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Integrating Geomatics, Geophysics, and Local Knowledge to Relocate the Original Fort Providence Cemetery, Northwest Territories

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INTRODUCTION

Unlike large community centres that may have formal, well-funded archives, small communities often rely on the knowledge of Elders to preserve local history. Increasingly, Indigenous and local knowledge is being combined with emerging scientific technologies to supplement historical data. In this paper we describe an example of how geomatics, geophysics, and the knowledge of Elders can be effectively used in combination to map the position, configuration, and subsurface conditions of a valued cultural-historic site. In the summer of 2003, the Fort Providence Métis Council requested a geophysical survey to delimit the boundaries of a cemetery no longer in use. Though we wrote this paper soon after the survey was completed, for a variety of reasons, it was never published. In light of the efforts in Canada in 2021 to uncover numerous unmarked graves at Indian Residential Schools, we are presenting this paper now in the hope that our experience will aid others as the search for graves continues.

Founded in 1862, Fort Providence, Northwest Territories (NWT), an historic Métis community, has a long history as a Catholic mission, trading post, and regional education centre. An important aspect of the town's history is the original cemetery, which operated for 61 years (1868–1929) before being relocated to a site farther from town. The number of local residents actually buried in the cemetery, why it was moved, and how many of the graves were relocated are unknown. As a significant and sacred area, the Dene and Métis residents of Fort Providence initiated a research project with the goal of eventually restoring the original Fort Providence cemetery (Lafferty, 1992). One of the early challenges in this project was to establish the boundaries of the cemetery. Formal records of the original cemetery are limited and there are very few residents in Fort Providence who were alive before it was closed.

The objective of this research was to integrate local knowledge with geomatics and geophysical technology to relocate the original Fort Providence cemetery and to determine if the different approaches provide complimentary information. These data sources were used to determine the position and size of the original cemetery as a first step towards the recognition of this valued cultural-historic site.

BACKGROUND

Brief History of Fort Providence

Fort Providence was established by the Roman Catholic Church in August 1861 (Table 1). The specific location, known as the "Rapids of the Mackenzie," was chosen because it provided an ideal base for expanding the Roman Catholic mission in the Mackenzie District (McCarthy, 1990). The bishop's residence, a cathedral, and engagé's house were constructed in 1862 (Lafferty, 2003). The mission grew steadily over the next few years as a two-story convent and an expanded bishop's residence were added. By 1867 the local population had increased significantly, prompting the addition of five Grey Nuns to develop a school and orphanage. That same year, the Hudson's Bay Company moved to Fort Providence, realizing that it could better serve the local Slavey population from the Mission (McCarthy, 1990). By 1871 there were 440 people living, or regularly visiting the mission, and by 1897 this population had increased to 587 (McCarthy, 1995).

Over the next few decades the mission continued to grow. In 1924 the current church, Our Lady of Providence, was opened, and the Sacred Heart Indian Residential School was constructed in 1930. By the mid-1960s, the Yellowknife and Mackenzie highways brought regular supplies and tourists to the community. At the time of the survey project, Fort Providence had a population of about 770 made up of predominantly Slavey-speaking Dene and local Métis families.

The Old Cemetery

In 1868 the community recorded its first death and burial, a five-year-old orphan named Eugene Charles (Lafferty, 1992). As part of the mission plan, the priests had selected an area for a cemetery northwest of the church and well west of the residential area of the growing community. The cemetery was described as being 80 by 40 feet in size

TABLE 1. A brief chronology of the Providence mission and cemetery.

1861	In July, Father Henri Grollier suggests that the “Rapids of the Mackenzie,” about 30 miles from Great Slave Lake would be a good location to centre a Catholic mission because the site had a good fishery, rich soil for cultivation, and was close to sufficient timber for building and fuel.
1861	In August, Bishop Grandin meets HBC Chief Factor Bernard Ross at “Rapids of the Mackenzie,” the current location of the community and immediately erects a large cross to mark the new “Providence Mission.”
1862	By the end of August, the Bishop’s residence, cathedral, and engagé’s house erected. Built by Joseph Bouvier and Joseph Forcier.
1864	Two storey convent constructed.
1865	Bishop Faraud builds a new residence with an outside verandah.
1867	HBC closes its post at Big Island and moves to Providence.
1867	Five Grey Nuns and a Franciscan tertiary arrived to run the school and orphanage.
1868	First burial in the Providence cemetery.
1881–82	School closed due to financial difficulty.
1882	Prime Minister John A. Macdonald approves a $300 annual grant for the school.
1921	Treaty 11 signed 27 June at Fort Providence by Chief Paul Lafoin.
1924	A new church, Our Lady of Providence, was opened.
1929	Original cemetery closed and new one constructed farther away from town.
1930	Sacred Heart Residential School opened.
1948	Remains of seven priests and nuns exhumed and moved to the new cemetery. Fence on old cemetery removed and field ploughed for vegetables.
1975	The residential school and the Priest’s residence were dismantled. Federal day school opened.
ca. 1975	Elder, Jean Marie LeMouel, marks corners of old cemetery from memory.
1994	Community dedicates and blesses a new monument near the old cemetery on Treaty Day (June 27th).
2003	GPR survey undertaken (August).

