Mapping the Graves of the Mapoon Mission Cemetery, Queensland, Australia, 2013

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With organization, field work, data processing and analysis by

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Introduction

Aboriginal people in Cape York Peninsula area (Figure 1) of Australia have strong emotional attachment to cemeteries and the burial places of their ancestors. Often, as at Mapoon, in northern Queensland, many such places are unmarked and neglected. The graves can be difficult to identify on the ground surface, either because they were never marked, or because the grave markers have subsequently decayed, been removed or destroyed. This neglect of burial sites is a cause of emotional distress to Elders and their families who have a high cultural sensitivity to these resting places of their ancestors.

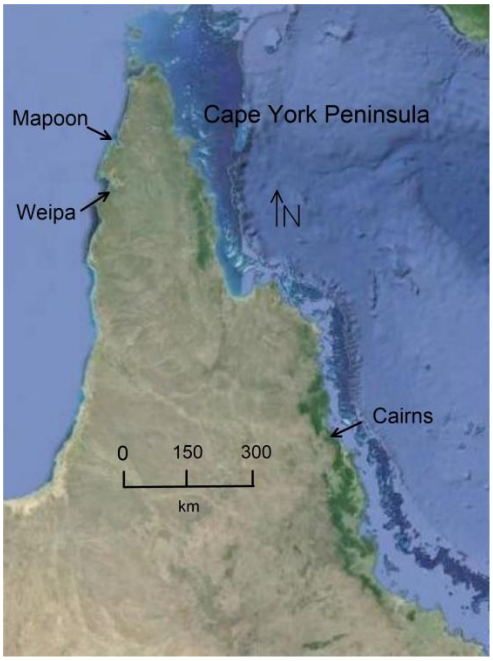


Figure 1: Northern Queensland with location of Mapoon on the Cape York Peninsula

The purpose of this project was to follow up on preliminary geophysical work that was done in December, 2010 (Sutton and Conyers 2013) using ground-penetrating radar (GPR) at the Mapoon Mission Cemetery. In that original project many graves were located and mapped, in what were defined as clusters, but much of the possible cemetery area remained un-surveyed due to thick vegetation and lack of field time. However, the project was quite successful and demonstrated that the GPR method was excellent in the soils and sediments at Mapoon (Conyers 2012) and plans were discussed at that time about follow-up work. In a report from the 2010 field work the general location of graves was determined, and the data collection and processing methods were experimented with and refined. That preliminary effort showed that there were between 100 and 120 possible burials in the Mapoon Mission Cemetery (Sutton and Conyers 2013). The exact locations and individual characteristics of each burial were not precisely determined, so follow up work was planned. That enhanced and extended study is the subject of this report.

With funding provided by the Northern Sub-Regional Trust, Western Cape Communities Trust through the Mapoon Aboriginal Council we returned to Mapoon in August, 2013 to build on and expand the initial results from 2010 (Sutton and Conyers 2013). In this project more of the possible cemetery area was cleared of brush and the GPR surveys were extended in all directions from those conducted in 2010. In addition new imaging and detection methods were

used that had not been tried before including high-resolution low-altitude photos, magnetometry and laser-theodolite total station global-positional system surveying. The results of all those data sets were integrated, interpreted and are discussed here.

The results of this project show that there are 95 graves that are known to exist in the cemetery, which were detected, imaged and interpreted. While there may be a few more than this, unless we were very sure of their location and extent, we have not included them as "known" in this report. Those other less-distinct graves may be very old and deteriorated, or they might not be graves at all but other objects in the ground from ancient times. This report will therefore discuss only those 95 known graves and do so individually. The locations of these known graves was surveyed on the ground surface in December, 2013 by Ian Moffat and staked with semi-permanent metal fence post stakes in preparation for permanent markers and a boundary fence (Figure 2). Each grave was given a number, placed on the stakes, which will hopefully be transferred to permanent markers in the near future. All graves are discussed in detail here with regards to possible age, cultural affiliation and burial characteristics and in some cases an analysis of associated artifacts.

