SEARCHING FOR THE UNMARKED HENRY KINSEY FAMILY GRAVES AT THE VA HOSPITAL GROUNDS IN DAYTON, OHIO, USING MAGNETIC, ELECTROMAGNETIC, AND RADAR METHODS

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science

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ABSTRACT

Bergman, Andrew William, M.S. Department of Earth and Environmental Sciences, Wright State University, 2017. Searching for the Unmarked Henry Kinsey Family Graves at the VA Hospital Grounds in Dayton, Ohio, Using Magnetic, Electromagnetic, and Radar Methods

The Henry Kinsey family was among the first to settle in the Dayton, Ohio, region in the early 19th century. Henry, and his wife Eva, were buried near what is known as the deer keeper’s lodge, a small building where the deer keeper lived, on the modern-day Dayton Veterans Affairs hospital grounds. In the time since they have been buried, the location of their gravesites has been lost. The main purpose of this thesis is to locate and map their graves using multiple geophysical methods. A secondary purpose is to compare the effectiveness of each geophysical method.

Three geophysical methods were used in this work: magnetics, electromagnetics, and ground penetrating radar. The magnetics survey was conducted using two Geometrics 857 proton precession magnetometers in a gradiometer configuration. The results of the magnetic survey show that there is a large magnetic anomaly running through the center of the survey area, likely an old utilities pipe. The data also show a significant anomaly coinciding with a surface artifact site, which is most likely the structure that stood next to the Kinsey family graves.

The electromagnetics survey was conducted using a GSSI EMP-400 Profiler which utilized three frequencies simultaneously: 5kHz, 9kHz, and 15kHz. The electromagnetic data revealed a large anomaly through the center of the survey area, similar to the magnetics survey results. The data also showed a slight anomaly under the artifact site, although without the strength and clarity of the magnetics survey.

The ground penetrating radar survey used a GSSI SIR-3000 system with a 400 MHz bistatic antenna. This survey yielded the best results, showing the extent of the
artifact site in the subsurface. A small 3D survey was conducted over a unique anomaly that is a potential grave location. The GPR data would have shown even more, however, there are numerous trees within the survey area and their roots severely interfered with the GPR data.

Based upon the data collected over the course of this report, no precise location for the Kinsey family graves can be stated, although the artifact site can be said to be the location of the deer keeper’s lodge. This allows for future, more focused surveys to be conducted over this site to definitively locate the Kinsey family graves.
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1.0 Introduction

1.1 Historical Background

During the early 1800s, the area of present-day Dayton, Ohio, was beginning to be settled by families from the original American colonies. One such family was the Henry and Eva Kinsey family. The Kinsey family was originally from Botetourt County, Virginia, and was among the first families to settle in the region in 1800. They purchased 640 acres from the government and built a log cabin on the grounds of the modern-day Dayton Veterans Affairs (VA) hospital, located on the west side of Dayton. The location in relation to Dayton is depicted in Figures 1.1 and 1.2. The Kinsey family also was the first to discover the fresh water springs in the area. Henry and Eva’s children also settled here, with their house eventually becoming the headquarters of the National Soldiers Home (NSH), which later became the VA hospital.

When Eva Kinsey died in 1821 at the age of 83, she was buried in a grave on the same hillside as the deer keeper’s lodge, per family history. Her husband, Henry, had died several years earlier, although the exact year is not known. Several years before they died, the deer keeper’s lodge was built. The deer keeper who resided there oversaw tending to the NSH deer herd. The location of this lodge was recorded on multiple aerial renderings conducted between 1870 and 1898 and appears in multiple historic photos. However, at some time following the 1898 rendering, the deer lodge was torn down. At present time, the exact location of both the deer keeper’s lodge and the Kinsey graves are not known.

In 1992, the living descendants of the Kinsey family requested the VA to locate the missing graves so that the family could place a proper memorial. However, the VA was unsuccessful in locating the missing graves, although they did not carry out surveys of any kind.
Figure 1.1: Location of the Dayton VA hospital grounds and military cemetery. The main hospital is in the center of the map on the left side. Images courtesy of Google Maps.
Figure 1.2: Location of the survey areas in this research relative to the VA grounds. The two survey areas, A and B, are outlined as yellow boxes. Images courtesy of Google Maps.

1.2 Purpose of Study

The main purpose of this research is to apply and compare three different geophysical methods that attempt to locate the historical graves of Henry and Eva Kinsey. While there have been numerous studies conducted on this topic, this research is particularly relevant for conditions in southwest Ohio. As cities continue to expand and redevelop, the knowledge and skill to locate and identify graves will become important as old cemeteries are being rediscovered all the time. To prevent destroying any graves while searching for graves, it is important to be able to search without using invasive methods, such as excavation. Non-invasive geophysical methods can also be applied to other projects, such as locating old foundations and industrial waste.

A secondary purpose is to assist the VA in locating the missing graves of Henry and Eva Kinsey. The VA has expressed interest in redeveloping the area that was surveyed for this report at some point in the future and they need to know if there are any unmarked graves that need to be relocated. Using non-invasive geophysical methods allows the area to be searched without having to undergo costly excavation.
1.3 Site Description and Selection Process

The area surveyed in this report is an open grassy hill with multiple trees scattered around the site. The area is kept clear of underbrush by the VA grounds crew and is mowed regularly. An old road runs down the hill towards the old springs, both of which have appeared on maps since 1870. This area of the VA grounds has been in use since the mid-1850’s and is still used with a nursing home across the road. There are two old Victorian homes directly west of the survey area and there was a third one that was demolished last century.

The process of selecting a survey area had several stages. As stated in the introduction, family history says the Kinseys were buried near the location of their original cabin on a knoll. The cabin was replaced by a deer keeper’s lodge in the 1800s and was torn down near the start of the 20th century. A surviving picture of the deer keeper’s lodge can be seen in Figure 1.3. However, the deer lodge appears on several “aerial” maps that were produced between 1870 and 1898. These maps are shown in Figure 1.4. There are numerous structures on these maps that still exist today and were used to select an area that the deer lodge likely stood upon.

Figure 1.3: One of two known surviving pictures of the deer keeper’s lodge. A road can be seen running through the center of the picture in the background. Based on the direction of the shadows visible, it appears that this picture is looking approximately north. Image courtesy of the Dayton VA.
Figure 1.4: Two historical aerial renderings of the VA hospital. The top rendering is from 1870, and the bottom image is from 1898. Both renderings are oriented facing west. Common landmarks can be seen in both, including a large stone church and a white gazebo. Both are located approximately in the center of each rendering. The deer lodge can be seen on the far-left center. Images courtesy of the Dayton VA.
Figure 1.5: Current picture of the white gazebo that appears in historical renderings. This structure is the original one that has been in this position for over 150 years. Picture is looking east. Image taken by author.

Figure 1.6: Current picture of the large stone church that appears in historical renderings. The church is constructed of limestone blocks taken from the surrounding area. Picture is looking north. Image taken by author.

Two methods were used to define a survey area using these maps. The first method involves a copy of the 1870 aerial rendering being overlain on current satellite imagery of the
VA property. This requires both images to be aligned based on common remaining landmarks, including a white gazebo on the parade grounds, a large stone Baptist church, roads, and houses.

Current pictures of the white gazebo and the church can be seen in Figures 1.5 and 1.6. With all major landmarks identified, the images can be rotated and overlaid to allow the approximate coordinates of the deer lodge to be recorded on Google Earth for further analysis. This process can be seen in Figure 1.7 and the result in Figure 1.8.

Figure 1.7: Illustration of method to identify and correlate the 1870 rendering and modern satellite imagery. Lines connect features that appear in both images. Both images looking west.
Figure 1.8: Modern satellite imagery overlaid on 1870 rendering. An approximate location of the deer lodge is outlined with a box.

The second method involves a similar process but with a different approach. Using the most recent rendering from 1898, common landmarks can be lined up to create a “reference line” that can be extended to create a boundary of the likely area of the deer lodge. Once several reference lines are completed, a rough boundary of the area the deer lodge likely existed within. An example of a reference line can be seen in Figure 1.9. This area defined by the reference lines, used in conjunction with the location of the deer lodge from the 1870 map overlay, gives a good starting area. This process was only done to give a starting area, as the accuracy of the historical maps is questionable due to the maps being paintings, and not true maps. The resulting area can be seen in Figure 1.10.