(Lafferty, 1992), but it is not clear whether this corresponds to the initial or final dimensions before it was relocated. Between 1868 and 1929, 298 deaths were registered in the Church’s records (Lafferty, 1992). Whether all of these people were interred at the cemetery is unknown.

During the early years of the Providence mission, most of the local Dene lived on the land, hunting, fishing, trapping, moving in concert with the seasonal distribution of these resources, and visiting Providence for major religious holidays, or to trade furs for supplies. The Mackenzie River, especially near the rapids, was an important summer fishery, and people congregated along its banks in close proximity to the mission. It was common to bury the dead near where they died rather than bringing them to the post. Therefore, though the church records show 298 deaths over this period, it is impossible to know how many of these were actually buried in the local cemetery. The records suggest, however, that some of the interments might be those of children and infants because some orphans attending the local school succumbed to epidemic diseases during the cemetery’s tenure.

In 1929, for unknown reasons, the cemetery was closed. In 1948 the fence surrounding the original cemetery was removed and the remains of two priests, two brothers, and four nuns were exhumed and moved to a new cemetery located farther back from the river and community

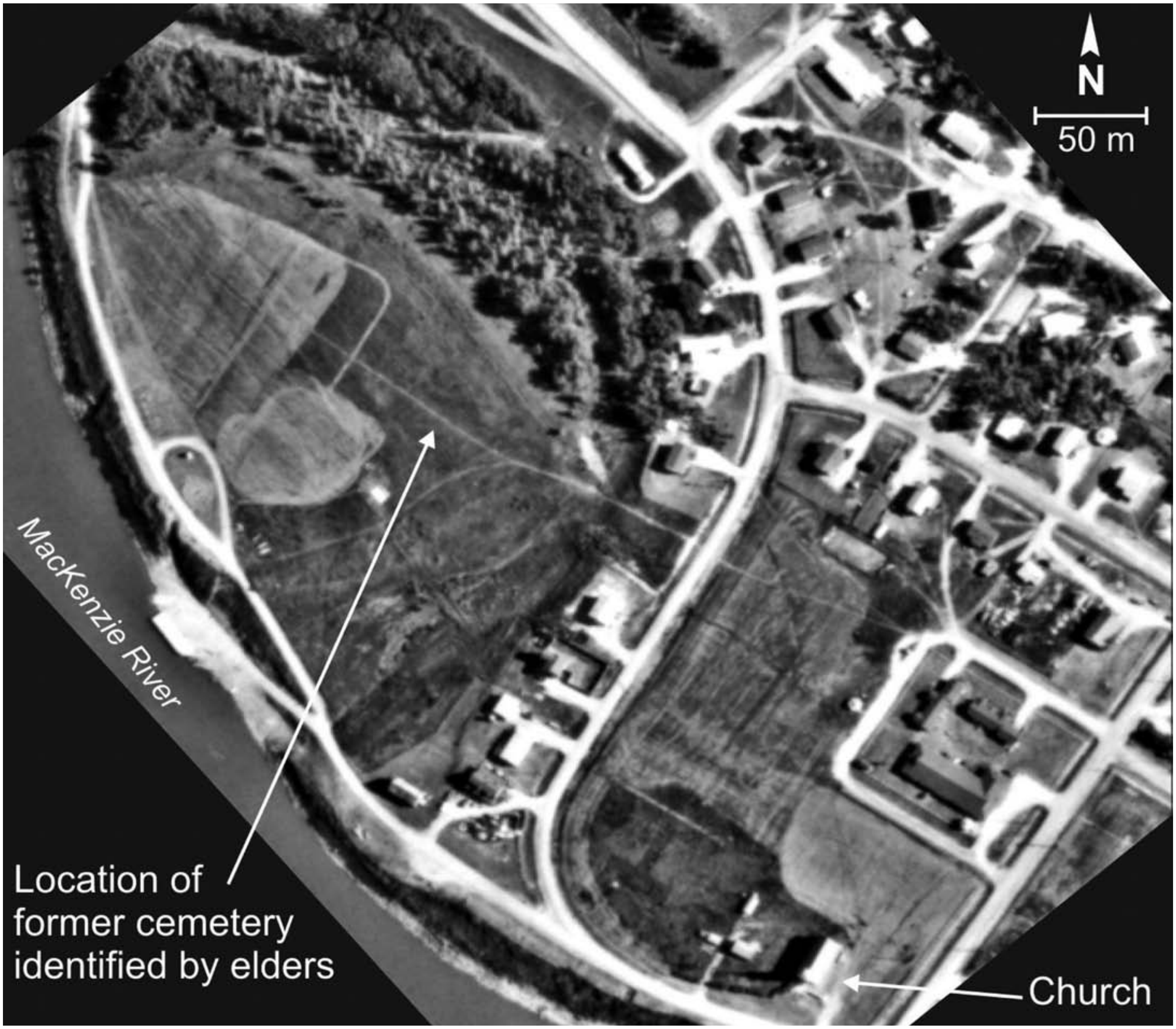

FIG. 1. Geometrically-rectified vertical aerial photograph showing the location of the original cemetery identified by Elders. The photograph was taken on 29 June 2001 (Source: NAPL, photo # A28470-40).