Figure 2: Example of the semi-permanent grave marker stakes placed in the ground in December, 2013

Historical Background Related to the People Buried at Mapoon

The Mapoon people, whose ancestors are buried in this cemetery currently live in the township of Mapoon, western Cape York, Queensland, Australia. They mostly identify themselves as Indigenous people, included the language groups of Tjungundji (the traditional owners of the Mapoon peninsula), Mpakwithi, Taepithiggi, Thaynakwith, Warrangku and Yupungathi. The Mapoon Mission, associated with this cemetery was a large removal center in the historic past for Indigenous people across Queensland. Therefore present day Mapoon people also include generations of people, who are descendants from other language group affiliations from across Queensland, and also non-Indigenous Australians, people from the Solomon Islands, Tonga, Samoa, China, Malaysia and other countries are included.

History of the Mapoon Mission Cemetery

The Mapoon Mission was first established by the Moravian church by Reverends Hey and Ward in 1891 (Sutton and Conyers 2013). It was the "mother mission" and the foundation for a network of other Christian missions in Australia (known as "daughter missions") that include as many as 20 others including Mile Mission, south of Mapoon at Weipa (Figure 1) that was established in 1898. The Mapoon Mission was closed in 1963 when the Queensland State Government's Department of Native Affairs (DNA) took over the land, coincident with the increase of mining interests for the aluminum ore bauxite that were occurring at that time. The closure of the mission resulted in the forced relocation and removal of many Indigenous families In Mapoon by police and DNA officials to the settlement of Hidden Valley (often referred to as "New Mapoon"), and to Weipa, with the burning of some Mapoon residents' homes. The burning of parts of the Mapoon Mission, particularly the former mission village, camps and houses of Indigenous occupants, has left a strong and emotive image in the minds of many of the affected elderly Mapoon residents who remember very well this turbulent and difficult time.

Today the geographic location of "Mapoon" is used by Mapoon people to describe both the former mission, its associated village and other settlements to the south. Both the Mapoon Mission and present-day Mapoon are part of the Mapoon Deed of Grant in Trust (DOGIT) lands, governed by trustees including the Mapoon Aboriginal Shire Council.

The Mapoon Mission Cemetery was established at about the same time as the mission in 1891. It appears from sparse historical records to contain the remains of both Aboriginal peoples and European missionaries within a coastal sand dune, approximately 50-100 meters landward meters from the high water mark. Prior to our clearing of the ground as part of this project the cemetery was overgrown with acacia and native vegetation, with only a few open spaces. It has no identifiable boundary or fence and is not actively managed or protected, but is well known to all the local inhabitants. The site is accessible via a four wheel drive vehicle track, which runs parallel to the beach (Figure 3).

Figure 3: Beach with dunes to the right, where the Mapoon Mission Cemetery is located in the trees.

Reports of spirits in the cemetery or within a nearby home have been made by the some Mapoon people (Sutton and Conyers 2013). The only existing headstone in the cemetery marks the location of the remains of Charles De Bosch, who died on February 19, 1918 (Figure 4).

Charles De Bosch's grandson, William Busch, lives in Mapoon today and is a past Chairman of the Mapoon Interim Land and Sea Advisory Committee. Other physical remains visible today include some metal and timber posts, which are likely the remains of head posts for burials and scattered coral rocks and white shells that might have at one time been the surface markers of burials. Wild horses frequent the cemetery today, disturbing surface remains and the sand dunes are actively eroding and being re-activated during storms, which have likely moved non-attached surface markers in the cemetery (Figure 5).

Figure 4: Uncle William Busch next to his grandfather Charles De Bosch's formal grave marking in the Mapoon Mission Cemetery.

Figure 5: Miscellaneous wooden posts that at one time were crosses and coral rock markers in the cemetery.

The Elders in Mapoon, as well as their children, have an emotional connection to this area and other smaller cemeteries throughout the region. They greet the "old people" when driving by or walking past the Mapoon Mission Cemetery, a custom that has historic roots (Sutton and Conyers 2013). These strong cultural ties make the identification of the many unmarked graves important to the Mapoon people as a way of "looking after our old people".