On the first trip to the site, the author, along with Dr. Ernest Hauser, walked the entire area bounded by the reference lines and found that there was a ridgeline that gradually went downhill northeast towards the springs. When standing on the hill looking northeast, the old road
Figure 1.9: This shows the process by which reference lines were created on both historical renderings and modern imagery. Using the old stone church and the white gazebo, a line can be drawn and extended out past where the deer lodge is likely to be.

that cuts through the area was visible in the background, very similar to the old pictures of the deer keepers lodge. After viewing the site and the topological conditions, it was decided to break the survey area into two sections, survey area “A” that follows the ridgeline downhill and survey area “B” that is directly south of the primary area and is the flat hilltop. Figure 1.2 shows the location of these survey areas.
Figure 1.10: Aerial view of area defined by reference lines. The yellow lines are reference lines and the blue box shows the approximate area created by the reference lines. This image is looking west.

Survey area A, as stated above, is an open hillside with multiple trees within the survey boundaries. Figure 1.11 shows how area A looked while conducting surveys. The dimensions of this survey area are 75 ft. (23m) by 260 ft. (80m). For this report, the side 75 ft. (23m) in length will be referred to as the X axis and the side 260 ft. (80m) in length as the Y axis. These dimensions were chosen since the rectangle formed would completely cover the hillside of interest and was orientated northeast, the direction of the hill. The southwest corner of the area is the common corner for both survey areas and is the origin (0,0) for A. Area A will be the focus of this report for several reasons. The first and primary reason is that the location and the topography of this area matches the description of both the deer keepers lodge and the Kinsey burial location. Another compelling reason is that, while on the initial trip to the site, visible artifacts were found on a level spot on the hillside. These artifacts consisted of old bricks and glass. Figure 1.12 shows some items recovered from the site. The specific location of these artifacts is important because it is located on a flat portion of the hill, which would be a good
spot for a small building or cabin. These artifacts appear to have been buried until recently when a tree was removed from the location and the material was brought to the surface.

Figure 1.11: Survey area A, looking downhill and northeast. Dr. Ernest Hauser is visible near center of picture. Picture was taken from grid coordinates (40, 45). Picture taken by author.

Figure 1.12: Glass, pottery, and brick specimens found in area A near coordinates (40, 205). Exact age is not known. Pictures taken by author.
Survey area B has dimensions of 90 ft. (27.5m) by 200 ft. (61m). Figure 1.13 shows area B. Because both areas are orientated in roughly the same direction, the naming convention for the X and Y axis will be the same, so the 90 ft. (27.5m) side is the X axis and the 200 ft. (61m) side is the Y axis. This area is of little interest for this report, as it contains no visible anomalies and is unlikely to be the location of the deer lodge since the topography does not match the historical pictures of the lodge. This area was surveyed mainly to both rule it out and to establish an undisturbed baseline for the locality. It also served as a practice area for the electromagnetic survey, as that survey requires a specific walking technique.

Figure 1.13: Survey area B, looking slightly uphill and southwest. Dr. Ernest Hauser is visible in the center of the image. Picture taken by author.

1.4 Site Geology

The near-surface geology of the VA grounds is important for this report, specifically the type of soil as this can affect the survey results. Geology of the bedrock is not important to this report, as it is far out of the range of any of the methods employed. Most the greater Dayton area, and, indeed, most of Ohio, is covered by glacial till (Schumacher, 2012). The online, interactive soil map tool from the United States Department of Agriculture Natural Resources Conservation Service shows that the predominant soil type within survey areas is Miamian-Urban land complex, rolling. A map of the soils found on the VA grounds is shown in Figure 1.14.
Figure 1.14: Soil map of the VA grounds provided by the National Cooperative Soil Survey. Note that the survey area is in the lower right-hand side of the map and the soil type is labeled as MoC, which is the clay-rich Miamian-Urban land complex, rolling. Survey area marked in yellow.

1.5 History and Practice of 19th Century Burial Customs

When using geophysical methods to search for graves, especially old graves, it is important to consider the burial practices of the time, as well as the predominant religion of the region as this can lead to vast differences in burial customs. Between 1810 and 1850, the population of the greater Dayton area expanded from 7,722 to 38,218 (population.us). Most of this population was made up of white Christians, generally Methodists (Sweet, 1920).
Although the exact religion of the pioneer Kinsey family has not been recorded, it can be assumed, for purposes of this report, that they were Christian, likely Methodist. Christian burial tradition dictated that the body be positioned with the head to the west and with the hands resting on the thighs.

By the mid-1800s, the body would be dressed and placed in either a coffin or a casket, shown in Figure 1.15. A coffin is an 8-sided box that could be made from any locally available wood. Typically, these would be made to order and fitted to the size of the deceased. A casket is a simpler 6-sided rectangular box and could be made of any available wood. Both would have metal nails holding the wood together. Handles and other ornamentation could be attached if the deceased’s family was wealthy. Normally the lid would be nailed on, although hinges were available at this time (Coffin, 1976). If the family was poor, plain wood with no decoration would be used, or the deceased could be buried in a cloth shroud (Coffin, 1976). The deceased would generally be buried with jewelry or other valuables made of metal. Determining what kind of metallic objects could expect to be buried with the body is important for both the magnetic survey and the electromagnetic survey.

Figure 1.15: Differences between a casket (top) and a coffin (bottom). This also shows how large the metal handles could be, which would produce a significant magnetic anomaly. Courtesy of coffinsupplier.com
1.6 Previous Research

Because of their non-invasive nature, geophysical methods are very popular in the historical and archaeological communities. However, because of soil composition and moisture content, geophysical methods are restricted by their local conditions. For example, areas with soils that have a high clay content are not ideal for GPR surveys, while an area with soil that has a lower clay content is better suited to GPR. Because of this, the limitations of the methods in this report are generally pertinent to the Dayton/Cincinnati region of Ohio.

For this work, two primary types of research were done, historical and scientific. Historical research was limited to family documents and historical pictures supplied by the VA. A copy of the family history was acquired for this research and briefly recounts the lives of the Kinsey family, although not with detail. Most the family history relates the story of Eva Kinsey being taken by Native Americans when she was young, although this story cannot be verified. The full family text is reproduced in the Appendix of this report. A report that was made by the VA in 1992 gives some background on the long running search for the Kinsey graves. This report is also reproduced in the Appendix. The VA was contacted by the Kinsey family with a request to locate the lost graves so that a memorial could be placed. The VA was not able to locate the lost graves, although they did not conduct any kind of survey, geophysical or other. The only remaining research that could be done was to establish an approximate location of the deer keepers lodge, as described above. This was done using several maps and photos supplied by the VA.

To properly understand burial practices in the 19th century, research was undertaken to learn more about common burial methods and practices. Coffin (1976), Yalom (2008), and Colman (1997) proved to be valuable sources on burial customs of the 19th century, with a consensus from these sources being that there was no standard burial practice in the early 1800s, especially in the Midwest. There are a few common practices, including not embalming the body, using some type of burial device, either a coffin or casket, and orientating the body east-west. Beyond these similarities, most practiced their own customs with different items being buried with the body and different mourning practices.

Research on using geophysical methods to locate graves and other historical features is plentiful. Many papers were read during this work to learn common issues encountered when
conducting this kind of work, as well as to learn what kind of results that are common to look for. Bevan (1991, 1998) is well known in the geo-archaeological community for his work in using GPR to locate and define unmarked graves. He is especially good at showing what kind of signatures to look for that graves can produce. Figures 1.16 and 1.17 show examples of his work.

Figure 1.16: Diagram from Bevan, 1991, showing different burial signatures. The shaded areas show soil contrasts that might suggest a grave on a radar section. The broken lines indicate the cross-sections of the grave shafts. Image from Bevan, 1991.

Figure 1.17: Radar section showing 6 grave shafts, which are located side by side on the left portion of the image. In this example, grave shafts are clear diffractions, which is an ideal case. Image from Bevan, 1991.

More recently, Schultz (2012) produced an excellent paper that explored the effect of different burial conditions over time on GPR data. His work can be seen in Figures 1.18, 1.19 and 1.20.
Figure 1.18: Six pigs were buried in different conditions; some were covered with a tarp while others were covered with small stones. This was done as part of a project investigating the effect that the age of a burial has on a radar section. Image from Schultz, 2012.