(Lafferty, 2003). Shortly thereafter, the cemetery was ploughed over and used primarily as a potato field for several decades (Lafferty, 1992). In 1975 the residential school and the priests' residence were dismantled, and the fields were no longer used for potato farming. Soon, grasses and other local vegetation reclaimed the fields.

DATA AND INTERPRETATIONS

Local knowledge

In the mid 1970s a prominent Métis Elder, Jean Marie LeMouel (1911–2004), was asked to mark the boundaries of the original cemetery. From memory and local landmarks, Mr. LeMouel marked the four corners of the fence constructed around the original cemetery. The corner locations were corroborated by Mr. Eddie Sanderson, another local Métis Elder, in 1992. These activities culminated in the installation of permanent steel posts to indicate the extent of the original cemetery. The area delineated by the posts was 19 m by 17 m. A large stone monument was constructed near the site in 1994. The monument contains the names of all 298 people recorded to have died between 1868 and 1929. Other than the steel posts, there was no other indication of the location of the original cemetery as seen from the surface or on recent aerial photographs (Fig. 1).

In 2002, concerned that expanding development might impact the original cemetery, Albert Lafferty, President

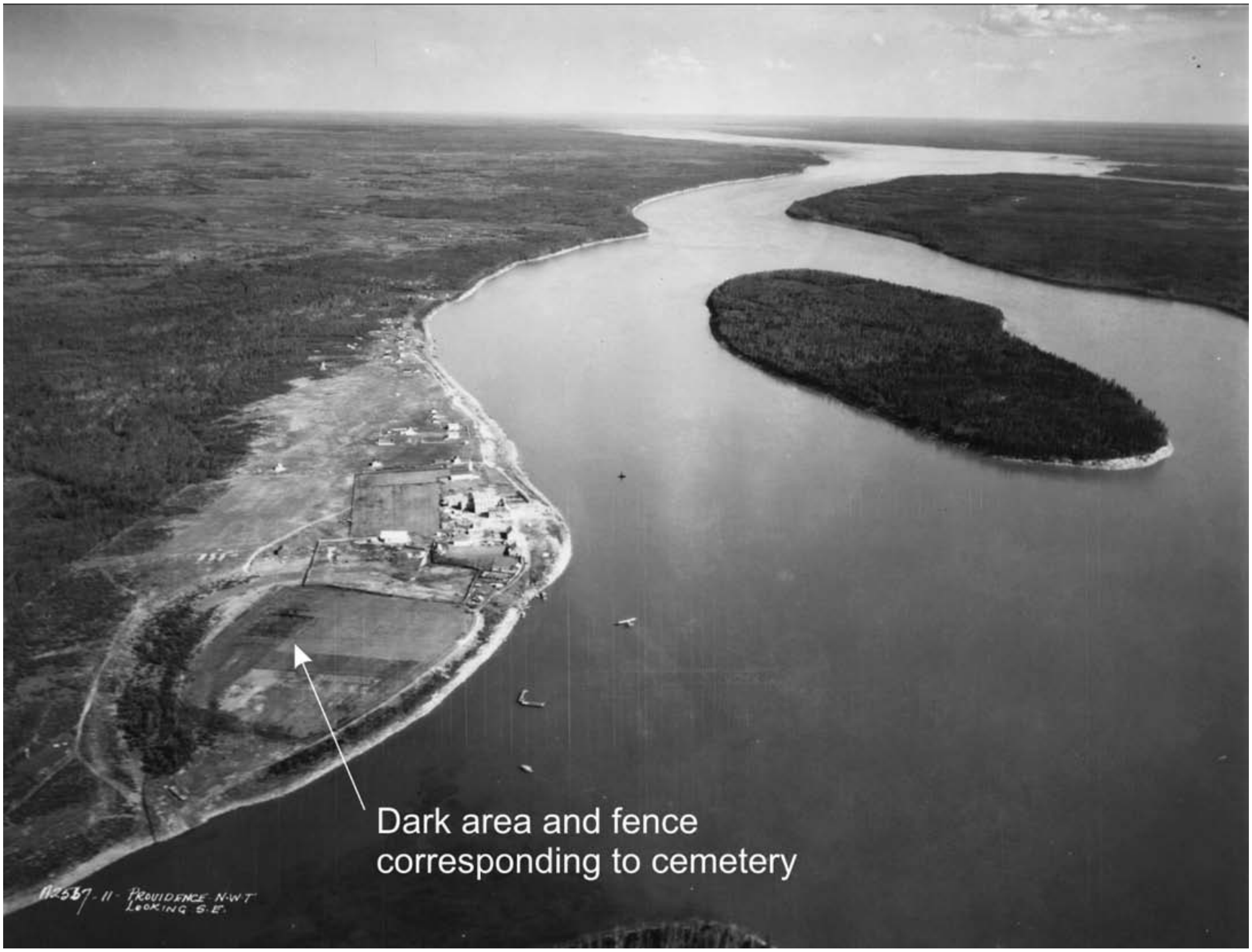

FIG. 2. Low-angle oblique aerial photograph looking south at Fort Providence, NWT. Note the dark area (disturbed surface) on the field where the cemetery was located. The photograph was taken on 12 July 1930 (Source: NAPL, photo # A2567-11).