Mortuary Practices from Oral and Historical Records

Prior to this work reported on here and the 2010 study (Sutton and Conyers 2013), there was no formal oral or historical investigation of mortuary practices or unmarked burial places within the Mapoon DOGIT lands. Oral history interviews were carried out by Mary-Jean Sutton to document the cultural heritage values of the Mapoon Mission Cemetery as well as other nearby unmarked graves as part of a broader, doctoral research project on the Mapoon Mission. Her work shows that from late 1920s to 1930s local timber was used to make caskets that were European in construction, constructed from nonda plum wood cut in the Mapoon Mission sawmill, which operated until the 1950s. However, not everyone who was buried in the Mapoon Mission Cemetery was buried in European-style wooden coffins. For instance a man named Peter Peter who died from a crocodile attack, was carried to the cemetery on a canvas stretcher and laid out covered in blankets. He was then buried wrapped in a blanket tied with rope and string (Sutton and Conyers 2013). Also during the 1950s there was a similar burial at a nearby outstation cemetery located south of the nearby Cullen Point, where a woman called Amy was buried wrapped in sewn blankets. It appears that the textile-wrapping burial method, which is very traditionally Aboriginal, was commonly used to wrap the deceased until at least early 1930s using tea tree bark. Associated with these traditional burials were surface markers of coral stones and shells, which can be seen on the ground surface today (Figure 5). During mission times the "old people" would collect shells from the beach in handmade baskets and later use them to line graves and mark pathways through the cemetery (Sutton and Conyers 2013). Mapoon Elders do not remember if there was ever a fence confining the cemetery, but they do remember well-developed pathways among the graves. The orientation of graves is also not remembered but it is likely that the European-influenced burials were east-west, which is common in Christian cemeteries. There is some evidence from oral histories that bones of already decomposed bodies in the possession of male relatives were later wrapped in bark cloth and buried here. This traditional Aboriginal burial practice is confirmed by Mapoon missionaries who observed this practice (Sutton and Conyers 2013). Mortuary practices were likely highly influenced by age, gender and whether the deceased had any surviving kin. As a result of cultural influences and the blending and amalgamation of people from many areas some burials at the Mapoon Mission Cemetery are likely of the traditional variety while others highly influenced by Christian mission customs. Others might be a combination of these burial traditions. There may also have been burial variations within the traditional types that included partial decomposition prior to burial, mummification, cremation (complete or partial) and whole-body interment.

While it is not definitively discussed in the early historical records of the Mapoon Mission, it appears that Indigenous people were gradually influenced by missionaries over time to bury their dead using Christian methods that included wooden coffins, placed in the ground in a somewhat orderly fashion oriented east-west. There is some evidence that these Christian burial customs were accepted by some, but may have been wholly or partially rejected by other Indigenous people in at least the earliest decades of the mission's establishment (Sutton and Conyers 2013). There is a brief Mapoon Mission document that discusses a "newly laid out cemetery" that was used beginning about 1900, which is likely the cemetery discussed here. But in that brief document there is no discussion about burial practices or any associated archival records of the interred. Also, nothing is known about burials that might have been located here prior to 1891, but it is possible that the cemetery contains very old pre-mission interments. It is

common for cemeteries to be located in areas that are considered “burial grounds” and many have a long history in the minds of local inhabitants that can be transmitted to others who are newly-arrived.

In the discussion of the individual graves, which follows, some of these burial practices can be inferred in the GPR data. When appropriate and when the data are definitive, the possible age and affiliation of each individual burial is documented regarding possible burial customs. These differences, which infer the identity of the deceased are not noted on the surface markers and are only discussed here.

GPR and Other Geophysical Methods Used at Mapoon Mission Cemetery

The geophysical methods used here were approved by the Mapoon Elders and others involved as it was culturally important not to disturb the buried remains by digging or probing. Many Indigenous people in Australia and elsewhere around the world value these newly-developed non-invasive approaches to detect and map burial places without any invasiveness as they are deemed culturally appropriate. Unmarked graves have been studied around the world using similar non-invasive geophysical techniques as those used here (Bevan 1991; Conyers 2006; Ruffell and McKinley 2008).

Ground-penetrating radar is a near-surface geophysical technique that allows for discovery and mapping of buried objects and features not visible on the surface. The method consists of measuring the elapsed time between when pulses of radar energy are transmitted from a surface antenna (Figure 6), reflected from buried discontinuities, and then received back at the surface (Conyers 2013). The buried discontinuities where radar energy is reflected can be changes in lithology and the contacts between buried objects and the surrounding matrix. With graves, reflections can be produced from the tops, bottoms and sides of caskets, edges of the burial shafts, objects that were buried with the deceased, and only rarely the human remains themselves (Conyers 2006, 2012: 129).

Figure 6: Collecting GPR data with the SIR-3000 system and 400 MHz antennas with survey wheel attached for distance measurement.