Figure 1.19: Radar cross sections over the pig that was buried shallow without a cover or stones. These sections were taken over the course of 30 months. It shows very well how the diffractions from the pig body continually get less and less obvious as the pig breaks down. Image from Schultz, 2012.
Figure 1.20: Radar cross sections over the pig that was buried deep with small stones covering the body. Even though this pig is buried deeper than the one in Figure 1.19, the diffractions show up just as clearly even after the pig breaks down due to the stones that covered the body. The presence of the stones causes additional diffractions that mark the location of the pig body. Image from Schultz, 2012.

Figure 1.21: Electromagnetic data collected over an ancient Native American settlement. The units are in milliSiemens/meter, which is a conductivity unit. As a result, warm colors are high conductivity and cool colors are low conductivity. This data suggests that possible burial sites are not conductive, or are resistive. Image from Bigman, 2012.
Bigman (2012) has conducted work using electromagnetic methods to show how old graves appear in EM data. His work can be seen in Figures 1.21 and 1.22.

Figure 1.22: Magnetometer data collected over another Native American settlement. The blue arrows indicate possible fire pits, green arrows indicate metallic sources, and red arrows indicate the remains of possible structures. This data is magnetic susceptibility, which is the degree of magnetization of a material in response to an applied magnetic field. Positive responses mean that the material can be magnetic, while a negative response means the material can be non-magnetic. Image from Bigman, 2012.
2.0 Electromagnetic Method

2.1 Electromagnetic Theory

Electromagnetic (EM) surveying uses the response of the subsurface to the introduction of electromagnetic fields to detect subtle changes of the electromagnetic properties in the subsurface. When conducting EM surveying, various factors can be measured, including conductivity, susceptibility, in-phase, and quadrature. All EM systems work by utilizing transmitter and receiver coils. The electromagnetic field travels from the transmitter coil to the receiver coil via paths both above and below ground (Kearey et. al., 1984).

Figure 2.1: Simplified diagram showing interaction between primary and secondary electromagnetic fields and the resulting eddy currents produced by conductive material. Image from Kearey 2002.
The transmitter coil generates a primary electromagnetic field that propagates outward. With the presence of conductive materials in the subsurface, eddy currents are induced by the magnetic component of the electromagnetic field. The eddy currents generate their own secondary electromagnetic field, which is out of phase with the primary electromagnetic field. The receiving coil detects both electromagnetic fields and uses the results to determine conductivity (quadrature component) and susceptibility (in-phase component). This process can be seen in Figure 2.1.

The individual electromagnetic wave, which propagates as a sine wave, can be broken down into several components. The primary magnetic field is in phase and is perpendicular with its orthogonal electric component. The secondary magnetic field is the out of phase, or quadrature, signal. The voltage induced into a secondary perfect conductor as the result of the incident primary magnetic field lags the primary field by $\pi/2$ (Reynolds, 2011). This relationship can be seen in Figure 2.2.

![Electric and Magnetic Fields at Right Angles](astronomyonline.org)

Figure 2.2: This diagram shows the different elements of an electromagnetic field, with the magnetic component on the X axis and the electrical component on the Y axis. Image courtesy of astronomyonline.org.
As stated in Faraday’s Law of EM Induction, the magnitude of the induced voltage is directly proportional to the rate of change of the magnetic field (Reynolds, 2011). In context of EM surveying, this means that when eddy currents are produced within a conductor, they take a finite amount of time to generate, which is dependent on the subsurface materials and conditions. This is called the phase lag. In good conductors, the phase lag is large, and in poor conductors the phase lag is small. Once generated, the secondary magnetic field interacts with the primary to form a resultant magnetic field which has a total phase lag the primary field. This can be seen in Figure 2.3. This phase lagged field is detected by the receiving coil.

![Diagram showing phase difference between the primary electromagnetic field (solid line) and the secondary electromagnetic field (dashed line). Image from Kearey 2002.](image)

When conducting an EM survey, depth of penetration of the EM waves and the resolution as a function of depth is particularly important as this can determine whether an EM survey can be feasibly conducted. In a perfect, homogenous world, EM waves would propagate infinitely. However, in the real world, depth of penetration is limited and is dependent on the wave frequency and the conductivity of the medium being surveyed. This is known as skin depth, which is defined as the depth at which the amplitude of a plane wave has decreased to 1/e or 37% relative to its initial amplitude (Reynolds, 2011). Accordingly, high frequency waves do not penetrate very deep, whereas lower frequency waves will travel deeper into the subsurface. This allows high frequency waves to be used in shallow investigations and targets, while low frequency waves can be used in deeper surveys. Some modern EM instruments can utilize multiple frequencies simultaneously, which allows multiple depths to be surveyed at the same time.
2.2 Methodology

As opposed to the other methods used in this project, an additional area was surveyed for this section. The main reasons for this are outlined in Section 1.3. The additional survey area was located immediately to the south of the primary survey area. This spot was chosen due to its proximity to an access road, and because it was flat and open.

For the electromagnetic portion of this project, a GSSI Profiler EMP-400 was utilized. Using the separate PDA controller, the Profiler was configured to be used in walking mode (continuous data collection) as an inline vertical dipole. Coordinates for the survey area were entered so that the data was saved in a grid format. After all the settings were entered, two sets of calibrations were conducted. The field calibration is to account for the local ground conditions and was implemented finding an open area without any visible irregularities, placing the unit there, and letting it calibrate itself. The second calibration, the user calibration, accounts for the anomaly of the operator. Since someone must carry the unit while it is running, this calibration allows the unit to “ignore” the operator. To reduce noise during both the calibration and the surveying, the author removed all metal or magnetic objects from his person, including belt, phone, watch, etc. The Profiler was adjusted to the author’s height so that it could be carried comfortably for the duration of the surveying. The bottom of the coils was noted to be 1 ft. (0.3m) off the ground.

After all the calibrations and adjustments were made, the Profiler settings were completed. X and Y minimum coordinates were entered, which was (0,0) for both survey areas. X and Y maximum coordinates for the area B were set to (90, 200) and (75, 260) for area A. Entering the coordinates into the machine made sure that all data collected was correctly stored. The direction of traverse was also set, with the machine setting of yRBZ being selected. This setting represents the starting traverse starting at X max and Y min, moving in the positive Y direction and ending at X and Y max. From this spot, the next traverse would be the next line over and moving in the opposite direction. This pattern would be completed until the survey area was completed. With these coordinates, a grid spacing of 5 ft. (1.5m) was selected for both survey areas. Continuous surveying was selected, which allowed the author to walk continuously without having to take a reading at each discrete grid point.
After the coordinate settings were entered, the frequency settings were completed. The GSSI Profiler EMP-400 can collect up to three frequencies simultaneously. For both survey areas, frequencies of 15,000Hz, 9,000Hz, and 5,000Hz were selected. This range of frequencies also allowed a range of depths to be surveyed simultaneously, from the very shallow subsurface with high frequencies to several feet in depth with the lower frequencies.

A total of 18 lines were collected in survey area B, while 15 lines were collected in survey area A. There were no obstructions or visible anomalies in the practice area, while there were numerous trees in the primary survey area. Any time a tree was in the way, the author would simply walk around it and continue the line to avoid having to stop and save the data. The trees did not greatly affect the final dataset.

2.3 Data Processing

The GSSI Profiler produced three file types from each survey area, including a .EMI, .dzb, and .GPS. Since the data was collected on a grid, it was decided not to use the .GPS file that had been collected and use a grid during processing. The .EMI file was imported into Surfer 13 to produce maps of the data. The data was “gridded” using the Kriging interpolation method, which is a method of interpolation for which the interpolated values are modeled by a Gaussian process and gives the best linear unbiased prediction of the intermediate values.

This produced a .grd file that could then be used to produce different types of maps to display any electromagnetic anomalies. This process was repeated for all quadrature, in-phase, and conductivity values for each area for each frequency. With the .grd file, contour maps were created for each set of parameters. The resulting maps were then exported as a .png to be used in this document.

In the magnetic survey chapter, the data was processed in a similar fashion using Surfer 13. The main difference between the EM and magnetics data was that there were many more EM maps to make. This is because a map for each of the in phase, quadrature, and conductivity components was needed for each of the three frequencies. The same color ramp “Geology 1” was applied for consistency between maps.
2.4 Results and Discussion

For each survey area, 9 maps were created for each frequency and each component. Figures 2.4 and 2.5 represent area A. Each set of maps were created using its own unique scale. This helped accentuate any anomalies that may be present and is particularly useful for mapping geoarchaeological results. The system’s primary data output is the In-Phase and Quadrature components of the mutual coupling field ratio (Q) of the primary transmitted field to the induced secondary field in parts per million (PPM) at all frequencies. This is the unit of the scale used in these maps.