of the Fort Providence Métis Council, initiated a research project to relocate the original cemetery and identify if graves are present. It was determined that historical aerial photographs held the potential to locate the boundaries of the original cemetery, while ground penetrating radar (GPR), a shallow geophysical technique, would be used to resolve subsurface conditions.

Aerial photographic record

A search of local and national aerial photograph archives revealed only one photograph with visible signs of the cemetery. The 1930 summer oblique photo showed a dark area with sharp straight edges, indicating a fence that encompassed the cemetery (Fig. 2). When compared with a more recent vertical aerial photograph (Fig. 1) many common features could be resolved. However, the oblique perspective of the 1930 photograph were unsuitable for resolving the exact position and boundaries of the cemetery.

Since no vertical aerial photographs contain the information needed to determine the position of the cemetery, the only method for extracting accurate positional information was to digitally rectify the oblique aerial photograph. The process involves a geometric adjustment of the photograph to a vertical perspective, enabling planametric measurements to be made. In association with a large GPS database of ground control points (collected on-site in 2003), the 1930 photograph was scanned and digitally rectified using PCI Geomatica v. 9.1 software. Whereas the rectification of vertical aerial photographs is relatively straightforward, mapping from oblique photographs is more challenging (Scollar et al., 1992; Doneus, 1996, 2001). Problems arise due to perspective distortions, which are mainly the result of the oblique viewing angle and topographic variations of the site. Additional complications arise from the absence of photograph calibration parameters. Nevertheless, use of photogrammetric principles can be applied to overcome these issues and provide accurate rectified images (Scollar et al., 1992; Doneus, 1996, 2001).

