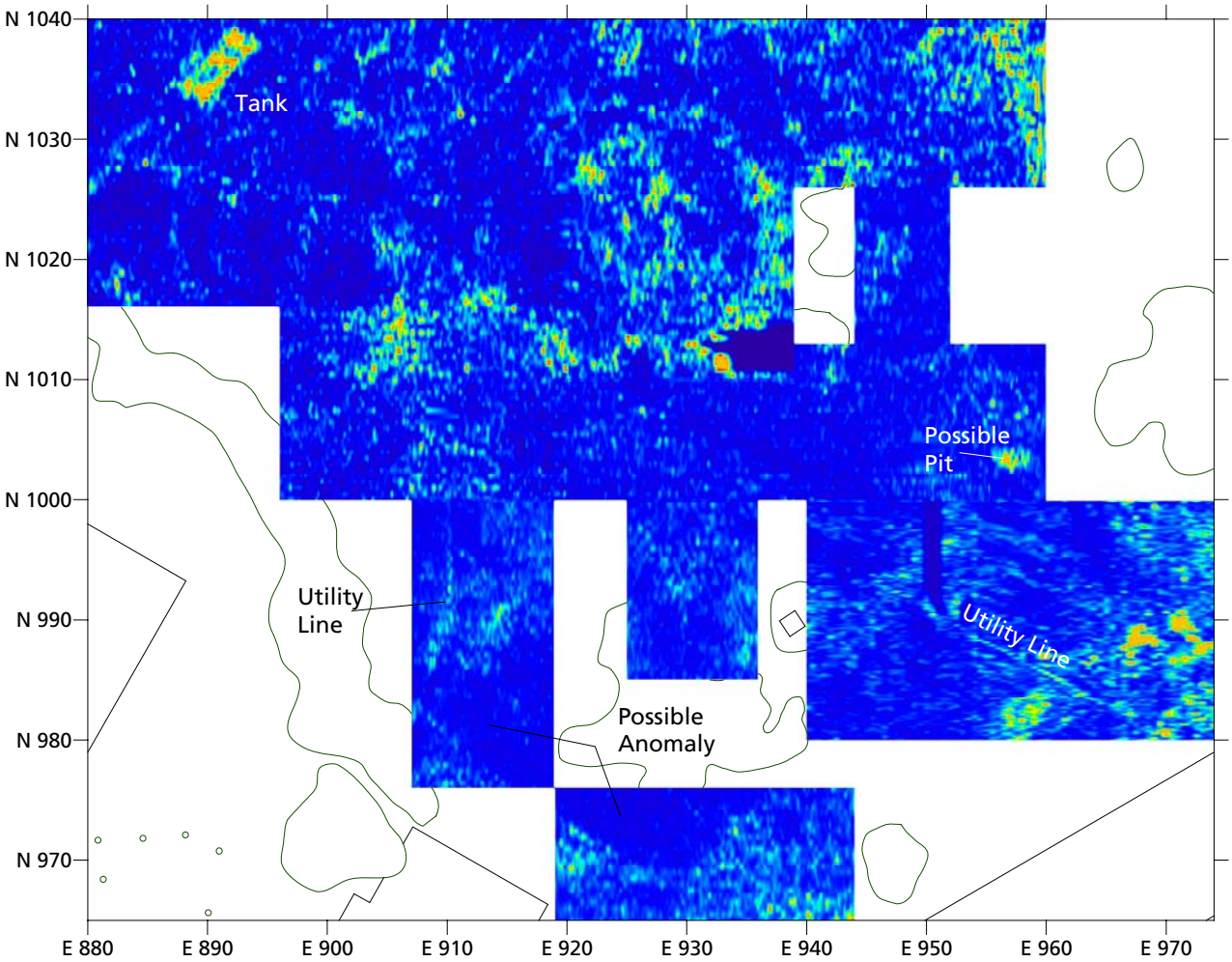

Figure 51. GPR time slice of Quadrant 7 from 25 centimeters below the surface.

(see Table 2). Survey of the four grids established on the beach was intended to determine whether any historic remains of structures associated with the fort's original construction camp or later use as a coaling station could be identified with the GPR. Presumably though, any such features that had not been physically removed had likely been lost to erosion some time ago. The single grid placed inside the first tier was established as a test to determine if the GPR could penetrate the stone, brick, and concrete of the casemate floor and image any of the construction features of the cisterns buried below the fort.

Results from the near surface data set collected from the four grids on the beach south of the fort (Quadrant 8) are presented in Figure 54. Several anomalies were encountered in the surface data including a footpath visible on the surface in Grids 37 and a vehicle path visible on the surface of Grid 40, as well as a reflection associated with a tree stump in Grid 38. The only anomaly of historic interest is associated with the remains of a concrete foundation in the northwest portion of the quadrant. The concrete is partially visible on the surface and represents a building foundation partially removed by the NPS in 1940 (the rectangular portion of the anomaly) and a portion of a concrete cistern wall (the angled feature slightly south of the rectangular foundation). The 1861 map of the fort displayed in Figure 5 shows a building in the same location as the concrete foundation and identified it as one of the structures used as barracks for the engineer workmen. However, given the number of buildings that were erected

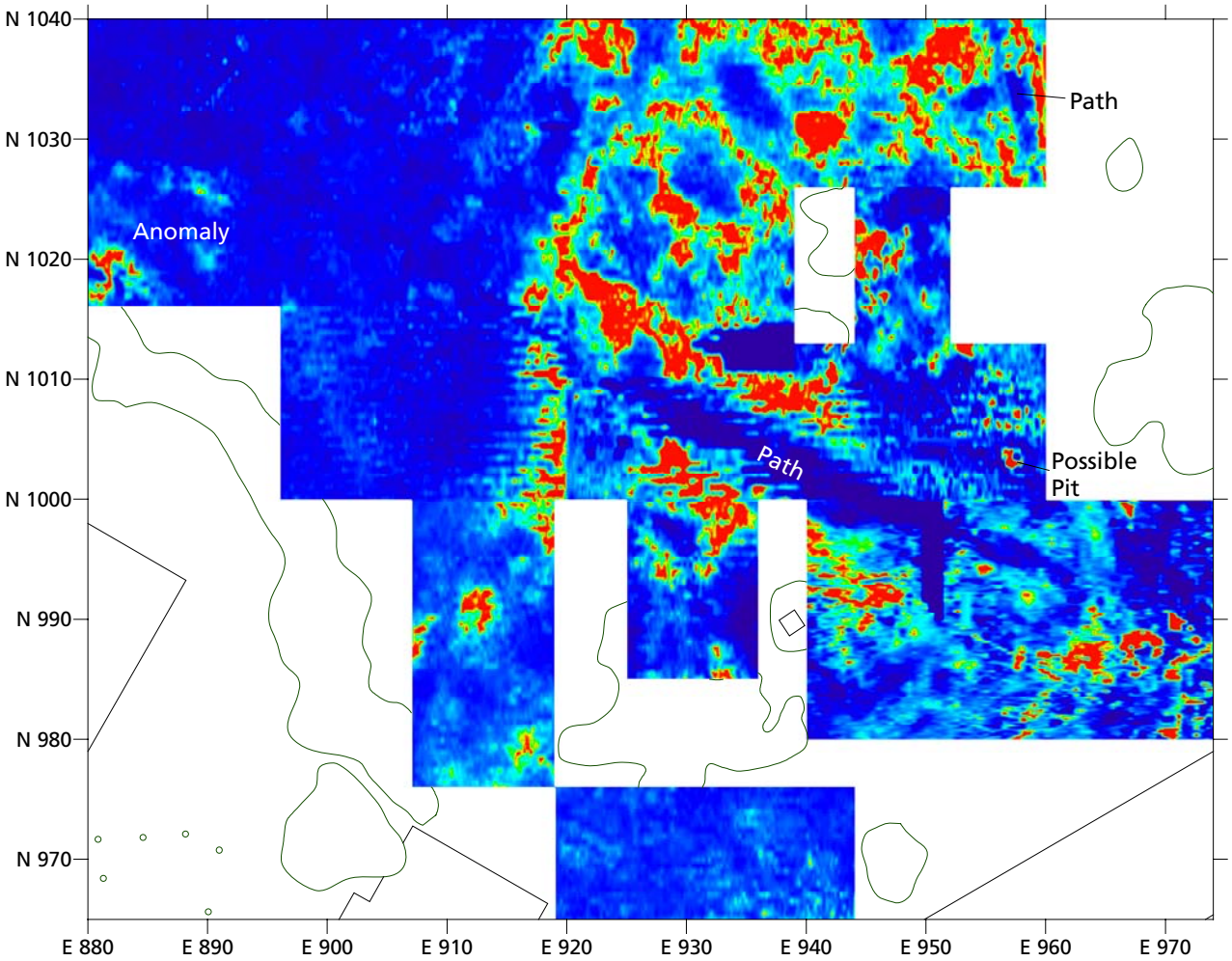

Figure 52. GPR time slice of Quadrant 7 from 50 centimeters below the surface.