Figure 2.4: Magnetic susceptibility (in-phase) component for each frequency for area A. Surface artifact site located within dashed circle.
Figure 2.5: Conductivity (quadrature) component for each frequency for area A. Surface artifact site located within dashed circle.

Another prominent anomaly is visible at coordinates (35, 175), which is the location of bricks and other artifacts on the surface. This anomaly is likely the result of this artifact site. Other smaller anomalies present are likely the result of tree roots and rocks that are buried shallowly. From this data, there is no definitive evidence of grave locations.

Figures 2.4 and 2.5 each show multiple anomalies. The largest and most noticeable is the anomaly running through the center of each map. This positive anomaly is visible in each component at each frequency, although it appears strongest at the lower frequencies. That it
appears better at lower frequencies suggests that this anomaly is deeper in the subsurface than surrounding anomalies. The high point of this anomaly can be seen at coordinates (10, 90) and continues across the map, although not as strongly. There is a slight dip that is present on the surface right over where this anomaly is present.

Figures 2.6 and 2.7 represent area B. There are almost no visible anomalies, except in the lower right hand corner. This survey area slightly overlapped an old gravel road right where this anomaly exists, which suggests that this anomaly is the result of compacted soil and gravel that makes up this road. No other areas of interest are visible, which completes the goal for this area for giving a baseline of what undisturbed ground looks like for this locality. Any linear features that appear to be anomalies are likely an artifact of the survey and processing. No further analysis will be conducted for area B, as this EM survey was the only survey over this area.
Figure 2.7: Magnetic susceptibility (in-phase) component for each frequency for area B.
3.0 Magnetic Method

3.1 Magnetic Theory

The geomagnetic field at or near the surface of the earth originates largely from within and around the earth’s core (Reynolds, 2011). The main component of this geomagnetic field is the dipolar field, which behaves like a bar magnet located at the center of the earth with an inclination of 11 degrees from the geographical north pole. This magnetic field changes both over time and depending where on earth it is being measured. Local anomalies can disrupt and change the magnetic lines of flux of the magnetic field. Because of this, magnetic surveys can be conducted using magnetometers that can detect those minute changes.

![Diagram showing typical bar magnet and lines of magnetic flux. Image from Kearey 2002.](image)

The density of the magnetic flux, measured over an area perpendicular to the direction of flow, is known as the magnetic induction (Kearey and Brooks, 1984). Historically, the unit of this measurement was called a Gauss, although modern convention is to use the tesla (T).
gauss is equivalent to 10^-4 Tesla. For small magnetic anomalies, the tesla is far too large a unit so the nanotesla (nT) is used. The nanotesla is equivalent to 10^-9 T. for this survey, the nanotesla will be used.

While there are no definitive magnetically susceptible objects present on the surface, there could be metal or magnetic objects buried beneath the surface from either the original cabin or the more recent lodge. It is possible that there could be metal objects that were buried with the Kinsey’s, which could include buttons, coffin handles, nails, or personal effects. Any of these metallic objects would represent themselves as more obvious magnetic anomalies. Rocks and earth materials that have been disturbed or are not original material could also give a slight magnetic anomaly.

All substances are magnetic at an atomic level (Kearey and Brooks, 1984). Because of this, each atom acts as a dipole, a magnetic anomaly will have a positive and negative peak, depending on the distribution of poles on the object generating the anomaly. Any object that is magnetically susceptible is affected either by an induced magnetic field from the earth or from its own permanent magnetic field. This magnetic field from an anomalous body can be detected by a magnetometer. When the affect from the magnetic field of the earth is taken out, the magnetic anomalies lines of flux are left and can be interpreted. When using a single magnetometer, readings must be taken at a base station occasionally to be able to correct for the diurnal variation, or the fluctuations in the earth’s magnetic field.

For this survey, a gradiometer configuration was used, which is two magnetometers separated at a fixed distance while both record data simultaneously. This prevents having to return to the base station and correcting for the diurnal variation since the effect of the total magnetic field is removed. This is due to the readings from the bottom magnetometer being subtracted from the top magnetometer’s reading, which creates a resulting gradient of the magnetic field.

There are several types of popular magnetometers, but for this survey a pair of proton precession magnetometers were used. This type of magnetometer monitors the precession of atomic particles in an ambient magnetic field to provide an absolute measure of the total magnetic field (Reynolds, 2011). The proton precession magnetometer consists of a bottle sensor that contains a proton-rich liquid, in this case decane, with a coil wrapped around the bottle and
is connected to a recording device. In an ambient magnetic field, such as the earth’s magnetic field, the protons in the liquid align themselves parallel to the field. A current is applied to the coil wrapped around the sensor, creating a magnetic field 50 to 100 times stronger than the earth’s magnetic field. When the current is turned off, the protons precess around the ambient magnetic field at the Larmor Precession Frequency, which is proportional to the magnetic field strength. Because protons are charged particles, they induce an alternating voltage into the coil surrounding the sensor when precessing. These precessions end after 2-3 seconds, which is enough for a resulting resolution of +/-0.1nT (Reynolds, 2011). Figure 3.2 shows a diagram of a typical proton precession magnetometer.

Figure 3.2: Diagram of typical proton precession magnetometer. (a) shows container filled with decane with a coil wrapped around it. (b) shows protons aligning parallel to ambient magnetic field. (c) shows protons after a new, larger magnetic field produced by the coil has been applied and they align in a new direction. (d) shows protons returning to their original orientation by precessing (spiraling) after current is turned off. Image from Kearey 2002.

The main drawback to using this type of magnetometer is that in areas of high magnetic gradients the ambient field can be different across the length of the sensor, meaning that the
sensor could be subject to different magnetic field strengths. Additionally, there are magnetometers that have 10x better resolution, such as cesium vapor magnetometers, which are better suited for detection of subtle magnetic anomalies.

3.2 Methodology

For this survey, two Geometrics G-857 proton precession magnetometers were used in a vertical gradiometer configuration. The bottom sensor was attached to a pole 3 ft. (1m) off the ground and the top sensor was 6 ft. (2m) above the bottom sensor when attached. The gradiometer array was used for this survey to view local magnetic anomalies as opposed to the entire magnetic field, in addition to avoid having to make corrections due to the diurnal variations. The control units were connected in a way that both units would measure and record simultaneously, with one unit controlling the other. Using the “master” control unit, the system was set up so that discrete points would be recorded instead of continuous walking data collection. Figure 3.3 shows the author with the instrument. It is important to note that the sensors had to be roughly orientated towards magnetic north during each reading to ensure proper alignment with the magnetic field.

The magnetic survey area covered the same area as both the GPR and electromagnetic surveys, however, the start coordinates were 75, 260 (northeast) instead of 0,0. This was done due to time constraints, since working from this corner first would allow the area of higher interest (flat areas, visible artifacts) to be surveyed first in case the sun went down before finishing. Measurement were taken in a grid every 5 ft. along the x-axis starting from 75, 260. Each line started on the east side and ended on the west side. Once finished with a line, the author would return to the other side and record the measurement number that the previous line had ended with, in addition to any problems that occurred on that line. A total of 53 lines were completed, comprising 856 individual data points. To ensure each data point was measured in the correct spot, paint marks were made at 5 ft. intervals along both the east and west boundaries of the survey area. To help with accuracy between endpoints of each line, two 100 ft. (30m) ropes were painted with marks every 5 ft. (1.5m) and were stretched across the survey area between line endpoints 10 ft. (3m) apart. With this method, the ropes could be used as guidelines for several lines before having to be moved for a new line. Although there was not a rope placed
along every line traversed, it was easy to estimate the midpoint between the paint marks on the ropes.

Figure 3.3: Author wearing and operating two Geometrics G-857 magnetometers. Note the sensors on the pole, these are the top and bottom magnetometers. Image taken by Bryan McCallister.
Due to the condition of the survey area, there were several cases where a measurement could not be taken at the exact 5 ft. (1.5m) grid. There are numerous trees and stumps that blocked the path of the survey. In these cases, a measurement was taken as close to the proper position as possible and the measurement number was recorded so that the measurement at that point could be reviewed. Due to the nature of the recording system being used for this survey, there were two instances where one of the control units saved a measurement while the other did not, causing the measurement file numbers to become out of sync. This would be fixed by repeating the same measurement and overwriting the incorrect file.