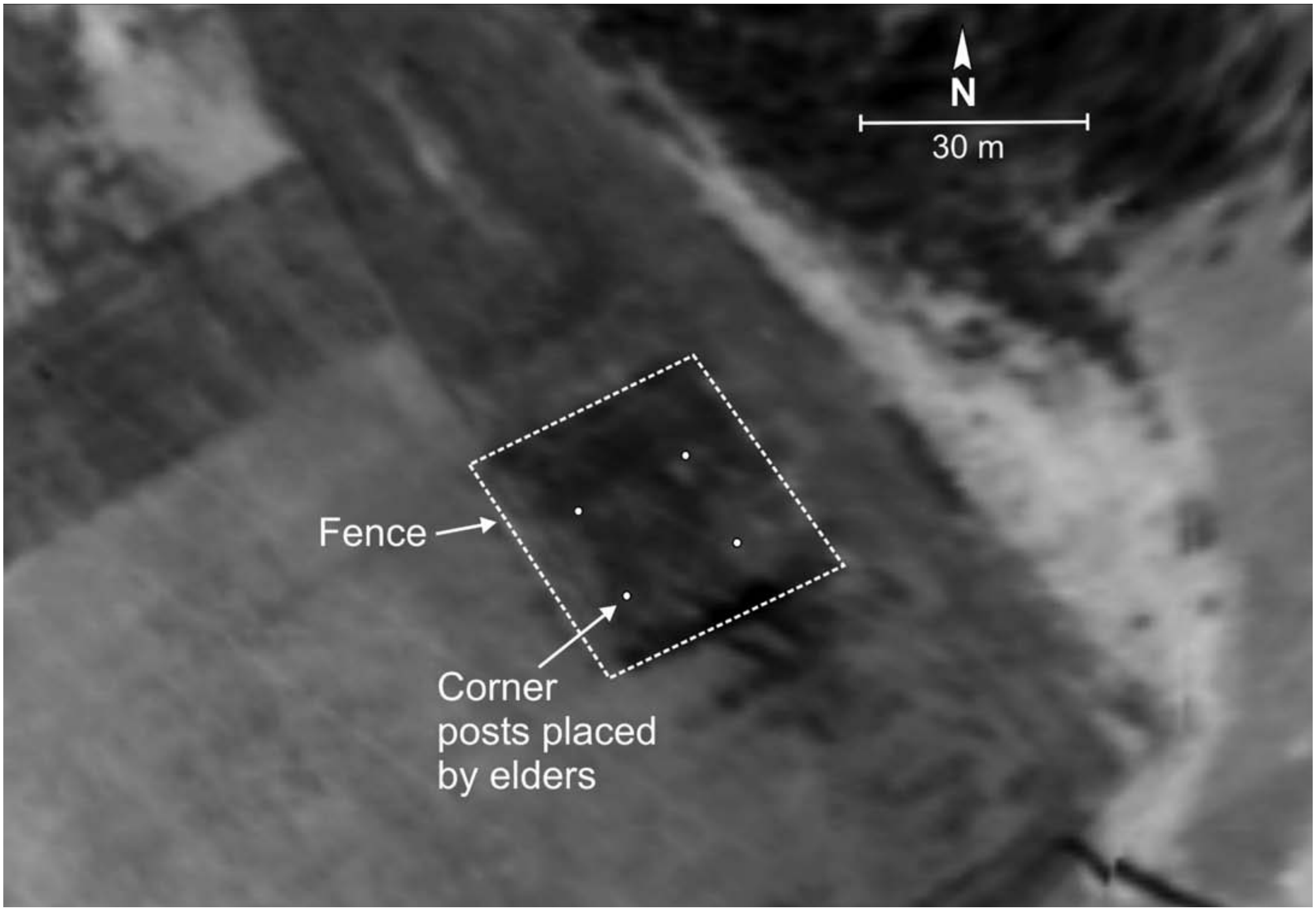

FIG. 3. Subset of the rectified oblique aerial photograph from 1930. The location of the corner posts, placed by Elders, are indicated. The aerial photograph shows the cemetery as a larger feature than indicated by the Elders, but the overlap between these two sources is remarkable.

In this study, the oblique photograph was geometrically adjusted using tie points from rectified vertical aerial photographs. A digital terrain model was not available for the study site in order to orthorectify the photographs, yet the terrain is generally flat and does not pose a significant problem in terms of topographically-induced image distortion. The 2001 vertical photograph was rectified using 31 control points collected with a GPS, resulting in a 2 m root mean squared (RMS) error. Because of significant changes in land cover between 1930 and 2001, it was necessary to use a vertical aerial photograph from 1948 to track the position of various tie points through time. Unfortunately, the brightness of the 1948 photo made it impossible to resolve the cemetery. Following correction of interior orientation based on fiducial marks and camera calibration parameters, the 1948 vertical photograph was rectified relative to the 2001 photograph. The RMS values of the tied vertical photographs were all below 1 m, which indicates limited positional error.

Interior rectification of the 1930 oblique photograph involved a procedure similar to the one outlined by Doneus (2001) in which the image corners were used to created an image coordinate system in place of fiducial marks. The oblique photograph was then subsetted to improve the interpolation of tie points in the rectification process. After rectification, the oblique photo had an RMS error of 9 m. This is quite high from a photogrammetric viewpoint, likely reflecting the limited number of tie points that could be used to rectify the oblique photo (n = 17). Ultimately, even with the high RMS error, the oblique photograph provided an important quantitative contribution towards the identification of the position and boundaries of the cemetery.

The rectified oblique photo taken in July 1930 shows the boundaries of the cemetery in relation to the corner posts placed by Mr. LeMouel and Mr. Eddie Sanderson (Fig. 3). The posts lie within the dark area representing the cemetery. The dimensions of the cemetery in the rectified photograph are approximately 36 m by 34 m, while the posts are 19 m by 17 m. Although the dimensions from the aerial photograph are larger, there is some inherent error in each method that reduces overall accuracy and correlation among data sources, which is to be expected given the passage of time and the geometric challenges of rectifying

FIG. 4. Photograph showing the GPR survey in 2003. Individuals crouching are securing a metric tape measure for one of the transects across the cemetery. Note steel posts used to delineate the cemetery boundaries as positioned by Elders.

oblique photographs. The most notable contribution, therefore, is that despite the limited number of landmarks, the posts placed by the Elders are within the area identified as the cemetery in the rectified photograph.

Subsurface imaging – (GPR)

Employing a similar approach as Wadsworh et al. (2021) used, a GPR survey was conducted in 2003 to image the subsurface in the area identified to be the location of the old cemetery by the local Elders (Fig. 4). As described in Conyers and Goodman (1997) and Moorman et al. (2003), GPR images the subsurface by sending pulses of electromagnetic energy into the ground and recording the strength of subsurface reflections and their travel time. A 250 MHz Sensors and Software Noggin GPR system was used allowing the detection of features as small as 10 cm in size. The detection of subsurface features is, however, dependent on the contrast in dielectric properties of the feature versus the surrounding sediment. Sedimentary layering is usually observable because of the differences in grain size (Jol and Smith, 1991). Graves are frequently detected because of the disruptions in the sedimentary layering associated with excavating and the differences in the dielectric properties of the body and casket (Conyers and Goodman, 1997). The age and rate of deterioration of the grave deposits are important in determining the dielectric contrast that a grave displays.

The GPR survey grid at the old cemetery site extended well beyond the metal posts placed by the Elder, covering 3480 m^2 (58 x 60 m). Grid dimensions account for some of the uncertainty in the estimates of the position and size of the site determined by local knowledge and aerial photographs. The GPR grid consists of closely-spaced parallel transects (20 cm) running north-south with traces being collected every 10 cm. This provided data points close enough together that any ground disturbance the size of a small grave or larger would be detected. By collecting the GPR data over a grid, a three-dimensional image of the subsurface can be constructed, enabling profile (pseudo cross-sections) and planview (depth slices) perspectives of the subsurface.