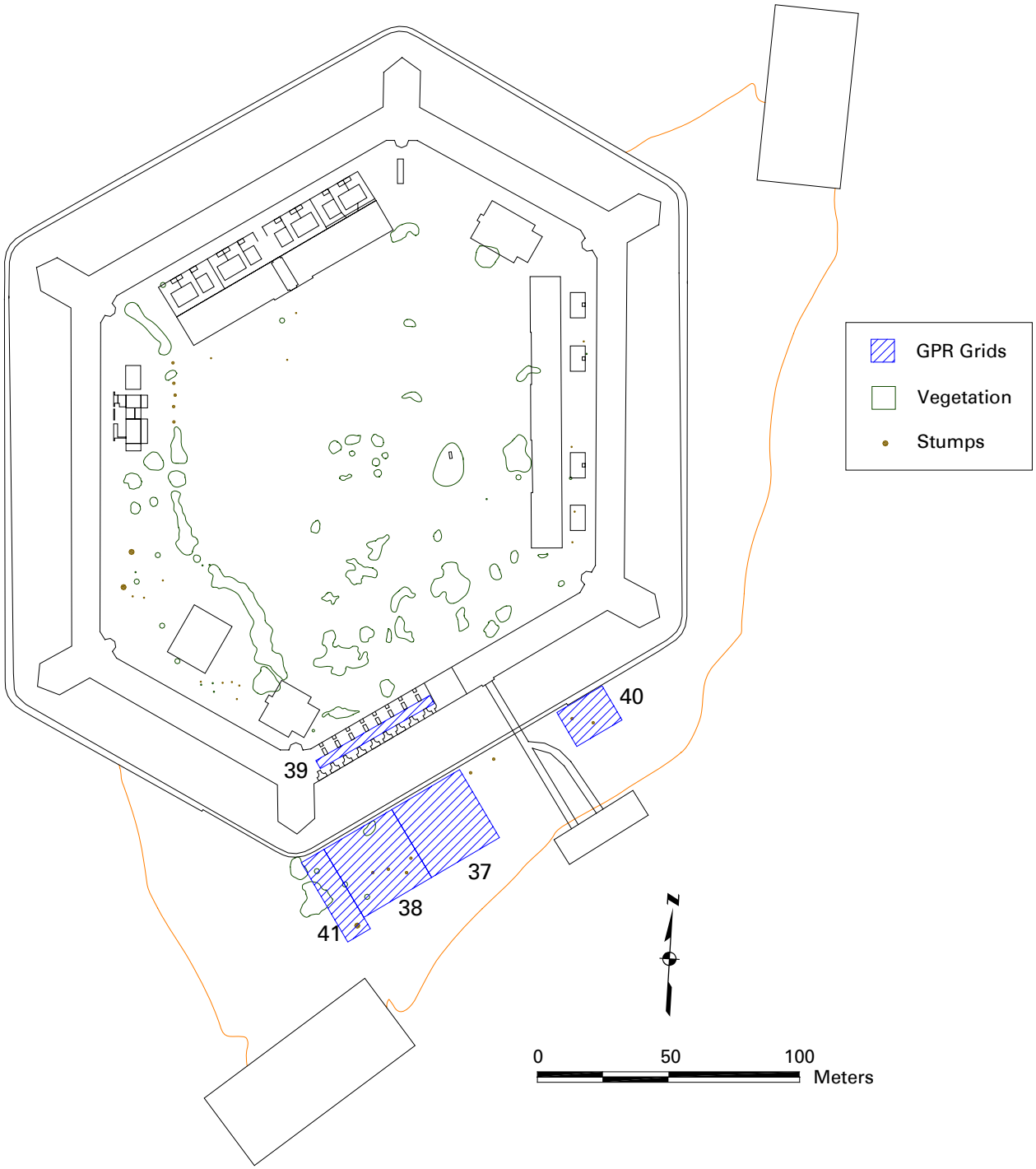

Figure 53. Location of the five GPR grids established outside Fort Jefferson's parade ground.

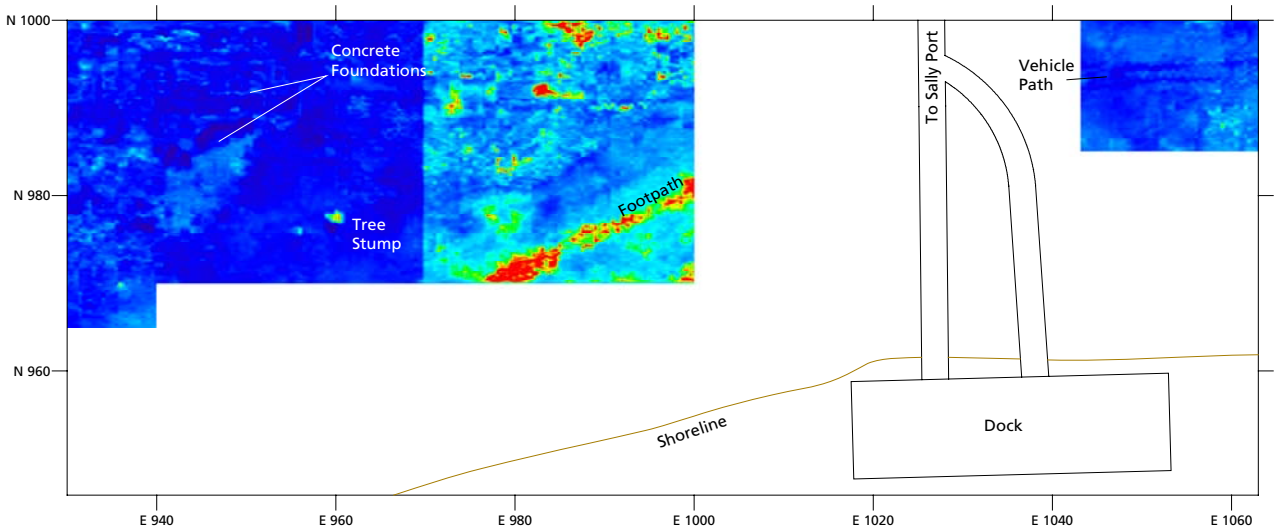

Figure 54. GPR time slice of Quadrant 8 from the near surface reflections. The amplitude variation between Grid 37 and the rest of the quadrant is the result of a rain shower that occurred after GPR data was collected in Grid 37 and before the rest of the quadrant was collected.

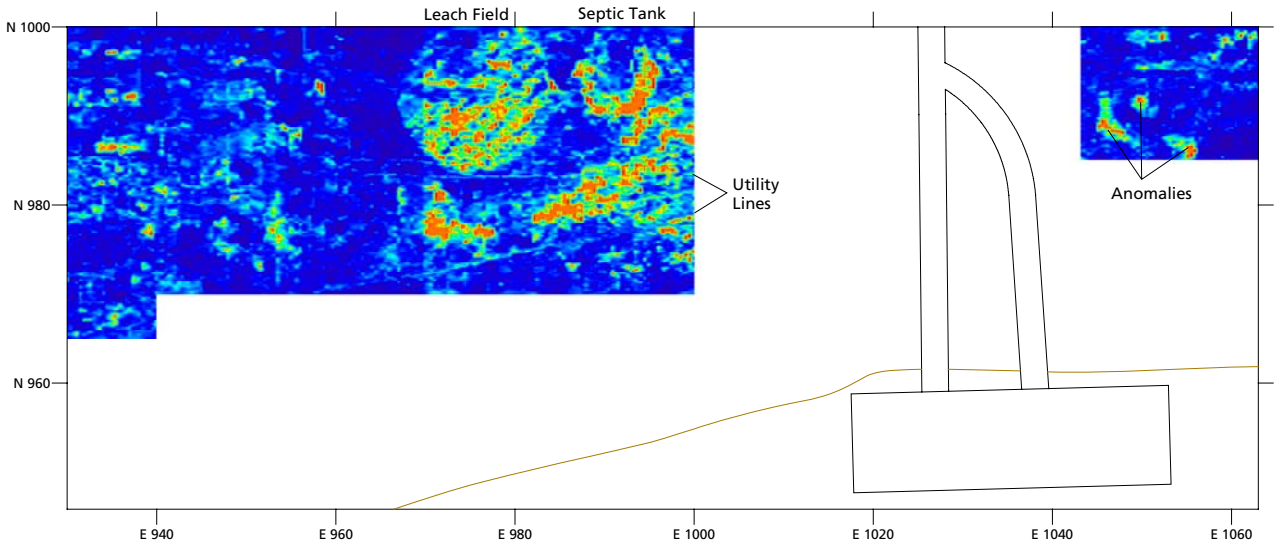

Figure 55. GPR time slice of Quadrant 8 from 30 centimeters below the surface.

outside the fort during the military occupation of Garden Key, the concrete foundation may also be part of a structure built at a later date.