Ground-penetrating radar is a technique that is most effective at burial sites where remains are located within 1-3 meters of the surface (Conyers 2008, 2013). As radar pulses are

transmitted through various materials on their way to the buried remains, their velocity will change, depending on the physical and chemical properties of the material through which they are traveling (Conyers 2013: 15). Each abrupt velocity change generates a reflected wave, which travels back to the surface to be recorded. Velocities of radar energy in the ground are important because only the wave travel times are measured, not their actual depth in the ground. However, velocity through the ground can be calculated then distance (or depth in the ground) can be accurately calculated (Conyers 2013: 49), producing a useful three-dimensional data. Velocities at Mapoon were calculated using hyperbola fitting, producing velocities from which all reflections measured in time were converted to depth in amplitude maps and reflection profiles. The one-way travel time velocity averaged 20 cm/ns across the grid. All profiles illustrated below show calculated depth on the vertical axis.

Typically with GPR mapping for grave identification and analysis, antennas are moved along the ground surface in transects (Figure 7) and two-dimensional profiles of a large number of reflections at various depths (as measured in travel time) are created, producing profiles of subsurface stratigraphy and buried archaeological features along lines (Figure 8). When data are acquired in a closely-spaced series of transects within a grid and reflections are correlated and processed, an accurate three-dimensional picture of burials can be constructed (Conyers 2013: 171). This can be done visually by analyzing each profile, or with the aid of computer software that can create maps of many thousands of reflection amplitudes from all profiles within a grid producing maps at various depths (Figure 9).

Figure 7: Marks on the sand from GPR antenna transects 50 centimeters apart.

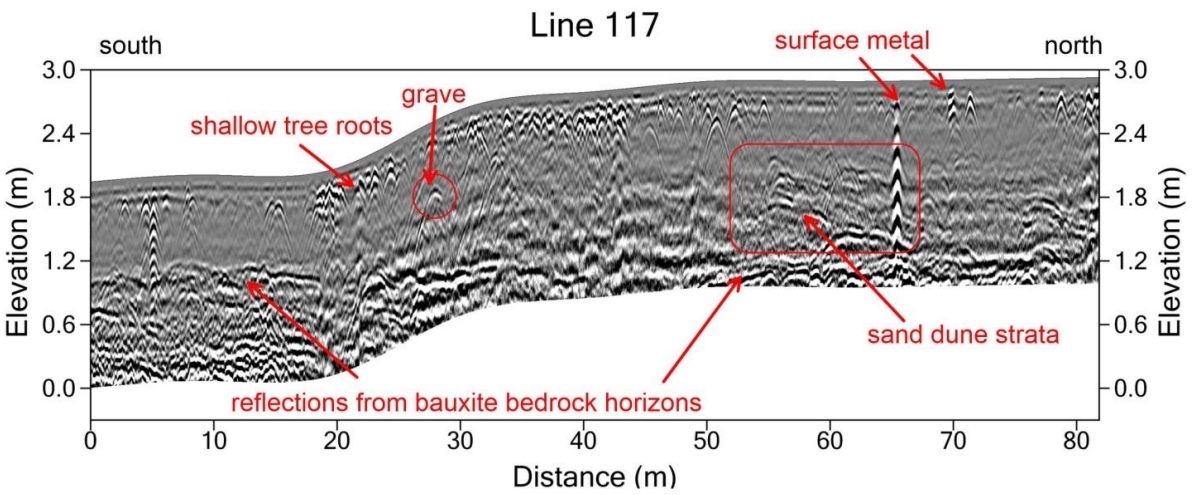


Figure 8: GPR reflection profile showing common types of reflections such as bedrock layers, tree roots, metal, sand dune layers and one grave.