3.3 Data Processing

Each Geometrics control unit produced one .stn text files, each of which contained a column of point number and the total magnetic field (nT) reading. To put this data into Surfer, the two files had to be reformatted. A new Microsoft Excel worksheet was opened and seven columns were defined: line number, station number, X-coordinate, Y-coordinate, top sensor, bottom sensor, and gradient. Using field notes from the data collection, the data from the two .stn files were moved into the Excel worksheet and were proper X, Y coordinates and individual station numbers. The top and bottom sensor readings were subtracted from each other and the result was the magnetic gradient, or the localized magnetic anomaly at the spot of the measurement. This had to be done very carefully, since if it was in the wrong format Surfer would not be able to grid and display the data correctly.

Once this Excel file was completed and checked for accuracy, the file was opened in Surfer 13. The following process is very similar to the process used in the EM section. Using the X, Y coordinates assigned in the Excel worksheet, the data was “gridded” using the Kriging interpolation method using the X and Y coordinates and the gradient values, similar to the electromagnetic data. This produced a .grd file that could then be used to produce different types of maps to display any magnetic anomalies. This process was repeated for both the top and bottom sensor values. With the .grd file, contour maps were created of the gradient, top sensor, and bottom sensor data. The resulting map was then exported as a .png to be used in this document. A color ramp was also applied to each map made to display the data, in this case a Surfer- created ramp called “Geology 1” was used. All magnetic values shown in the maps are in nT and nT/ft in the gradiometer maps.
The maps for all available data using the method outlined above revealed a high amplitude linear anomaly went through the center of the area of interest. This anomaly was strong enough that the resulting scale prevented smaller anomalies on the north portion of the map from being visible. To be able to see the northern anomalies, the data set was reduced from the full survey area to just the north portion from Y coordinates 175 to 260. This allowed the subtler anomalies to be visible because a new scale was used.

3.4 Results and Discussion

A total of 8 maps were produced for this section, six for the full dataset and two for the partial dataset. Two maps were made for the top and bottom magnetometer and the gradient with different contour intervals for each map. This was done to show the difference that the contouring level can make in distinguishing anomalies. Figure 3.4 shows both maps representing the top magnetometer, while Figure 3.5 shows both bottom magnetometer maps. Figure 3.6 shows the gradiometer maps, which is the difference between the top and bottom magnetometers and shows local anomalies better. Figure 3.7 shows both maps made for area A from Y-coordinates 175 to 260.
Figure 3.4: Top magnetometer results. Note the difference that the different contouring level makes on the anomalies.
Figure 3.5: Bottom magnetometer results. Note the difference that the different contouring level makes on the anomalies.
Figure 3.6: Magnetic gradient results. Note the difference that the different contouring level makes on the anomalies.
Figure 3.7: Gradient data recontoured for Y-coordinates 175 to 260. Notice that large anomaly in center is much clearer on these maps than the full survey area maps due to the removal of the large linear anomaly.
As noted in section 3.3, there is a large, linear anomaly that runs through the center of the data on each dataset. This anomaly is very similar to the large anomaly present in the EM dataset, although in this data the anomaly appears to be more linear and not a point anomaly. This could be an old pipe or drain location, due to the strength and shape of the anomaly. On the full dataset, there a several other anomalies but no fine details can be seen due to the overpowering linear anomaly.

In the recontoured data, smaller anomalies are much clearer and have more detail. In the center at coordinates (45, 215), there is an anomaly that appears as a “doublet”, or two anomalies next to each other with opposite magnitudes. There is a similar anomaly at (30, 200). These double anomalies could be objects that have a strong magnetic signature, possibly a boulder. The scale of these anomalies could also indicate possible foundation remains. These two anomalies partially form an area approximately the size of a small building such as the deer keeper’s lodge. The foundation of the lodge was likely limestone blocks buried several feet into the ground. A definitive conclusion cannot be made due to the lack of higher resolution data. In the top left corner, there is a very strong magnetic signal that is only partially visible since the survey area does not cover the entire anomaly. This anomaly was not investigated further since there was no surface evidence indicative of the deer keeper’s lodge, and this location is not a likely burial site since it is at the bottom of the hill.

While this data is useful, a more sensitive magnetometer, such as a cesium vapor magnetometer, may provide higher resolution data, especially over the artifact site. This would be helpful in determining if there are any possible grave sites or old foundations, since there are no visible anomalies that could represent a grave.
**4.0 Ground Penetrating Radar Method**

**4.1 GPR Theory**

Ground penetrating radar (GPR) is a particularly useful method when searching for shallow features. A typical GPR system is comprised of a signal generator, one or more transmitting and receiving antennae, and a control console for managing generation and recording (Reynolds, 2011). Figure 4.1 shows how a typical GPR system works.

![Figure 4.1: Simple diagram showing main parts in a GPR system. Image courtesy of bchazmat.com.](image)

In general, the antenna and control console are mounted on a cart which then can be pushed over the ground to collect GPR profiles. The antenna, in this case a monostatic antenna (antenna is both transmitter and receiver), generates a pulse of radio waves at a frequency determined by the characteristics of the antenna being used. The radio waves travel into the
ground and a portion of the transmitted waves will return to the surface after reflecting off an object. As the antenna is moved over the ground, the received signals are detected and displayed as a function of their two-way travel time.

![Figure 4.2: Wright State University’s GPR cart being operated by Dr. Ernest Hauser across an area of visible artifacts in survey area A. Picture taken by author.](image)

The electromagnetic properties of materials are related to their composition and water content, both of which exert the main control over the speed of radio wave propagation and the attenuation of electromagnetic waves in materials (Reynolds, 2011). Put another way, it is important to have an idea of the composition of the material being surveyed to have an estimate on the loss of signal. This loss of signal is directly related to what is known as the reflection coefficient, or the proportion of energy reflected in the subsurface. The reflection coefficient is directly affected by the dielectric properties of the subsurface material around the target object, as well as the target material as well.

When discussing the theory of radio wave propagation, it is important to include the concept of two-way travel time. The two-way travel time is the amount of time between the transmission of a wave and the eventual detection of the reflected wave by the receiver. When collecting GPR data, the results that are displayed on the control console are in the form of a
radargram, which is the representation of the two-way travel time. This radargram represents all the scans for the current survey and shows any reflections that have been detected. Diffractions, the hyperbola shapes that can been seen amongst the reflections, are the result in the change in the two-way travel time of a radio wave and can be result of an anomaly.

In GPR surveying, it is very important to collect data in at least two directions. Figure 4.3 shows the effect of collecting data in different directions, as the diffractions drastically change in shape when traveling perpendicular to parallel to an object. In this case, the diffractions are very strong in one direction and almost not visible in the other direction. When data is collected in two directions over the same target area, this allows one dataset to be parallel to the target and one dataset to be perpendicular. Generally, when traveling perpendicular with the target, the diffractions are greatest.

Figure 4.3: Example radargrams that show the effect that orientation can have on GPR data. Top left shows radargram perpendicular to buried pipe, following radargrams show change in orientation relative to the pipe. Image courtesy of Reynolds 2011.

4.2 Methodology

For this project, the GPR unit used was a GSSI SIR-300 (subsurface interface radar) with a 400MHz shielded, bistatic antenna. This antenna was selected because it has, for the soil present at the survey site, good resolution and depth penetration up to approximately 5 ft. (1.5m). While this antenna is rated to have a maximum penetration of up to 12 ft. (3.5m) for non-
attenuating soil conditions, the survey site soil attenuates radio waves much more, resulting in a lower depth of penetration. This antenna also has reasonably good resolution at this depth. Before any data could be collected, the distance wheel that determines distance traveled had to be calibrated. The calibration distance was set to 30 ft., which means that the cart had to be pushed exactly 30 ft. (9m) so that the distance wheel could accurately determine distances.

The control console attached to the antenna was used to set-up the antenna and to view the data as it was collected. To start, the GSSI “Utility Scan” settings were selected, since the target of this survey was analogous to searching for buried utilities. These settings use 512 samples per scan, 16 bits per sample, 100 scans per second, 24 scans per foot, and a dielectric constant of 4. The survey area measured 260 ft. (79m) by 75 ft. (23m). Paint marks were made at every 5 ft. (1.5m) interval on all sides, since the grid survey would be conducted at every 5 ft. (1.5m).