A number of modern features are exposed at a depth of 30 centimeters below the ground surface of Quadrant 8 (Figure 55). Three utility lines crossing Grid 37 and running into Grid 38 can be seen, as well as a circular leach field and hexagonal septic tank, both of which presumably serviced a comfort station that was, until recently, present on the dock. The comfort station was damaged by storms and removed and replaced with chemical toilets in the campground. Finally, there are several anomalies present in Grid 40 on the eastern side of the quadrant, but they show no pattern indicative of their identity and would require excavation to identify.

Moving eleven centimeters deeper provides a better visualization of some of the radar anomalies present in Quadrant 8. In Figure 56, the reflections associated with the septic tank and leach field are more clear, as is the large buried utility running to the southeast across

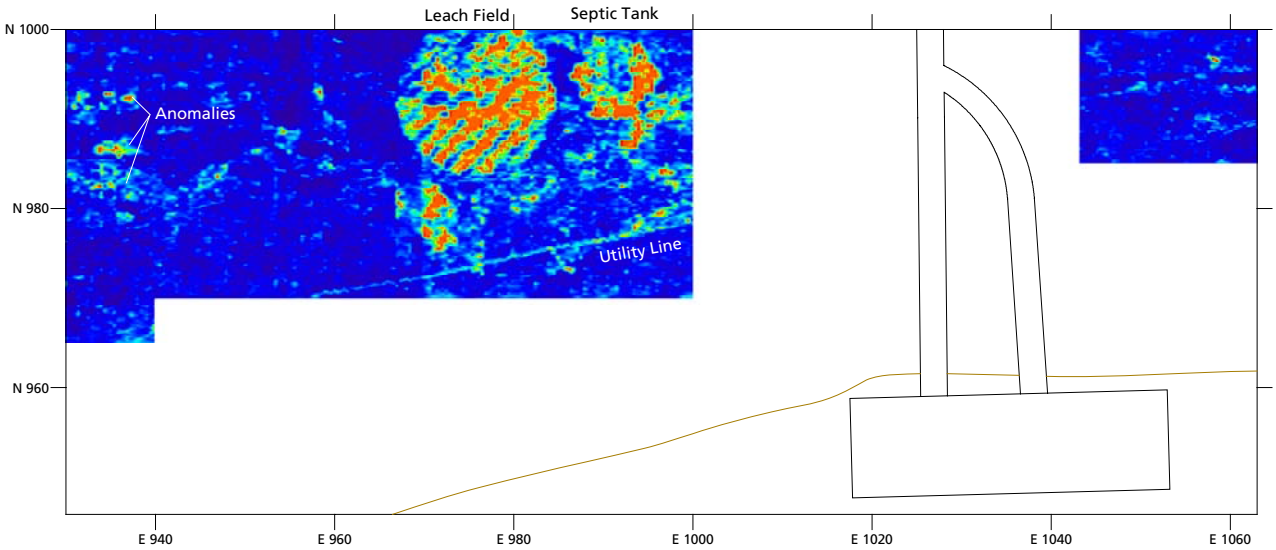

Figure 56. GPR time slice of Quadrant 8 from 41 centimeters below the surface.

Grids 37 and 38, presumably toward a large utility junction box present off the southeast corner of Grid 41. Once again, there are no obvious indicators of historic features in the data, only evidence of modern disturbances. However, there are several unidentified anomalies on the east side of the quadrant in an area that was once part of the fort's construction village and held several frame barracks buildings, privies, and kitchens. None of the anomalies identified appear to represent complete building foundations but they may be associated with debris or fragmented structure foundations that have been impacted by erosion and modern utility installation.

The final GPR results to examine are those from Grid 39, located within the first tier casemates of the fort. This grid was placed on the same project area grid as the other extra-parade ground grids (see Table 2), but the collection traverses were spaced at 25 centimeters, rather than the 50-centimeter transect interval that all of the other grids were collected with. The grid was established to evaluate the performance of the GPR over the substrate below the fort. Two views of the GPR data from Grid 39 are presented below. Figure 57 shows the results from a depth of 56 centimeters below the ground. The graphic shows a series of half moon shaped reflections associated with the cannon traversing rails installed along the floor of the casemates. From the radar results it appears as though each rail is supported by three square blocks that differ from the surrounding substrate. Presumably, a material stronger than that used for the rest of the casemate floor was placed below the rails to support the weight of the guns. Moving deeper below the casemate floor, Figure 58 displays a view of the radar data at 1.68 meters. At this level anomalies associated with the cistern voids can be seen below the support columns of the casemate walls.

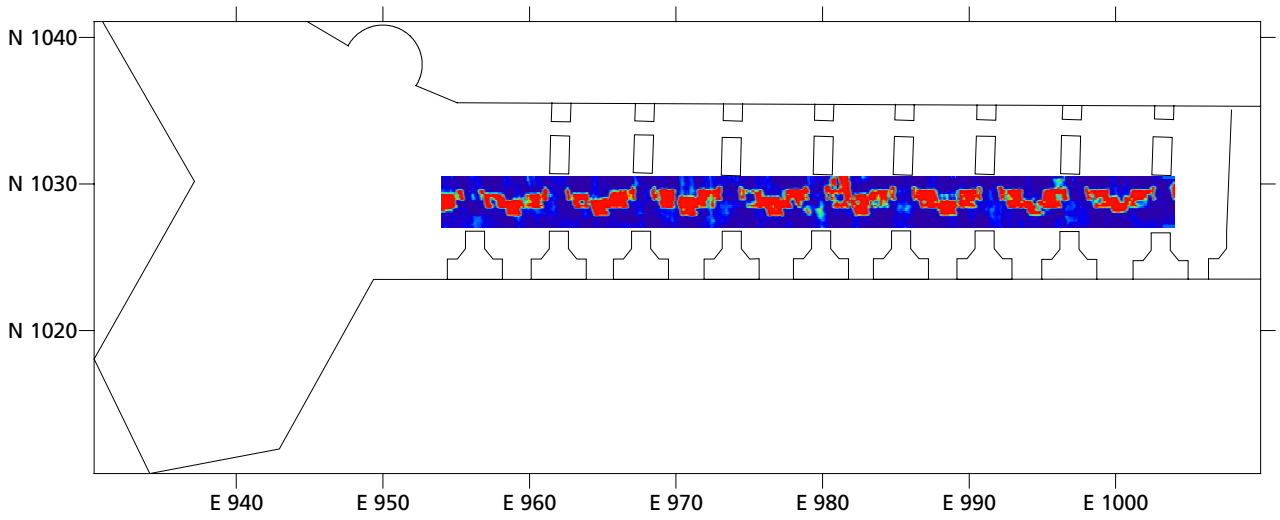

Figure 57. GPR time slice of Grid 39 from 56 centimeters below the surface.

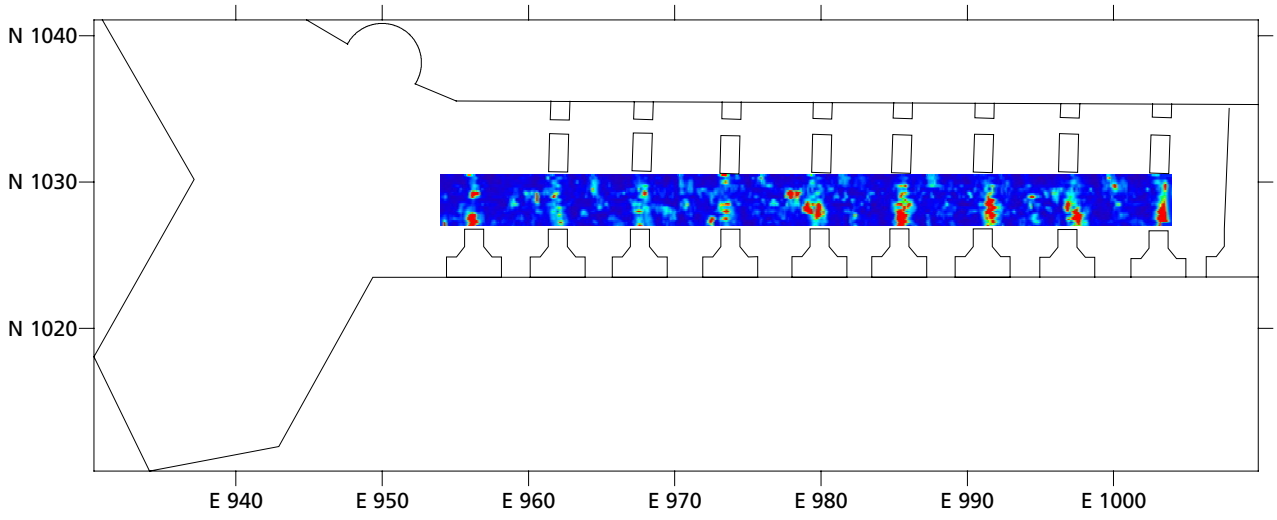

Figure 58. GPR time slice of Grid 39 from 1.68 meters below the surface.