An example of the vertical pseudo-section through the ground generated from the GPR data displays reflections

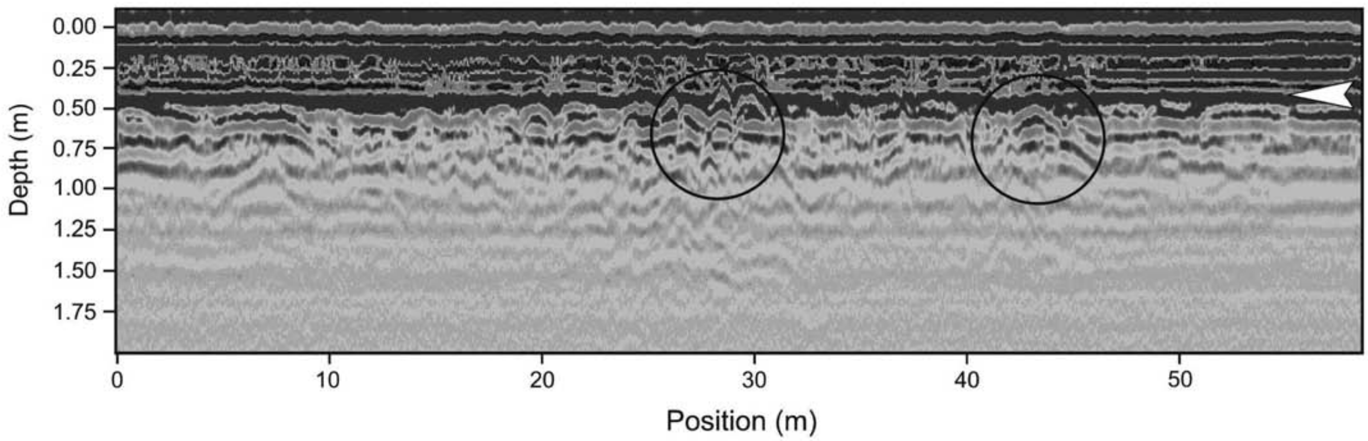

FIG. 5. An example of a GPR profile showing a pseudo cross-section through the subsurface. Hyperbolic reflections (indicated by circles) are generated by buried objects or localized disturbances in the sedimentary layering. The base of the plow layer is indicated by an arrow.

from several layers within the subsurface (Fig. 5). A continuous horizontal reflection at 40 cm depth likely represents the base of the plow layer. Above this reflection, the subsurface is relatively homogeneous with a few horizontal continuous to discontinuous reflections. At and below the plow layer reflection there are a series of hyperbolic shaped returns indicating the presence of point-source reflectors. These are evident on the GPR profile shown in Figure 5. They are similar to other Arctic burial sites (Moorman, 2002, 2004) and are likely caused by soil disruption associated with grave digging.

The planview depth slice through the GPR data displays the spatial distribution of features within the subsurface (Fig. 6). There is a general lack of reflections from within the plow layer (up to 40 cm depth) due to the churning of the soil during plowing. The few small anomalies (light areas) are likely from subsurface clasts that lie directly on the GPR survey transect. A pile of cobbles was discovered at the edge of the field, likely picked-up from the field and put aside when the field was actively being farmed. The clasts were probably ice rafted onto the floodplain during past ice jams and subsequently buried by overbank deposition of finer sediment during floods.

In comparison to the relatively homogeneous plow layer, Figure 7 shows a depth slice from beneath the plow layer with a band of strong, spatially extensive reflections (0–20 m in the X-direction and 0–58 m in the Y-direction). These reflections are interpreted as truncated sedimentary bedding planes associated with relict point bar deposits. This kind of reflection pattern also appears on the very right side of the survey area. In the centre of the survey area (25–40 m in the X-direction and 20–40 m in the Y-direction), a series of small isolated anomalies are present. This is the plan view appearance of the hyperbolic returns displayed in Figure 5. Due to the spatial resolution of the GPR survey, and likely post-burial alteration, the precise shape of the anomalies cannot be delineated. However, a number of them appear to be elongated and are of an appropriate size for a grave typical of old graves in northern environments (Moorman, 2002, 2004).

Summary of data sources

Overall, the GPR data provide subsurface evidence to indicate disturbance associated with graves, but there is no diagnostic reflection signature that confirms the presence of human remains. Furthermore, there is no clear indication of disturbance associated with graves outside the area marked by the Elders. Thus, the posts placed by the Elders appear to represent the approximate location of the original cemetery, though the actual dimensions appear to be slightly larger according to the aerial photographs. Given these results, boundaries can be established to preserve this valued cultural-historic site by extending out (10–20 m) from the posts placed by the Elders. This provides a spatial allowance for the rectification error of the aerial photographs while also enabling adjacent land uses that do not impinge on this valued cultural-historic site.