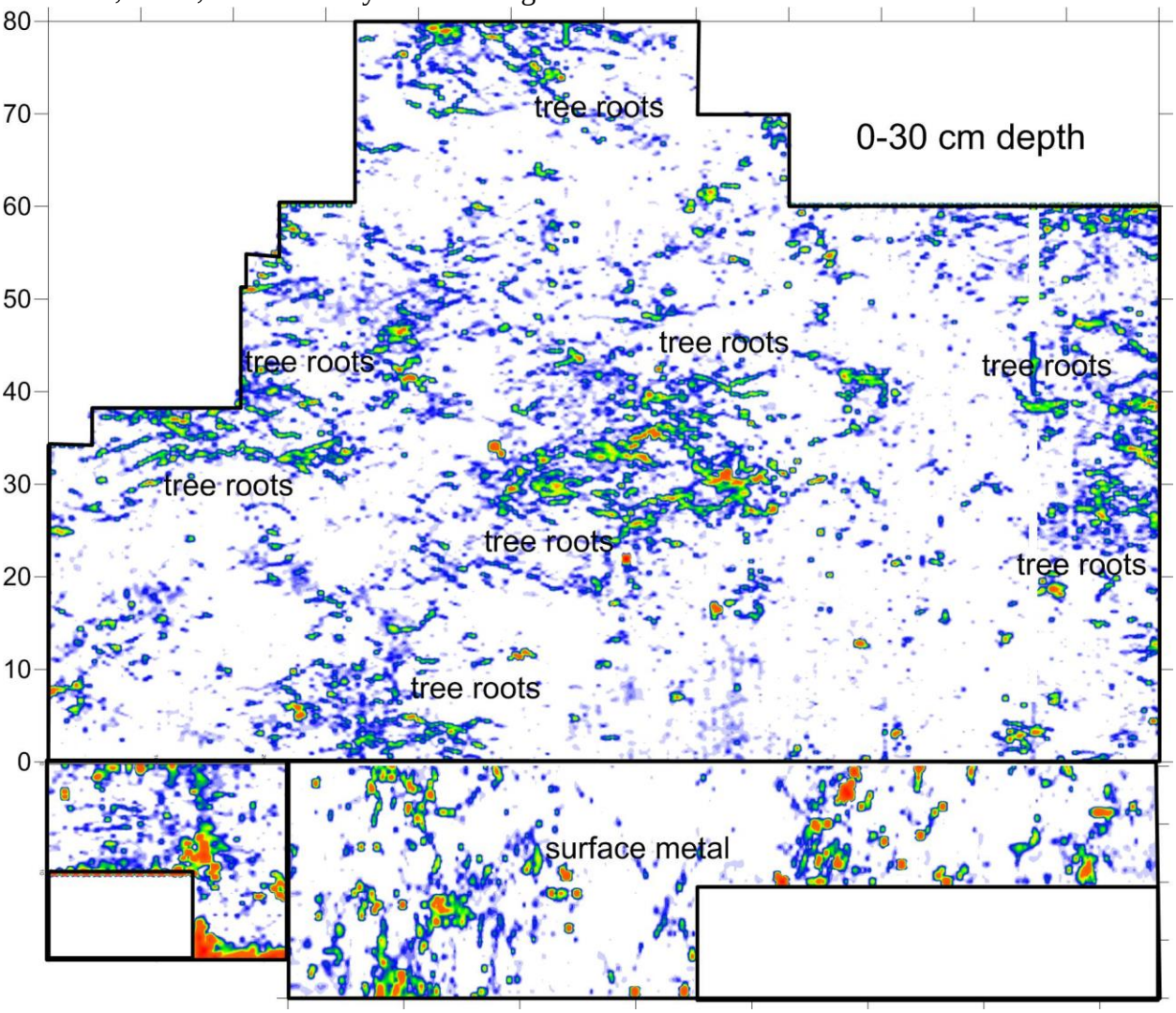


Figure 9: GPR amplitude map of the survey area from slice 1 between 0 and 30 cm depth showing surface metal and many tree roots.

Ground-penetrating radar surveys allow for a relatively wide aerial coverage in a short period of time, with excellent subsurface resolution. This three-dimensional resolution is what gives GPR an advantage over other near-surface methods with respect to mapping burials in most geological contexts. Different antenna frequencies are used for varying depth penetration and subsurface resolution (Conyers 2013: 42). The higher the frequency waves that are produced from a surface antenna, the shallower the depth of energy penetration, but the greater the resolution of subsurface features (and vice-versa for lower frequency antennas). In this study the 400 MHz antennas were capable of resolving burials and associated features as small as about 15-20 cm or so in dimension and transmit energy to a maximum depth of about 5 to 9 meters (far deeper than the burials of interest). Waves will not be reflected if the objects in the ground are less than about one half of a wavelength (Conyers 2013: 62). In the very dry sand at Mapoon the 400 MHz energy moving through the ground had a wavelength of between 30-40 cm, making the minimum resolution between about 15- 20 cm. Depth of energy penetration is calculated by determining the depth at which no coherent reflections have been received back at the surface and only background noise is recorded (Conyers 2012: 96). At Mapoon it was far below the interments of interest.