For the GPR collection, it was split into multiple phases to ensure that all areas of interest were covered. The first phase involved collecting lines over areas of visible interest. The second phase was to collect lines in a grid over the entire survey area. For the first phase, there was not a strict grid enforced, rather a series of lines were survey that were over areas of interest, such as the visible bricks and other artifacts and visible depressions. A small anomaly was found near the center of the survey area, so a small 3D dataset was collected over this area, consisting of 6 lines in each direction with 2.5 ft. (0.8m) spacing. The locations of these lines can be seen in Figure 4.4. For the second phase, lines were collected along the 5 ft. (1.5m) grid that was laid out earlier with the paint marks. To speed up collecting the lines along the grid, only one direction, east-west/ X-axis, was collected. While a 3D dataset cannot be made with this amount of data, it allows the entirety of area A to be covered with 2D lines. After the second phase was collected and analyzed, a third phase was done to collect a small, high resolution 3D dataset over a unique anomaly near coordinates (35, 95).

4.3 Data Processing

When collecting GPR data, the lines are individually saved as .DZT files. The start and end coordinates for each line were recorded along with the file name to ensure that the location of each line was correctly recorded. To process these files, the software RADAN 7 was used.
RADAN 7 allows GPR lines to be displayed either individually or processed together to create a 3D GPR profile. For this project, each line will be processed and displayed individually.

Figure 4.4: Gridded map of area A showing location of individual GPR lines and visible surface objects. The blue dashed line shows extent of artifact site. Individual GPR lines are numbered 1 to 21.
For this data to be displayed accurately, three steps were taken when processing each line. First, the background of each line was removed. This was completed using the Background Removal tool, which acts as a finite impulse response (FIR) filter. This tool works by removing the average scan from several adjacent scans. This allows the background noise and surface multiples to be removed while preserving the data of interest. However, removing the background from each radargram results in low amplitudes of remaining reflectors, making the reflectors difficult to see properly. As a result, the second step was to adjust the gain of each line so that the saturation of the remaining reflectors was increased. A range gain was applied to each line after making sure that the gain was sufficient to be seen both on the computer screen and after printing.

For the small 3D area, the same processing took place on the lines collected. Using RADAN, a 3D grid was created and the lines were imported, creating a 3D volume. This was done so that the results could be compared in 3D space and to see how the anomalies changed through the volume.

After these two steps were applied, each line was saved as a .DZT file. In order to view the lines without using RADAN, each .DZT file was put into rad2bmp, a free software from RADAN that converts the .DZT file into a .bmp (bitmap) file, which can be viewed as a regular picture.

4.4 Results and Discussion

While the GPR data did not yield any definitive grave locations, it did assist in determining the extent of the artifact site and gave a potential grave location. The field, beyond what is visible, continues under the surface covering several times the area of the surface area. It also has definite boundaries, with undisturbed ground surrounding it. There are several deep diffractions near the artifact site that are likely large rocks, possibly glacial boulders. Along the two north-most lines, there is a large single anomaly, approximately 10 ft. (3m) in width. Collection of more data over this area could be of interest in determining the nature of this anomaly.

When looking at the full dataset, it is important to note the blank spaces in several lines. These blank spaces occur when a tree or other large object is on the line and data collection must
be paused, moved around the obstruction, and continued. As a result, these blank spaces can be used to visually estimate where surface obstructions are. Refer to Figure 4.4 for full location of surface objects.

Individual lines collected over the artifact site are shown in Figure 4.5, the small 3D dataset can be seen in Figures 4.6 and 4.7, and select grid lines can be seen in Figures 4.7 to 4.14.

Figure 4.5: Individual GPR lines collected directly over the artifact site at different orientations. Maximum depth of 4 ft. (1.2m) and time of 24ns. Refer to Figure 4.4 for exact locations of each line. Note the strong diffractions in each line, all originating in the shallow subsurface. Also, note the amount of high amplitude diffractions, the result of the surface being very rough and the antenna not staying level over the ground.
Figure 4.6: Sample of 3D volume created in RADAN. Note the strong hyperbolic diffraction labeled, as it is the characteristic shape of a grave. This is looking SE.

Figure 4.7: Additional example of 3D volume. Time slice at 20 ns looking down from the top (surface). Top of image is facing north. Note linear anomaly aligned east-west.
Figure 4.8: Beginning of artifact site, lines from Y coordinates 260 to 230.
Figure 4.9: Lines from Y coordinates 225 to 195.
Figure 4.10: Lines from Y coordinates 120 to 90.
5.0 Discussion and Comparison of Survey Methods

When viewing the results from each geophysical method used in this report, it is apparent that each method has unique advantages and disadvantages. For example, the EM and magnetic surveys revealed a large anomaly running through the center of area A, while the GPR survey did not reveal the same anomaly. The magnetic survey produced the best results over the visible artifact site by showing two sets of magnetic doublet anomalies. The GPR was able to reveal the approximate boundaries of the artifact site, although specific objects were not distinguishable because of the amount of noise produced by the rough surface. The EM survey also showed an anomaly over the artifact site roughly similar in size to the area shown in the GPR data. The difference in the EM surveys between area A and area B shows the difference between undisturbed soil in area B and the highly disturbed soil in area A. Both the magnetic and GPR surveys show a large anomaly in the upper right hand corner of area A while the EM survey does not.

There are several ways to improve the quality and resolution of the data of each method. For the GPR survey, a tighter grid of lines, 2.5 ft. (0.8m) or even closer spacing, would likely improve the ability to show the movement of anomalies across the data. In addition, conducting lines going north-south in as well as to east-west would allow for making a 3D model of the subsurface in area A. This could be useful in viewing the smaller anomalies that are not distinct in the 2D dataset. The main issue with using GPR on this site is the high clay content, which attenuates the radio waves at a high rate. This limits the usability of GPR for this survey area, even with additional lines and closer spacing. Another drawback to using GPR here is the amount of large trees present, with large root systems. However, this was an issue for all three methods used, as every single tree was an obstruction at some point.

That said, the GPR data collected during this report has been highly useful. Along with the other methods, it has shown that the artifact site of bricks and other building material does not extend over the entire area, rather it is isolated to an area approximately 200 ft² (19m²). This area can be confirmed as the location of the deer keeper’s lodge.
The GPR data has also shown that there is a linear trend of compacted soil moving north approximately 100 ft. (30m) through the center of area A. This could be evidence of an old walking path, possibly leading to the deer keeper’s lodge or the Kinsey family cabin. Several small anomalies that could be potential grave locations were observed in the surveying of area A. The most promising anomaly was chosen to have a small 3D survey conducted over it. The results from this 3D survey are inconclusive, although there is evidence that there could be a grave present. It could be beneficial to conduct additional 3D surveys over other anomalies; however, this may not be feasible due to the number of trees present in area A. At time of writing, there are several that are in the process of being removed, although likely not enough will be removed to conduct a thorough GPR survey.

The GPR method was possibly the fastest in collecting survey data on the site, similar in time to the EM survey over area A. However, processing and interpretation time for the GPR method was the longest by a wide margin. Each individual line had to be processed one at a time and put into a format usable for presentation for this report. In the end, though, the total amount of time spent on the GPR method was about equal to both other methods, with the GPR being likely the best data quality.

The magnetics method produced excellent data, although the quality can be improved using a cesium vapor magnetometer, as opposed to a proton precession magnetometer. The cesium vapor magnetometer is much more sensitive to the local magnetic anomalies and would provide better resolution of known anomalies, as well as possibly revealing subtler anomalies. Even without using a different magnetometer, tighter grid spacing would give a higher resolution dataset. However, the main drawback to this change is the large increase in data collection time. The magnetic method is, by a large margin, the slowest method for data collection since each discrete point must be measured individually. For example, a grid spacing of 5 ft. (1.5m) in area A resulted in 856 discrete measurements, each of which takes several seconds to complete. If the spacing were halved from 5 ft. (1.5m) to 2.5 ft. (0.8m), the amount of measurements, and time, would double. If hard pressed for time, that may cause an issue. To balance this out, the magnetic data was very easy to process and interpret, similar in time to the EM method.