Chapter 5
Conclusions and Recommendations

In December of 2006, SEAC conducted a ground penetrating radar survey of the parade ground and selected exterior areas at Fort Jefferson National Monument. During the survey, numerous buried anomalies were encountered, including modern utilities and disturbances, interpretable historic features, and unidentified anomalies of potentially historic origin.

Prior to conducting the survey, a series of historic maps displaying the locations of now extinct structures on the parade ground were digitized into a GIS to provide some guidance on the identification of GPR anomalies. Several GPR anomalies identified during the survey appear to correlate with the historic map data, including a buried materials distribution road south of the soldier's barracks (Figure 59), the possible foundation remains of an 1847-1857 storehouse (Figure 60), anomalies possibly associated with the 1847 carpenter's shop and lime house (Figure 60), a near surface anomaly possibly associated with the original blacksmith shop (Figure 61), foundation remains outside the fort possibly associated with the engineer workman's barracks (Figure 62), and the foundation remains of Garden Key's original lighthouse (Figure 63). Anomalies possibly associated with structures displayed on an 1887 map of the lighthouse keeper's quarters were also located, but if so, the accuracy of this particular historic map is significantly compromised (Figure 64).

Several identifiable historic features not present on the maps were also encountered. The most significant of these features were the walking paths that were found throughout the parade ground (Figure 65). Historic photographs indicate that these paths were once lined with cannonballs, and previous archeological investigation found that the surfaces of the paths were plastered and the edges were lined with bricks. The absence of these bricks in historic photographs showing the cannonball lined trails indicate that the bricks are a later addition put in place after the cannonballs were removed. The buried brick linings are known to exist along the path leading from the engineering officer's quarters to the officers quarters, where they were found during a previous archeological investigation, and along the westernmost path leading from the sally port to the officer's quarters, where occasional remnants of the bricks are visible on the modern surface. It is unknown whether all of the paths identified in Figure 65 are lined with brick.

The probable foundation remains of a temporary structure not on any historic map were also identified. Located west of the soldier's barracks is a large rectangular shaped buried surface that may be the remains of a covered shed in use during the construction of the barracks.

Foundation remains of the patio that existed south of the original officer's quarters (which was a smaller building located on what is now the eastern end of the ruins that was expanded into the full structure at a later date) are also visible in the GPR data. The patio feature is notable because it was found only in association with the original structure, even though the veranda and balconies were eventually expanded to cover the front of the entire completed building. The existence of the patio foundations exclusively on the east end of the building is indicative of either a variation in the construction technique for this portion of the patio, or of the incomplete removal of the foundation on this end of the building.

The remainder, and vast majority, of the anomalies recorded by the GPR are either modern utilities or remain unidentified. Un-

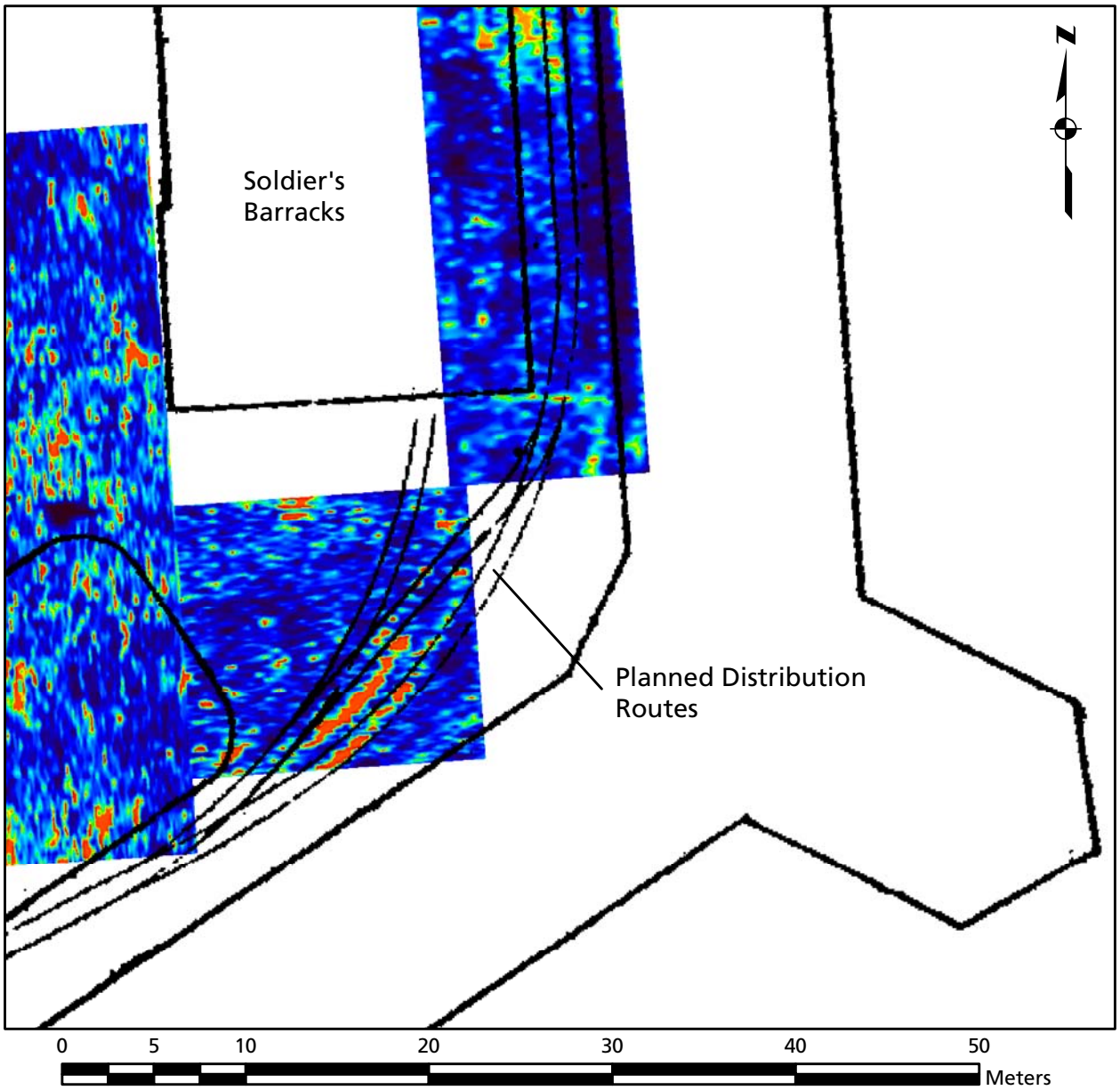

Figure 59. GPR data from approximately 50 centimeters below the surface overlaid on a portion of an 1861 map showing planned construction at the fort and a materials distribution route (see Figure 14).

identified anomalies abound in the northern portion of the parade ground and include large possible dumps to the east and south of the hot shot furnace; two square shaped pavilion-like features associated with the walking paths leading to the officer's quarters and soldier's barracks; a series of pit features south of the veranda associated with the original officer's quarters; foundation remains (partially visible on the ground surface) adjacent to the Major Smith monument; a large rectangular surface comprising the entirety of the center of the parade ground (50 meters N/S by 40 meters E/W) that may be associated with gardens, livestock pens, or a muster area; two large amorphous anomalies on the northern boundary of this surface; and two large rectangular anomalies to the southwest of the officer's quarters west of the modern leach fields. Unidentified anomalies in the southern half of the parade