CONCLUSIONS

Indigenous and local knowledge have long proven to be a valuable support for testing and verification of cultural-historical data. Other archived data such as aerial photographs can provide information on the broader physical character of an area, however, they frequently do not offer the historical context in which the information can be placed. Finally, modern geophysical techniques such as GPR provide details on the physical alteration of the subsurface, however, this too provides no context, and without ancillary information, can easily be misinterpreted. Individually, each one of these sources of information have their own strengths and weaknesses. Together, these sources of information complement each other and can provide a more comprehensive picture of the past.

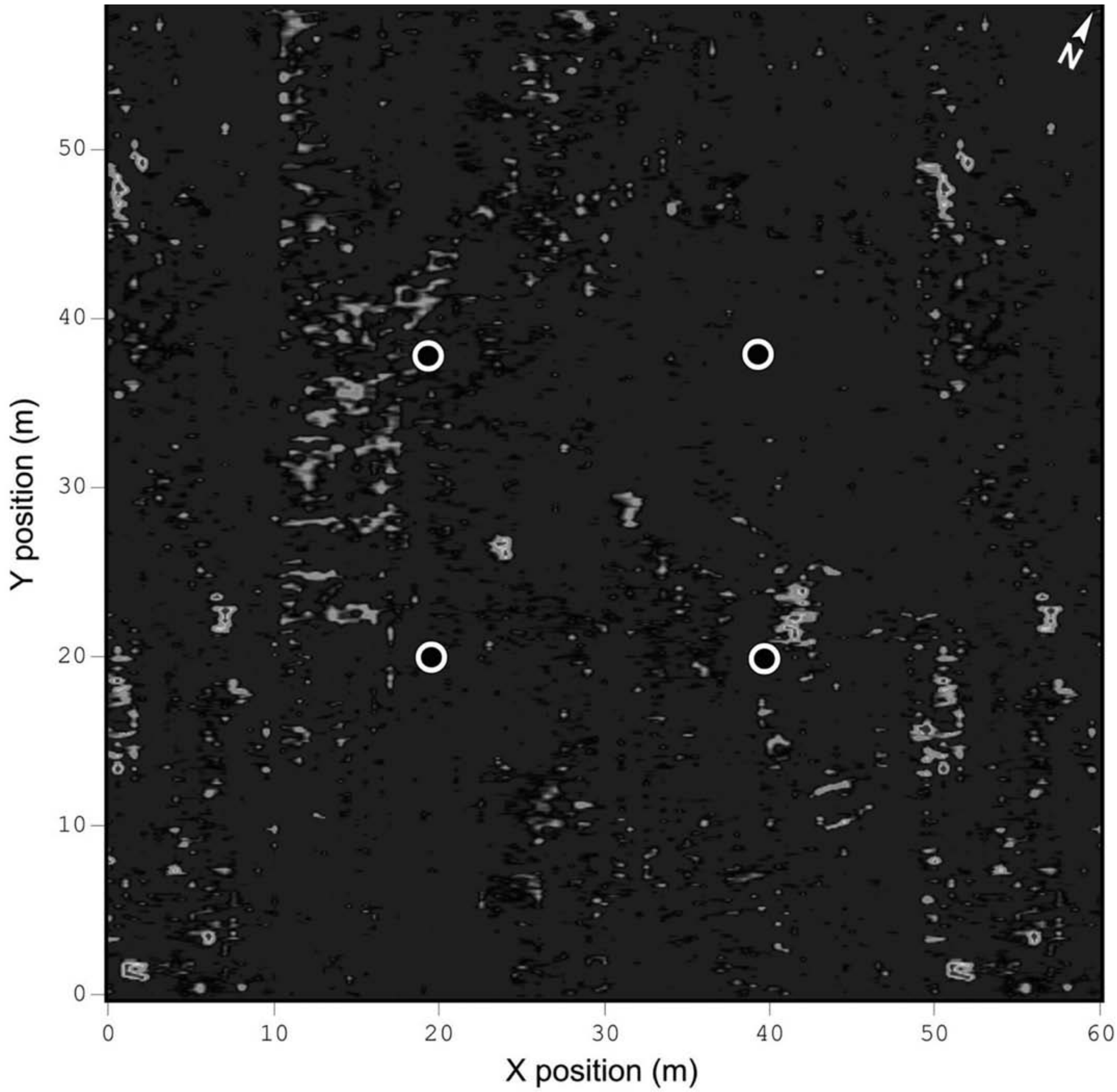

FIG. 6. Planview depth slice for the near surface (top 13 cm). This depth range shows that reflections are spatially homogeneous with few anomalies (light grey areas). North is towards the upper right corner. The circles represent the corner posts placed by Elders.