The data from the magnetic method was similar in quality to the GPR data, in that the artifact site was easy to distinguish and confirmed the interpretation of the GPR conclusions. The
main difference in the results is the large anomaly running through the center of the magnetic
data. This anomaly does not appear in the GPR data, which is begs the question of what is the
source of this anomaly. Considering that this anomaly shows up in both the magnetic and EM
datasets, it is likely that this anomaly is metallic or magnetic in nature, likely an old utility pipe
or drain system. It is possible that it did not appear on the GPR data since it is deeper than the
reach of the GPR antenna used. If this the case, an easy way to confirm this theory is to run
several lines over the spot of the anomaly with a lower frequency GPR antenna, which allows
deeper penetration of the subsurface.

The EM method proved to be the least useful. The main advantage to this method is it
confirms and reinforces the results from the magnetic survey. The best results are the lowest
frequency data, 5 kHz, which showed the clearest and largest anomalies, suggesting that
anomalies could be buried deeper. The results from this method could be improved by
decreasing the line spacing and by collecting lines in both directions. This would massively
increase the resolution and possibly reveal subtler anomalies. Different frequencies could be
tried as well, possibly focusing on the lower frequencies as opposed to the higher frequencies
used in this report.

To show the locations of the artifact site and the path anomaly topographically, a section
of Lidar data was downloaded for the extent of the VA property. Lidar, which stands for Light
Detection and Ranging, is a remote sensing method that uses light in the form of a pulsed laser to
measure ranges. Figure 5.1 shows the location of Route 35 and the southeast corner of the VA
property, the location of the surveys. The warm colors, reds and yellows, show higher elevations
while the cooler colors, blues, show lower elevations. The southeast corner shows as being a
topographic high within the VA property. Figure 5.2 shows area A and its position on a knoll
extending from the hilltop. Figure 5.2 also shows the location of the artifact site and the walking
path anomaly in relation to the topography.

Electrical resistivity tomography (ERT) might be usefully applied to this site. This
method sends an electrical current into the ground and measures the change in voltage
distribution at the surface from which the apparent resistivity of the ground can be determined.
ERT could work very well here due to the soil composition and the nature of the target. It is also
Figure 5.1: Lidar data showing ground elevations around the VA property. Rt. 35 is visible in the center of the image. Warm colors are higher elevation and cool colors are lower elevation.

It is possible that a 3D dataset using ERT may prove useful. Depending on the amount of precipitation, graves can either appear to be very resistive, due to the compaction of the soil, or very conductive, due to water invading the void left by the grave. It could also be used in locating large subsurface rocks, which are very resistive. A drawback to this method is the amount of time and labor needed to lay out the survey equipment, which is the lengthiest by a large amount. However, the processed results are very high quality and can show, with high
Figure 5.2: Lidar data showing ground elevations around area A. The artifact site is marked with a dashed circle and the footpath anomaly marked as a solid box. The artifact site, the location of the deer keeper’s lodge, appears on a level spot on a knoll extending from the top of the hill, trending northeast. Accuracy, the discrete layers in the subsurface. A future survey could benefit from using this method.
6.0 Conclusions

The main goal of this report was to plan, conduct, and process the data from three different geophysical methods to attempt to locate the missing graves of Henry and Eva Kinsey. Based on the results of the surveys undertaken, no definitive evidence of the graves was discovered, although it can be stated that it is likely that the deer keeper’s lodge has been located. From this, it can also be concluded that the missing graves are nearby on the same hillside, since Kinsey family history states that Henry and Eva were buried on the same hillside as the lodge. The small 3D radar survey results show a potential grave location just up the hill from the lodge, although the radar data is inconclusive.

The method that produced the most useful data was the GPR method, as the data collected showed the subsurface extent of the artifact site. This artifact site can be said to be the location of the deer keeper’s lodge, as antique bricks and glass have been found that seem to correspond to the correct age for the deer lodge. This method provided relatively quick data collection, although also taking the longest to process and interpret. The GPR data also revealed what appears to be an old walking path leading towards the likely location of the deer keeper’s lodge. This path appears both in the GPR data and on the surface as a visible depression. Tree roots caused a major issue in the interpretation of the data, as they covered possible diffractions of interest. The small 3D survey results show a potential grave signature.

The magnetic method produced data that was similar to the data from the GPR survey. The magnetic data also shows the approximate extent of the artifact site in area A, especially when looking at only the top portion of the data as opposed to the full dataset. The reason for this is the large anomaly that runs through the center of the magnetic data, with such a strong amplitude that it reduces the smaller anomalies elsewhere in the survey area. The magnetic data took the longest to gather, although only taking a short while to process the data. Future surveys conducted could be improved with the use of a cesium vapor magnetometer, as it is far more sensitive to local anomalies. The results from the EM survey were of the least use from the three methods used. The artifact site that was shown in the magnetic and GPR data was much
less defined and could not be used to establish the extent of the field. This data also showed the large anomaly through the center of area A, although the amplitude was not as strong it was in the magnetic data. No other anomalies of interest were visible in the EM data from area A. This method was also used over area B, the only to do so, to confirm that there were not significant anomalies that could be the missing graves or the deer keeper’s lodge. Doing this also provided a type of baseline for the area, in that most of area B was undisturbed ground.

Overall, the author feels that this investigation was a success, since the location of the deer keeper’s lodge has likely been discovered, although conclusive evidence of the missing graves was not found. The identification of the artifact site and associated anomalies both above and below the surface provides the needed evidence that this is the location of the deer keeper’s lodge. The missing graves must be located near this site, likely on the same hillside, based on the Kinsey family history.

This work also allowed the author to plan and carry out multiple types of geophysical surveys, while learning about each method used and how to apply the skills acquired in the real world. While the missing Kinsey graves were not found, the author is confident that future, more focused surveys will reveal their location.
7.0 References


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McIntire, T., 1997, RADAN to Bitmap Conversion Utility:


8.0 Appendix

8.1 Additional Site Photos

Figure 8.1: Photo of survey area A looking south uphill. Artifact site is located around tree stump near center of image. Photo taken by Bryan McCallister.
Figure 8.2: Three stones visible on surface near artifact site. Appear to have been shaped at some point, based on flat surface and squared edges. Photo taken near coordinates (20, 180). Photo taken by Bryan McCallister.

Figure 8.3: The author taking a break from collecting GPR lines in survey area A to consult with Dr. Ernest Hauser. Photo taken by Bryan McCallister.
Figure 8.4: Dr. Ernest Hauser collecting GPR lines over artifact site. Noticeable brick and rock artifacts can be seen very well in this image, especially in the lower right hand corner. Photo looking east. Photo taken by author.

Figure 8.5: Dr. Ernest Hauser collecting GPR lines over artifact site. Numerous brick and rock artifacts are visible throughout the photo on the ground. Note the large amount of debris visible under tree stump in center of photo. Photo looking west. Photo taken by author.
Figure 8.6: Photo showing the large volume of artifacts that was uncovered while the VA grounds crew worked to clear this area of undergrowth. Large rocks and bricks are visible throughout the photo. Photo looking northwest. Photo taken by author.

Figure 8.7: Photo taken during initial trip to the VA hospital. Photo looking north over survey area A from south boundary of area. Photo taken by author.
Figure 8.8: Photo looking northeast from west of survey area A. This photo was taken approximately 10 months before the first survey was conducted. Notice the dead tree and underbrush on the top right hand side of the photo. This is the artifact site area, at this time unexposed and buried beneath underbrush. Photo taken by author.
8.2 Area A Radar Lines

Figure 8.9: Lines from Y coordinates 190 to 160.
Figure 8.10: Lines from Y coordinates 155 to 125.
Figure 8.11: Lines from Y coordinates 85 to 55.

Slight depression on surface, could be old path that compacted soil.
Figure 8.12: Lines from Y coordinates 50 to 20.

Slight depression on surface, could be old path that compacted soil

Likely small glacial rocks
Figure 8.13: Lines from Y coordinates 15 to 0.
8.3 Kinsey Family History Documents

This is the traditional story as reported in "Wampler Ancestors and Descendents in America, Journal #1," Barbara Wampler (1977, pp. 23-24): During last summer (the year being 1899), Mrs. Z. Luther of Oakland, California on a visit to her old home in Dayton, Ohio, called upon the Dayton Historical Society and told the story of her great-grandmother, who was buried in the Soldiers Home grounds. She visited the graves of this pioneer family. The spot was soon located on the knoll where the Deer Lodge now stands. Mrs. Luther requested of the managers that she be granted the privilege to place the unkept graves in good condition, and the privilege to mark the historic spot with a monument in honour of the soldiers of 1812, the pioneer family, and Eva Wampler, her great-grandmother, who was the little girl stolen by Indians in 1745.