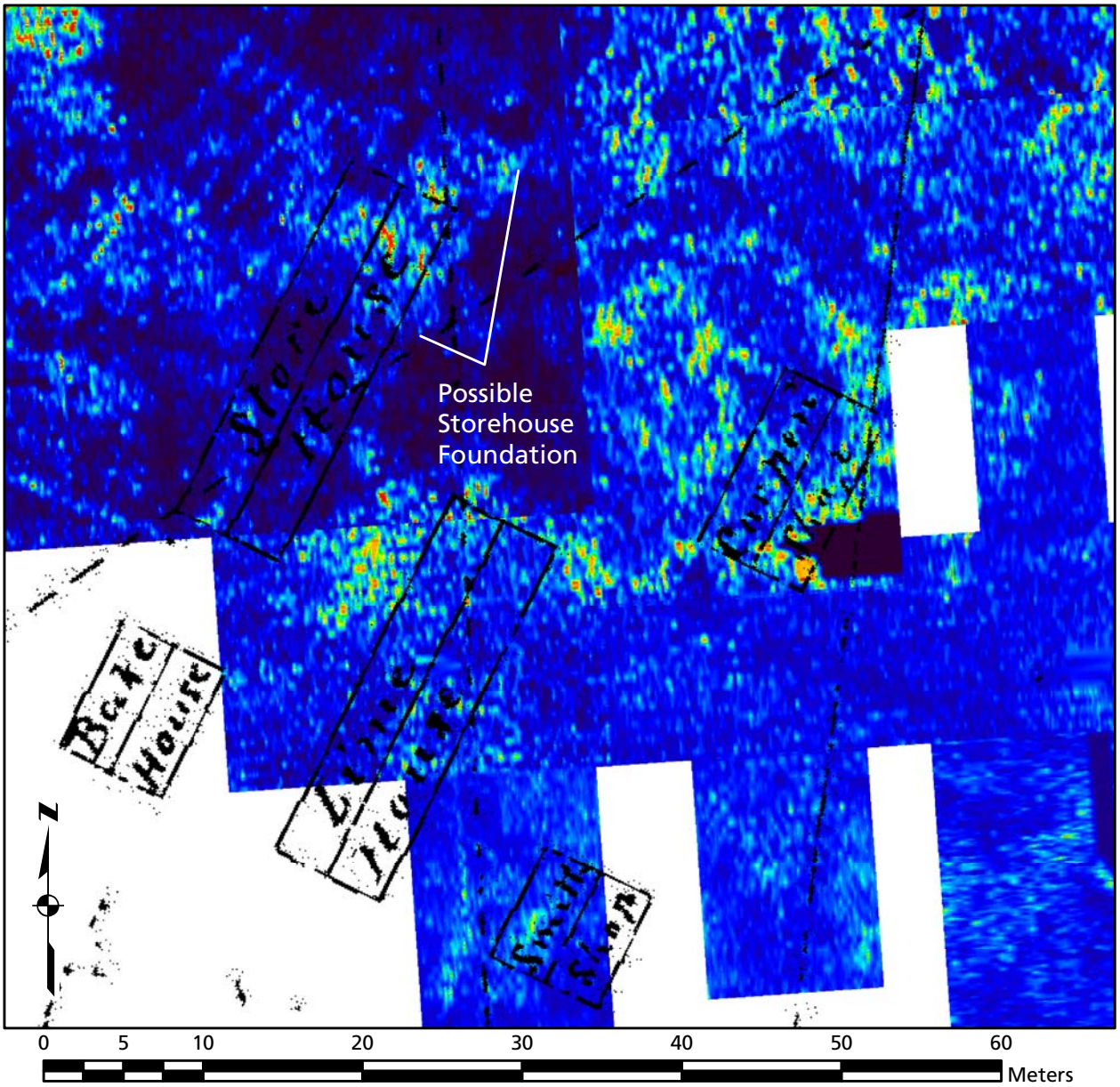

Figure 60. GPR data from approximately 65 centimeters below the surface overlaid on a portion of an 1850 map showing the locations of the five original temporary frame structures (see Figure 4). A rectangular anomaly is present in the expected location of the storehouse and general high amplitude reflections surround the presumed locations of the lime house and carpenter's shop.

ground include three rectangular anomalies in the space between the known locations of the soldier's barrack's kitchens; the probable near surface reflection of what remains of the Italy grave; a possible privy vault associated with the second lighthouse keeper's quarters; and two other pit-like features, possibly cisterns associated with either the first or second lighthouse keeper's quarters. All of these anomalies are identified and marked in the "GPR_UID_Anomalies" GIS shapefile provided in Appendix 1. Also in Appendix 1 is the shapefile titled "GPR_Relict_Paths" indicating the location of the buried walkways (see Figure 65), and a shapefile titled "GPR_Possible_Structures" that identifies anomalies associated with the historic map-predicted structure locations, as well as anomalies interpreted as structures

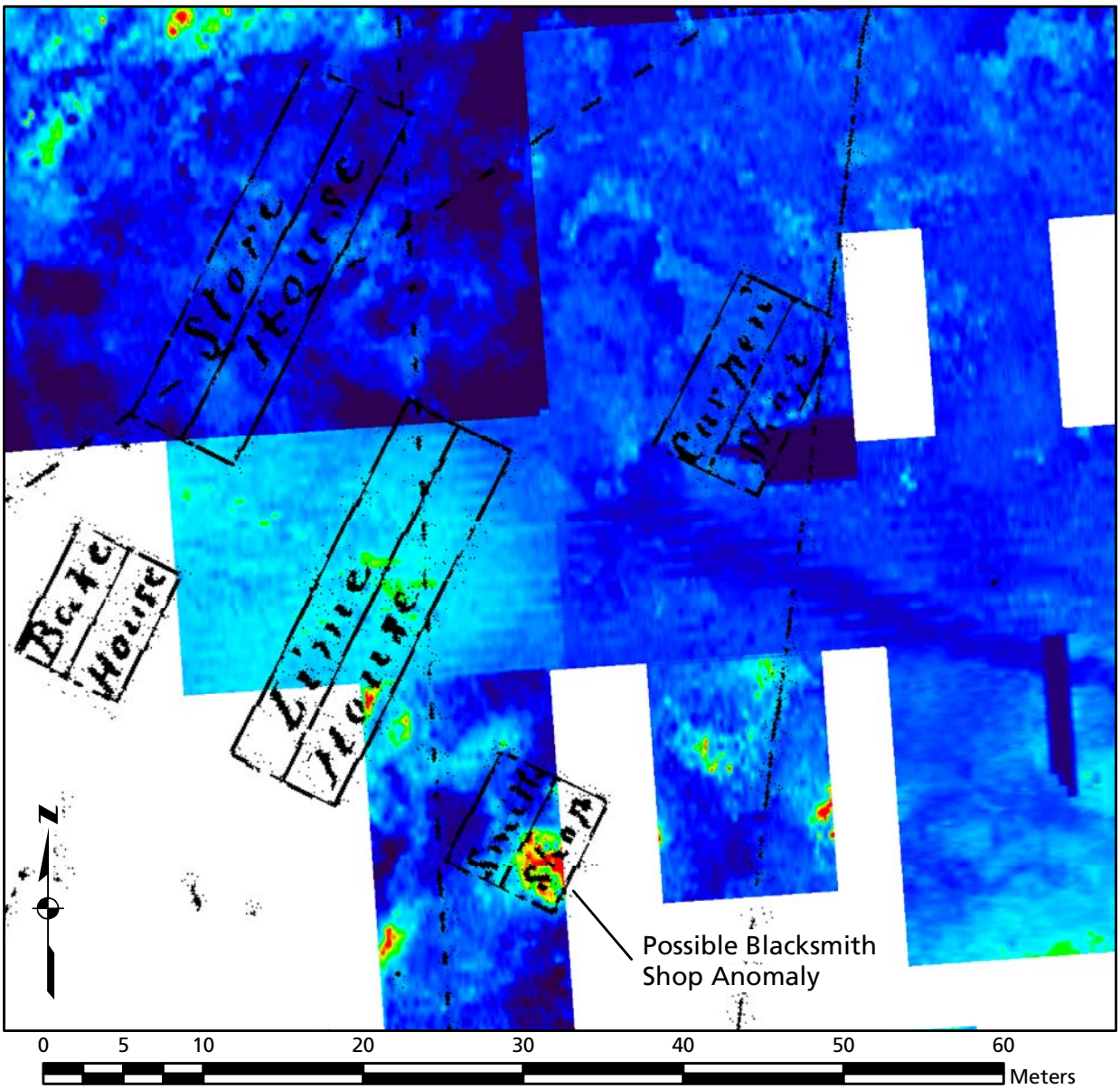

Figure 61. Near surface GPR data overlaid on a portion of an 1850 map showing the locations of the five original temporary frame structures (see Figure 4). An anomaly corresponding with the expected location of the blacksmith shop is present.

without the assistance of the historic maps. These shapefiles, and others depicting the locations of surface visible utilities, vegetation present at the time of the GPR survey, and the existing structures at the fort are provided in the digital appendix. Also included are the geo-rectified historic maps and maps of the radar results from various depths below the ground surface. All of the files are collected for display using ArcGIS 9 in the included geodatabase entitled "2006 Archeological GPR Survey".