This case study illustrates how the integration of different information sources can provide a more detailed reconstruction of cultural-historical sites. In addition to resolving the location, size, and condition of graves, this study provides an example of a scientific methodology involving a joint investigation with local knowledge, geomatics and geophysical technology. Local knowledge provided the initial hypothesis regarding the location and approximate size of the original cemetery, while digitally-rectified aerial photographs and GPR data were used to verify and refine the cemetery's dimensions and the state of graves. Collectively, results provide the basis for informed decision-making regarding the site's preservation into the future. Similar to other studies (Wolfe et al., 2007; Woo et al., 2007; Riedlinger and Berkes, 2009; Wadsworth et al., 2021) our results strongly indicate the value of integrating local knowledge with scientific investigations and for scientific technology to be used in conjunction with local knowledge to help guide local decision making. Our results also indicate that similar research approaches can be used to preserve a wide variety of northern cultural-historic sites.

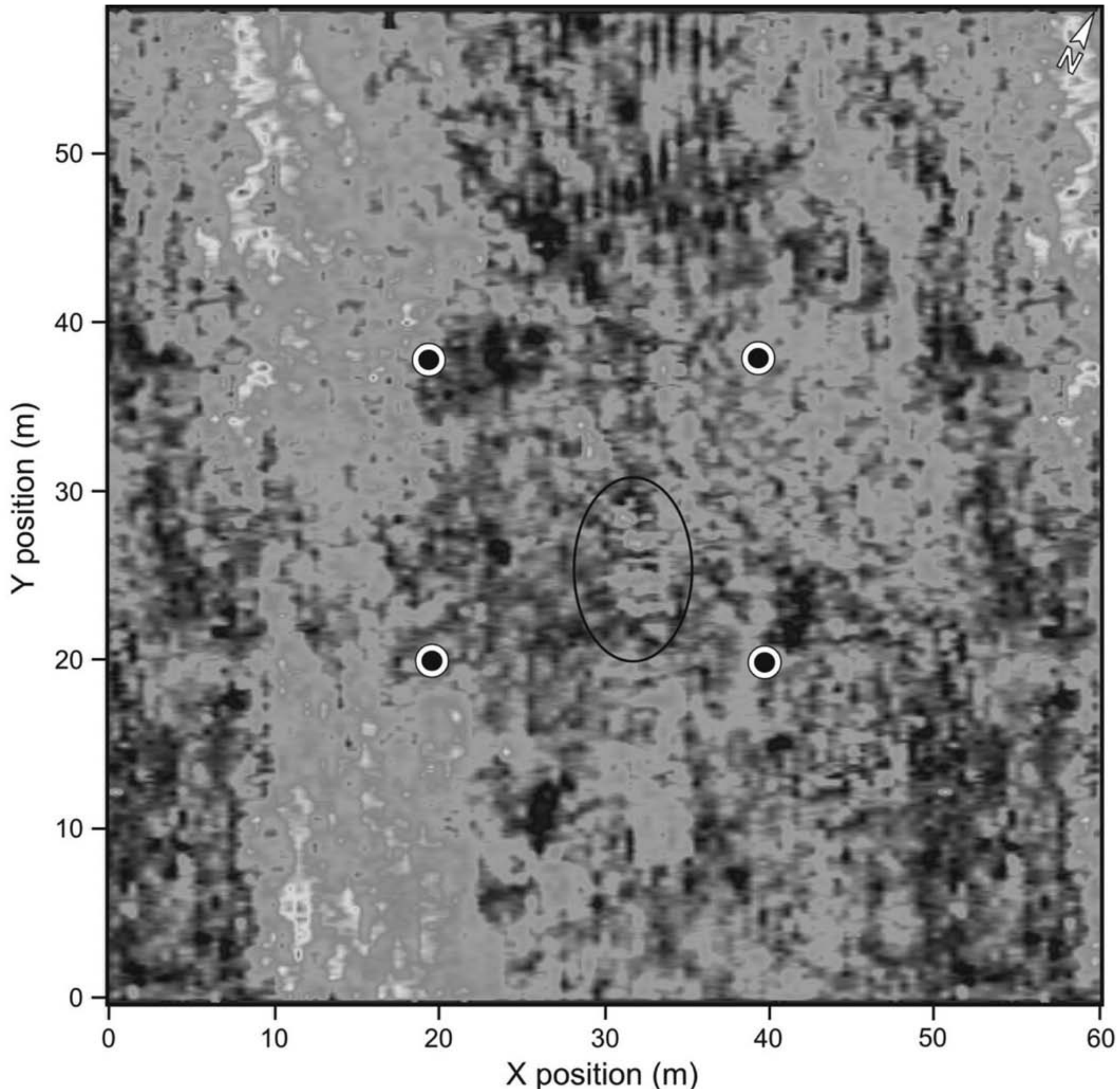

FIG. 7. Planview depth slice for the depth range 0.4–0.5 m. The cluster of small (1–2 m), medium grey areas in the center of the map (circled) are interpreted as the location of soil disturbance caused by grave excavation and removal. The light grey areas on the left and top are interpreted as the top of sedimentary layering that was truncated by the plough layer. North is towards the upper right corner. The circles represent the corner posts placed by Elders.

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