Eva Wampler was born in Botetourt County, Virginia in 1738. Her parents being of the early Holland settlers who emigrated to Virginia in 1710 and located on the frontier of the said state. The Indians were very troublesome. At an early age of seven, her parents left her in the house to care for the younger children while they went to work in the fields. A band of roving Indians came to the house one day, ransacked it and destroyed everything they could. They took the featherbeds and ripped them apart and poured molasses over them, not daring to burn for fear of being detected. They carried off the little girl, Eva (and according to other stories, some of her sisters as well). She was inconsolable and refused to eat anything. The Indians would take their tomahawks and chop into the trees and make motions to her that they would do the same to her if she did not eat. But, finding that didn't help and they couldn't force her with threats, they set her to feeding the Indian papooses and gave her sweet cakes; and in chewing the sweet cakes to give to the papooses, her hunger overcame her and she ate the cake, and in that way broke her fast. The Chief of the tribe became interested in her, and she became his favorite, and at the age of 14 was his promised bride. But, about that time, peace was declared and a reward was offered by the United States Government for the return of all whites stolen by the Indians. Eva was then soon away from her tribe and returned to her parents.

Upon her return, she was not able to understand a word of English. Her parents made great efforts to have her speak or understand but they could not arrest her attention. Finally they gathered around her and began singing a familiar hymn which she recognized, and she began to sing. But she could not speak a word for a long time. One day she went out into the field with her father who was making a fence. He had just brought a rail and started back for another when all at once she exclaimed "I will fetch that rail!" Her father was so overcome with joy that he took her home at once to tell the rest of the family the glad news that Eva had spoken.

At about the age of 23, Eva was married to Henry Kinsey. They raised a family of six children some of whom married and settled in Va., but around the year 1800, she with her husband and family emigrated to Ohio and a section of land six hundred and forty acres, now included in the Dayton's National Home. They left behind their two married daughters, one of whom married Jacob Wolf. The parents, anxious to have their daughter Hannah near them, wrote often to them to come to Ohio, and they would give them land. Finally, Jacob Wolf, husband of Hannah, wrote to the parents saying that if they could find him a good spring of running water they would come. They found the spring which now bears the name "The Grotto Spring". The Wolf family then moved to Ohio, arriving in 1805, and settled in the old log house which stood on the top of the hill at "Grotto Spring", which afterwards became the first headquarters of the National Soldiers Home, and the old red barn became the dining room which the veterans had, while the sugar grove nearby, which for years furnished the supply or sugar, cast its ample shade on hot summer days for the soldiers to enjoy.

Jacob Wolf served in the War of 1812 as a teamster, hauling supplies for the Army between Dayton and Fort Wayne, furnishing his own team of horses. He was protected by only one bodyguard on this long and dangerous drive. One night while in a dense forest they stopped to cook coffee, and attempted to start a

Figure 8.14: Part one of Kinsey family history. Courtesy of Dayton VA hospital.
fire by placing powder in the pit of the flintlock musket, but they forgot to close the opening into the barrel of the gun. The fire flashed into the lock causing a loud report. They were terribly frightened, thinking that the Indians would find them, but they were not disturbed. He was honorably discharged as a soldier and his wife received a pension after his death. While a teamster and upon arriving at Fort Wayne with his supplies, the officers would mess with him, and he would make chocolate for them as they were very fond of it. He served for three years in the Army and one night after his return from a trip to Dayton his horses were stolen at Fort Wayne. He was then allowed to return to his home.

Eva Kinsey closed an eventful life in the year 1821 at the age of 83 and was laid to rest in the knoll near the old Deer Lodge at the National Soldiers Home, which spot also marks the resting place of her husband, Henry Kinsey, who passed away several years prior to Eva’s death. Some years later the daughter Hannah died, and afterwards Jacob Wolf, in 1849.

Seventy-eight years have passed and what to this early pioneer family and veteran soldier in the days of the tomahawk and scout was an almost unbroken wilderness and cherished by them as their home has become the home in retreat for veterans of the late wars, and in the March of Civilization, the cooling spring for which the veteran while yet in Virginia has asked, has been transformed from the spring at the milk house to a beautiful romantic spot. The Grotto Spring where thousands have been refreshed by its cooling waters, and the old farm has become a historic spot that gives rest and shelter to the brave boys of 1861.

Figure 8.15: Part two of Kinsey family history. Courtesy of Dayton VA hospital.
1. On July 10, 1992, a meeting was held with Melissa R. Smith, Program Specialist (142D) to discuss the Kinsey/Wolf Family Cemetery location. Engineering documents were reviewed and an area toured which could be suspect of being a burial location.

2. A letter from a Kinsey heir and one from a VA Staff archaeologist, dating back to 1981, were turned over to Melissa.

3. The Deed Book of Veterans Home Land Transfers (contains photostat copies of property descriptions and date of sale) was examined. Nothing in these records show the extent of Henry Kinsey holdings. Henry Kinsey did transfer 80 acres to Jacob Wolf on October 9, 1818. The Deed of Record shows the transfer from Henry Kensey (note spelling) and wife Eva to Jacob Wolf. The property of Jacob Wolf was later sold to Jacob F. Leutz for $500.00 on January 1, 1850, and recorded on March 12, 1850. This sale was made by Jacob Wolf Jr., Executor of the will of Jacob Wolf Sr., and Jacob senior’s widow Elizbeth Wolf. This was the last sale of property recorded in the Deed Book by an Henry Kinsey descendant or heir. Jacob Leutz and Sophia Leutz sold the property to James Cosby for $6,500.00 on October 5, 1858, and James Cosby later sold the 80 acres to the National Home for $12,000.00 on August 3, 1867.

4. Although not mentioned by any of the Kinsey/Wolf inquisitors, there was another Kinsey, David, that owned property that eventually became part of the National Home. According to Montgomery county history, the often referred to Kinsey line in Montgomery county started with David Kinsey and wife Margaret. Property they owned was sold to Philip Rike for $500.00 on October 29, 1853. Philip Rike later sold the property to the National Home for $9,000.00 on August 3, 1867.

5. Acquisition of property for the National Home for Disabled Volunteer Soldiers started in 1867 and continued through 1897. According to the VAMC Deed Book, there was no property owned by a Henry Kinsey, David Kinsey or Wolf heir after 1853. There are no deed transfers to the National Home for Disabled Volunteer Soldiers by any Kinsey or Wolf property owners. During this thirty-year span, fourteen separate tracts of land of various sizes were purchased in the name of the National Home. A copy of a Deed Book sketch of properties acquired for the National Home.
is attached.

6. In the past, it was common practice to create a family burial plot. This could certainly have been true with the Kinsey/Wolf clan. The suspect burial site would have to be examined by archaeologists to authenticate its existence. The site location is not in jeopardy by Highway 35 construction.

7. The Kinsey/Wolf chroniclers seem to have made many erroneous suppositions. When stories are told over and over, embellishments often times become gospel. The Kinsey/Wolf clan and the VAMC both lack accurate research data. A start would be to find the original Henry Kinsey land grant and determine its exact location. The property descriptions described in the deed transfers should then be plotted to chronologically show property ownership through 1897. There is a rough sketch in the deed book showing names and size of properties acquired by the National Home. If this could be accurately transferred to current plot plans much could be learned. Melissa mentioned a friend in the County Recorder of Deeds Office. Perhaps this person would accept the challenge.

8. I’m sure none of our National Home or VA predecessors have intentionally “plowed under” any burial site. Authentication after 150 years, without site dedication, through many transfers of land ownership becomes extremely difficult.

9. Engineering can only suggest that Melissa politely continue correspondence and possibly suggest a tour of the Medical Center. The family could then be appraised of the history of the National Home, the VAMC, and the National Cemetery, also, examine the deed book. Engineering is ready to assist when requested. David Wells, Dayton National Cemetery Director, could probably suggest some additional avenues to pursue.

Gary Abreu
Figure 8.18: Part three of VA report. Document from 1897 showing transfer of plot ownership. No reference points noted in this document to suggest where these plots existed. Courtesy of Dayton VA hospital.