The results of this GPR survey can be used to aid in the management and restoration of the cultural landscape of Garden Key and when planning future archeological research on the parade ground of Fort Jefferson. Of primary interest for management is the fact that large areas of the parade ground were found to have been

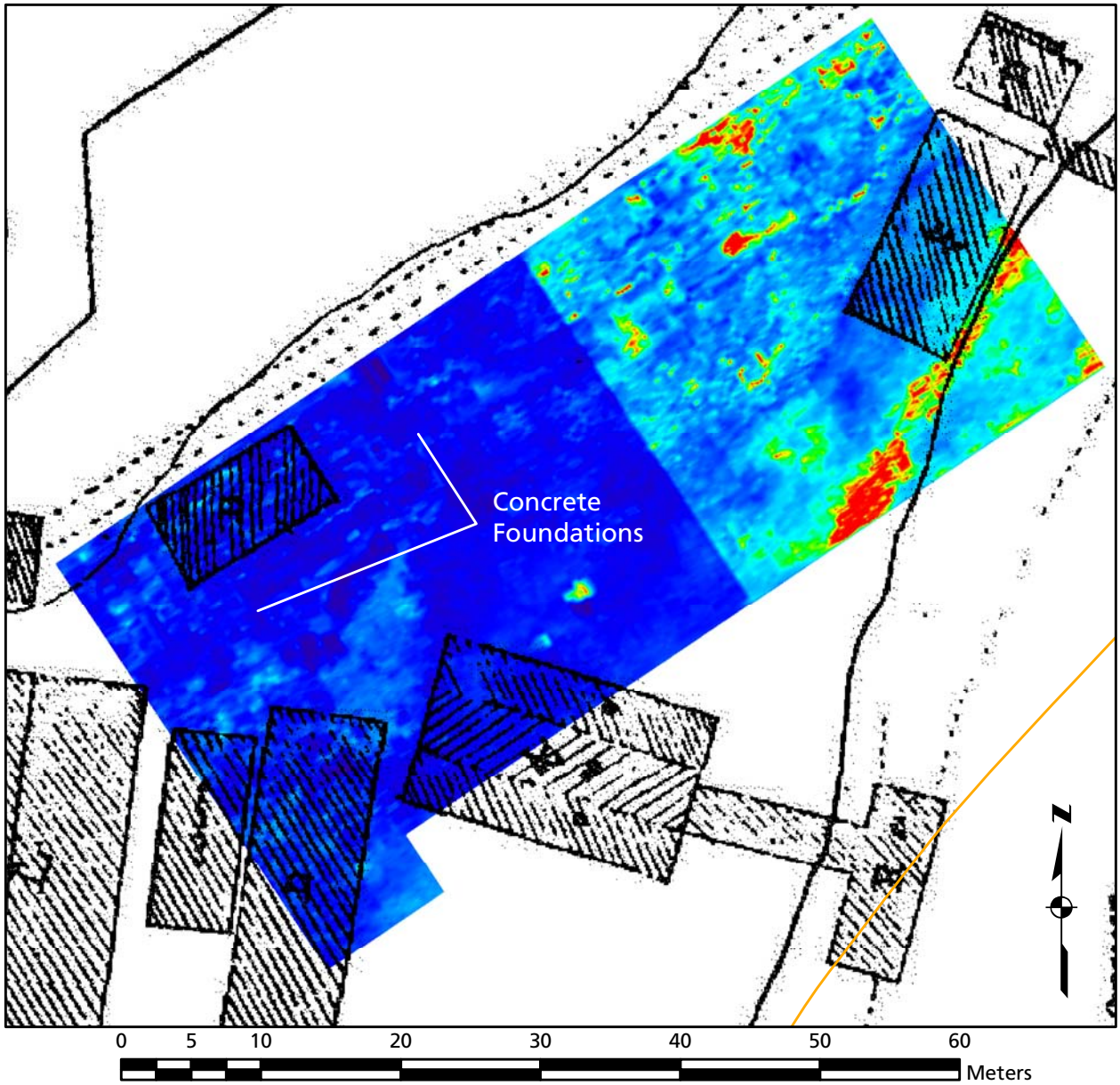

Figure 62. Near surface GPR data from outside the seawall overlaid on a portion of an 1861 map showing the locations of temporary frame structures present that year (see Figure 5). The structure over the GPR anomaly is identified on the 1861 map as the engineer workman's barracks, but its small size may indicate that the concrete foundation belongs to a more recent building placed in the same location.

significantly impacted by modern intrusions over the last seven decades of occupation by the NPS. Numerous utility pipes, cables, buried tanks, and leach fields were encountered on the western half of the parade ground facing the NPS residential and maintenance areas. Utilities were so ubiquitous in Quadrant 4 and the western half of Quadrant 3 that there is little likelihood that any significant remains of intact archeological features are present in the area. Utilities were identified in other areas as well, including a PVC line crossing the northern half of the parade ground and several lines in Quadrant 7 that probably supply the park office and the Audubon Fountain. However, these utilities are less concentrated and represent a minor disturbance to the overall area.

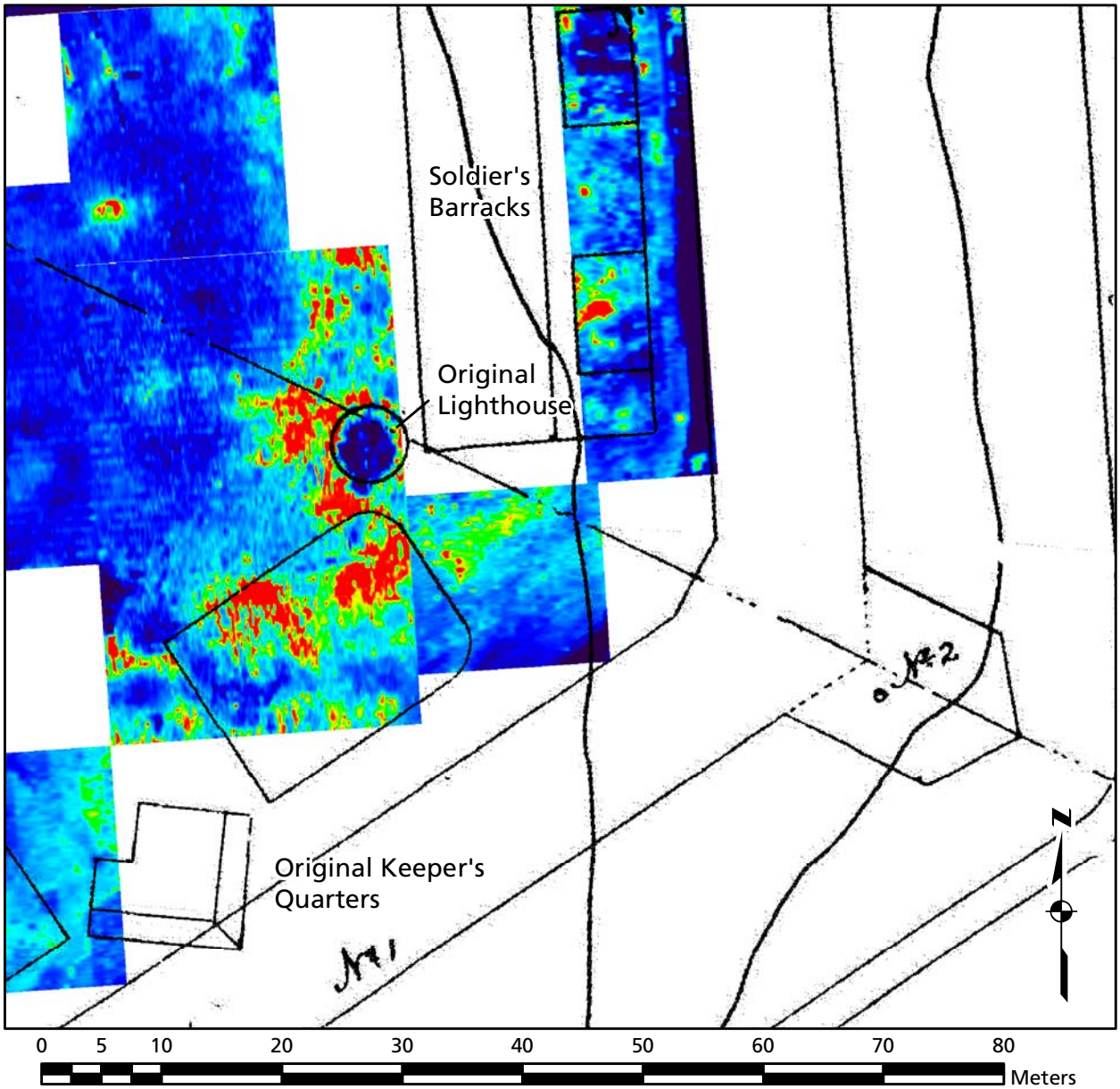

Figure 63. Near surface GPR data overlaid on a portion of an 1848 map showing pending construction plans and the then existing locations of the original lighthouse and keeper's quarters (see Figure 6). The low amplitude anomaly in the radar reflection is indicative of the last remaining remnants of the original lighthouse foundation.