While the GPR method has wide applicability in many different sediment and soil types, the best energy penetration and subsurface resolution occurs when the ground is electrically resistive (Conyers 2013: 47; Conyers and Connell 2007). In the Mapoon area the ground within which burials are located is very dry wind-blown quartz and carbonate sand, which was an excellent medium for radar transmission. This sand ranges in thickness from 2-5 m across the area, overlying a dark red bauxite unit, which is bedrock in this area of the Cape York Peninsula (Figure 8).

Field Methods

Prior to conducting the surveys as part of this project the Mapoon Land and Sea Rangers (Figure 10) cleared the prospective area and burned the removed vegetation and all other surface plants that might disrupt data collection (Figure 11). Soon after this clearing and burning the prospective area was photographed using a tethered kite with a camera (Figure 12). Using this method very high resolution photographs of the ground surface were collected, merged and stitched together into one composite photograph (Figure 13). This allowed for the very accurate placement of all results on the ground with associated roads, houses, fences, pathways and remaining trees and the beach and ocean. This method of photography has never been used before on a project of this type, and is far superior to using commercial photos or publically available satellite photos.

Figure 10: The Mapoon Land and Sea Rangers who valiantly cleared the land with Ian Moffat and Julian Travaglia .

Figure 11: Burning the recently cleared ground at the cemetery.

Figure 12: The kite with attached camera for obtaining high resolution photographs from the air.

A site datum was placed in the southwestern corner of the study area along the fence bounding the house (occupied by Auntie Harriett and her family) just to the southwest of the grids (Figure 13). From this reference point three large grids, within which data were collected, were constructed and marked with pin flags. That datum point was they surveyed in using a RTK global positioning system surveying device. Once all grids were constructed, the corners and important locations of trees, surface markers and other features were also surveyed using the RTK system. These points were then correlated with the high resolution kite photos so that all geophysical data could be put into space. The spatial accuracy of this method is about plus or minus 3-5 centimeters. All subsequent geophysical data and the results of the surveys showing the locations of all graves were then located relative to these datum points. These were in turn translated into UTM points (Universal Transverse Mercator) survey locations so that the results of this survey will be available to future surveyors and others in the world-wide surveying method that will never vary.