In 1962, the NPS removed the superstructure of the soldier's barracks and officer's quarters as well as their associated outbuildings. The archeological foundations of the two buildings remain, as do the foundation components of the officer's quarters kitchens and latrines and one of the soldier's barrack's original four kitchens. The GPR survey indicated that removal of the above ground material remaining of the other three kitchens behind the barracks was nearly 100 percent complete (save the two brick fireboxes of the northern two kitchens), with no apparent reflections from buried foundation features. Such a demolition would have resulted in significant ground disturbance, probably obliterating any other archeological features that may have been present in the vicinity of the kitchens.

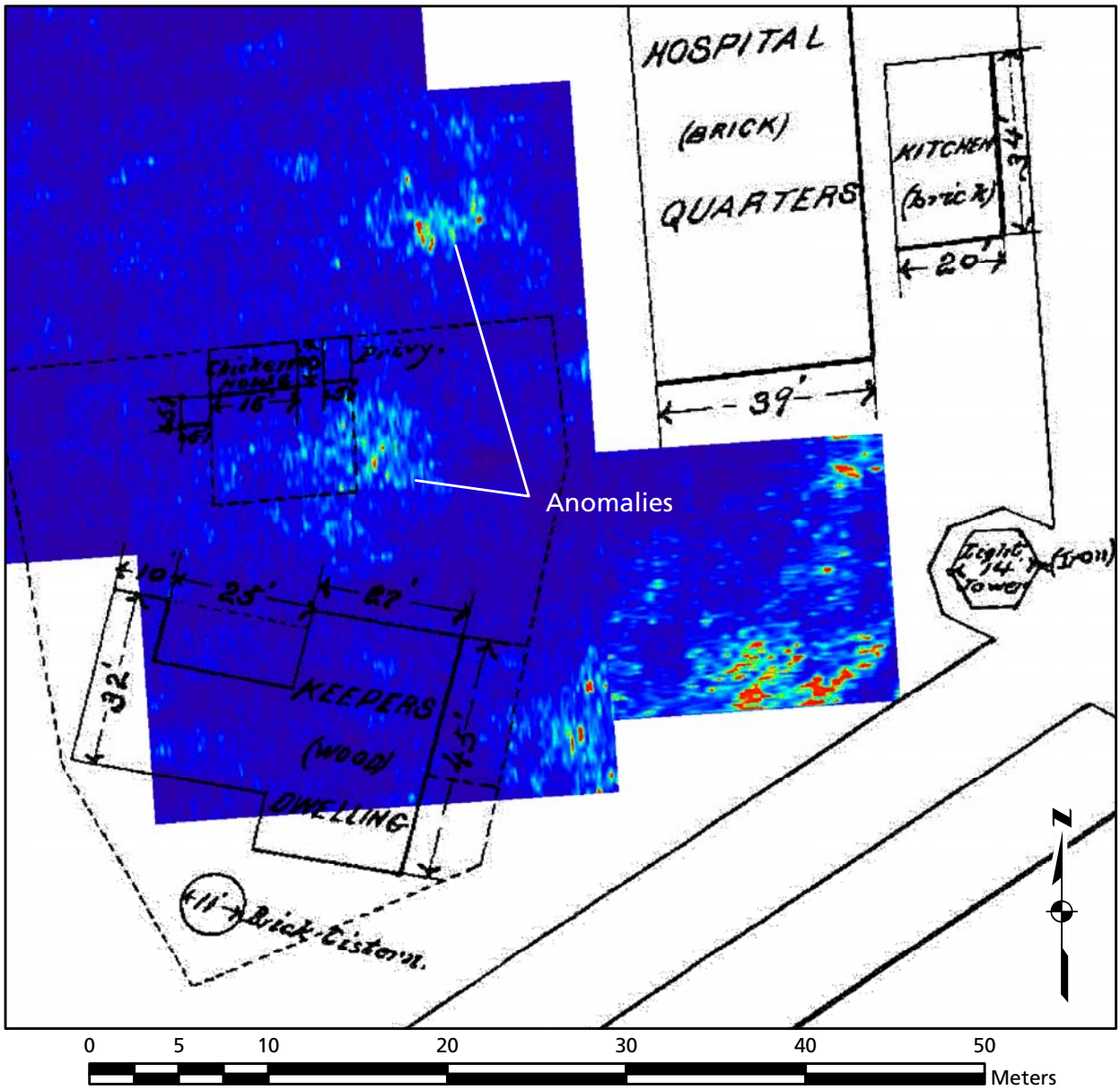

Figure 64. GPR data from approximately 50 centimeters below the surface overlaid on a portion of an 1887 map showing the conditions of the second lighthouse keeper's quarters (see Figure 11). The vague high amplitude reflections may be associated with remains of the house and compound of outbuildings, or with activity areas outside them.

The removal of historic fabric and degradation of subsurface integrity is also significant in the area tested outside the fort. The three radar grids that were placed in the campground and picnic area identified large utility features including a leach field and septic tank as well as utility lines crossing the area. Although some concrete foundations were encountered adjacent to the seawall counterscarp, there were no significant reflections indicative of the large number of structures and mechanical equipment that historically sat at this location. The physical removal of these features, natural erosion and storm action, and modern utility installation have apparently taken their toll on the extra-fort portion of Garden Key. It appears unlikely that significant intact archeological features will ever be identified buried in the

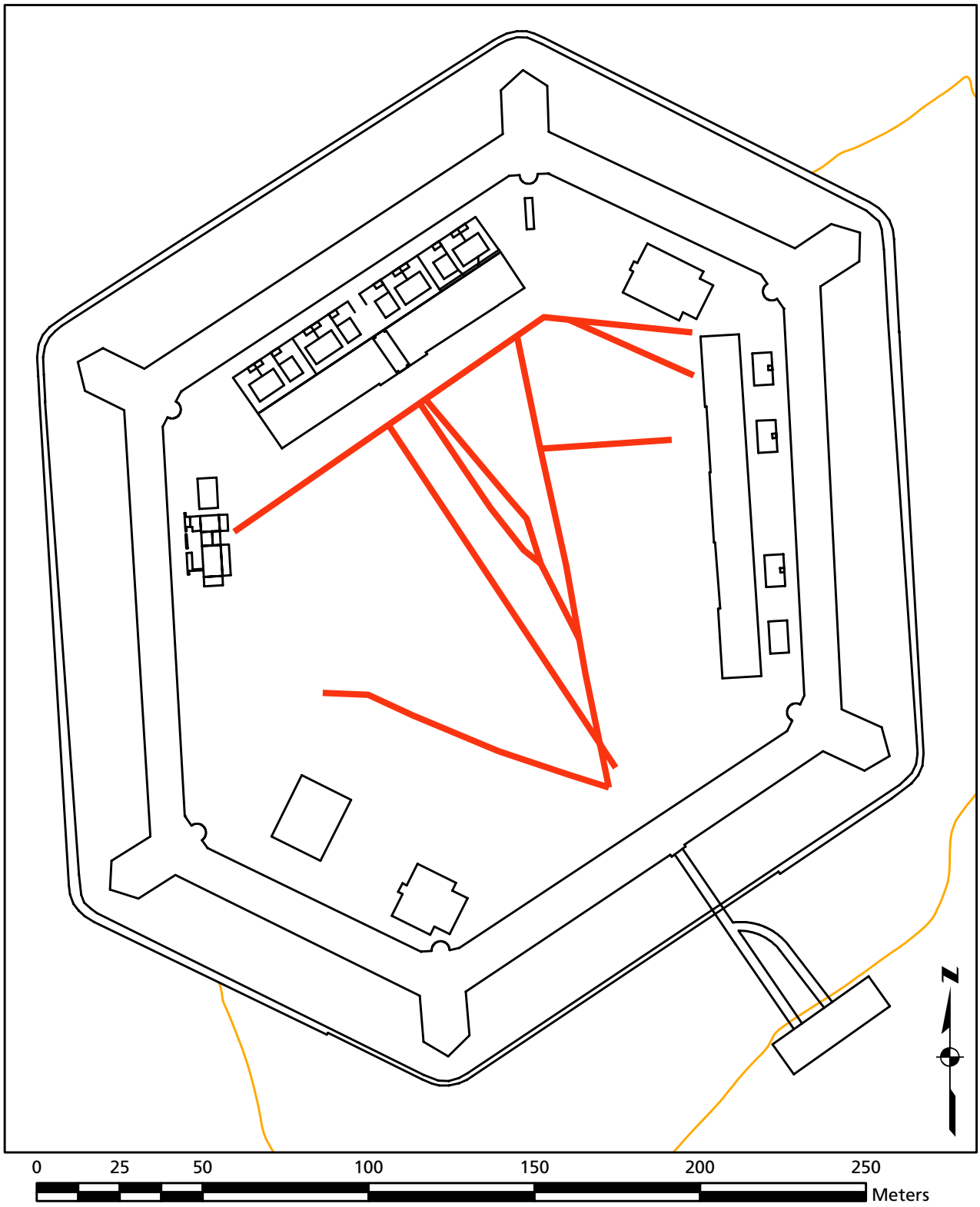

Figure 65. Locations of the historic walking paths (in red) identified during the survey.

sands outside the seawall (though only a portion of these grounds were investigated).

In consideration of the probable buried archeological features identified by the GPR, as well as the identification of buried utilities and negative data areas, the fort grounds were divided into two potential management areas: one with low archeological integrity, and one with potentially high archeological integrity (Figure 66). The low integrity area was designated as such because of cumulatively significant modern disturbances associated with utility installation, structure removal, and erosion. The high integrity area was designated based mainly on the lack of such modern disturbances, but also because of the presence of archeological geophysical anomalies. Any and all of these geophysical anomalies (the possible structures and unidentified anomalies discussed above) should be considered worthy of future archeological testing through excavation, but several stand out because of their potential to provide interpretive opportunities for park visitors. The first of these is the anomaly potentially associated with the 1847 storehouse (see Figure 34). Currently, there is no interpretation of the temporary structures on the modern parade ground and an examination of these anomalies (if they are indeed found to be associated with historic structures) could provide information for a wayside describing the construction history on the parade ground, provide material for display, and a provide an interactive visitor experience while the test excavations are carried out. Also worthy of further archeological examination are any of the possible pit features, including those in the vicinity of the lighthouse keeper's quarters and the larger ones near the east end of the officer's quarters and the hot shot furnace. The nature of these features cannot be definitively identified with the radar data alone, but likely comprise trash dumps near the officer's quarters and possibly cisterns or privies in the area around the old lighthouse keeper's quarters. These types of features are of archeological significance because they regularly provide vast quantities of material culture that may be of interest for the interpretation of life at the fort or for display purposes.

SEAC has several management recommendations stemming from the results of the GPR survey. First, if possible, no new utilities should be buried in the high archeological integrity area identified in Figure 66. New utilities should be limited to the low integrity area that has already been subjected to significant disturbances. All ground disturbing activities at the fort (regardless of their location) should still be reviewed for archeological impacts, as GPR does not respond to all possible targets and even in the low integrity area potential archeological resources may have escaped detection, but for purposes of facility planning, every effort should be made to avoid impacts in the high integrity area. SEAC also recommends that an archeological investigation designed to recover interpretable information and materials from the promising geophysical anomalies be carried out at some time in the future, and that in the meantime the geospatial information provided in Appendix 1 of this report be incorporated into DRTO's digital management databases.

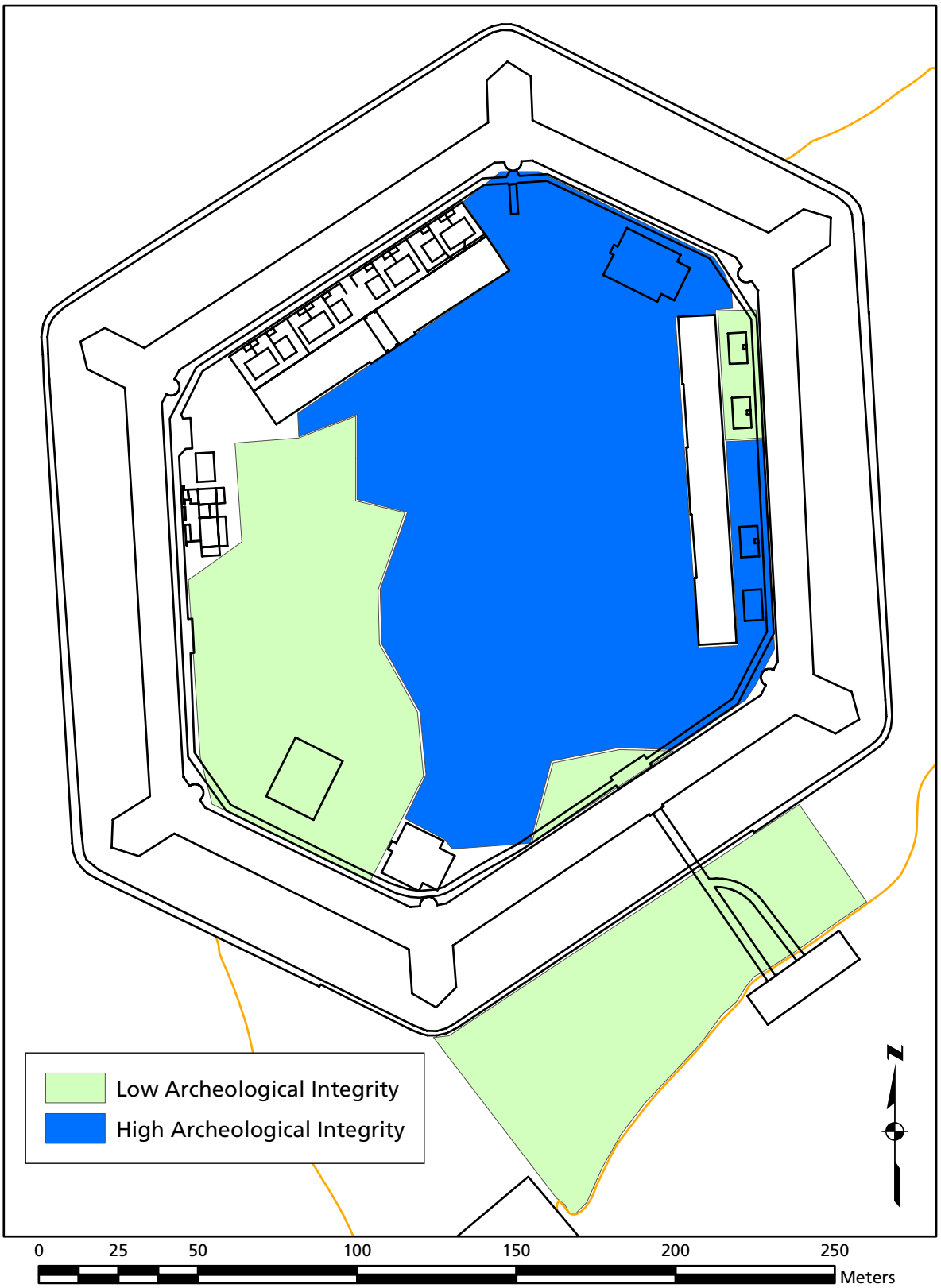

Figure 66. Recommended archeological management areas. Note that in some areas not surveyed the archeological integrity remains unevaluated.

Appendix 1
Digital Data

A DVD containing electronic files associated with this project can be found in the back cover of this report. Contents of that disk include:

1) A digital copy of this report (in PDF format).

2) Unmodified historic maps (PDF).

3) A GIS geodatabase (created with ArcGIS 9) including processed GPR data maps, mapped existing conditions, and rectified historic maps, and shapefiles continaing interpreted results and proposed management areas.

4) Autocad maps of the project area (AutoCAD LT 2006 or equivalent).

5) Relevant historic photographs (JPEG files).

6) All of the unprocessed GPR Grid data files (RADAN software required for viewing), as well as select processed GPR data displayed in Surfer plots (Surfer 8), with accompanying XYZ data in ASCII format.

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