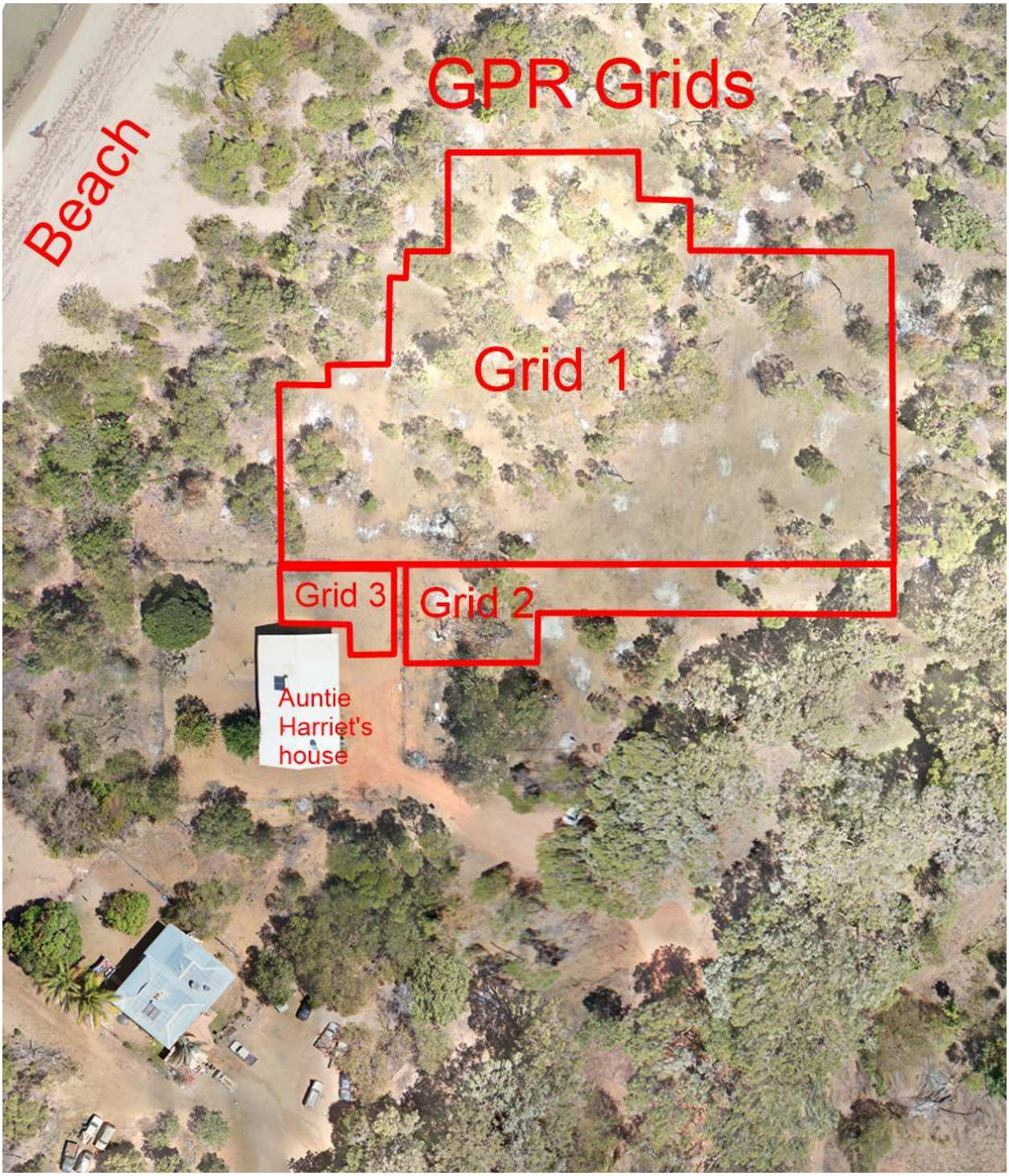


Figure 13: Location of GPR grids at the Mapoon Mission Cemetery. The 0,0 datum for the site grid is in the southwest corner of Grid 1. Every grave is measured from that point.

The GSSI (Geophysical Survey Systems Inc.) Subsurface Interface Radar (SIR) Model 3000 with a 400 MHz center-frequency antenna was used to collect radar reflections (Figure 6). A survey wheel was used for encoding distance into the reflection data string, which was then tied to the grid datum points discussed above. Reflections were recorded in a 40 ns time window (about 4 m depth) and all reflections were filtered prior to recording, removing all received frequencies lower than 200 MHz and higher than 800 MHz. Thirty reflection traces were

recorded each meter along all profiles. Profiles were spaced every 50 cm throughout for complete coverage (Figure 7). Profile length varied throughout the grids in order to avoid large trees and other surface obstructions, and also stay within the cleared and burned areas considered prospective. All reflection data were saved to disk and used to produce the images of profiles and amplitude maps discussed here.

The GPR data took 4 days to collect. A total of 408 reflection profiles were collected, totaling 17,725 meters (about 18 kilometers of linear reflection profiles). This is a massive amount of digital data consisting of 531,750 total reflection traces. Fortunately, computer software is now available to process and allow for the interpretation of such a massive data set in ways that would not have been possible just 5 or so years ago.

In addition to the GPR data, a magnetic gradiometer system was used to collect data in the same general area as the GPR grid. The resulting magnetic map does not perfectly overlay the GPR map, as it was possible to extend some of the data transects beyond the GPR lines into areas still overgrown with brush. Magnetic surveying produces two-dimensional images of the iron, brick and possibly fire-baked areas. It was hoped that this data set would supply information about possible metal within graves, indicating burial artifacts of the types of caskets that might be below the surface.

This magnetic method measures variations in the Earth's magnetic field as a function of other very slightly magnetic objects within about 2 meters of the ground surface (Aspinall et al. 2009). Unfortunately, it was found that the Mapoon Mission Cemetery was highly affected by the random dumping of trash, and the movement of discarded metal objects over time (Figure 14). The magnetic maps therefore were more indicative of recent occupation (three houses used to be located very near the cemetery to the north and east) and other refuse dumping. The magnetic map was, however, helpful in locating the remains of three historic house locations, which helped in understanding the use of this area over time.

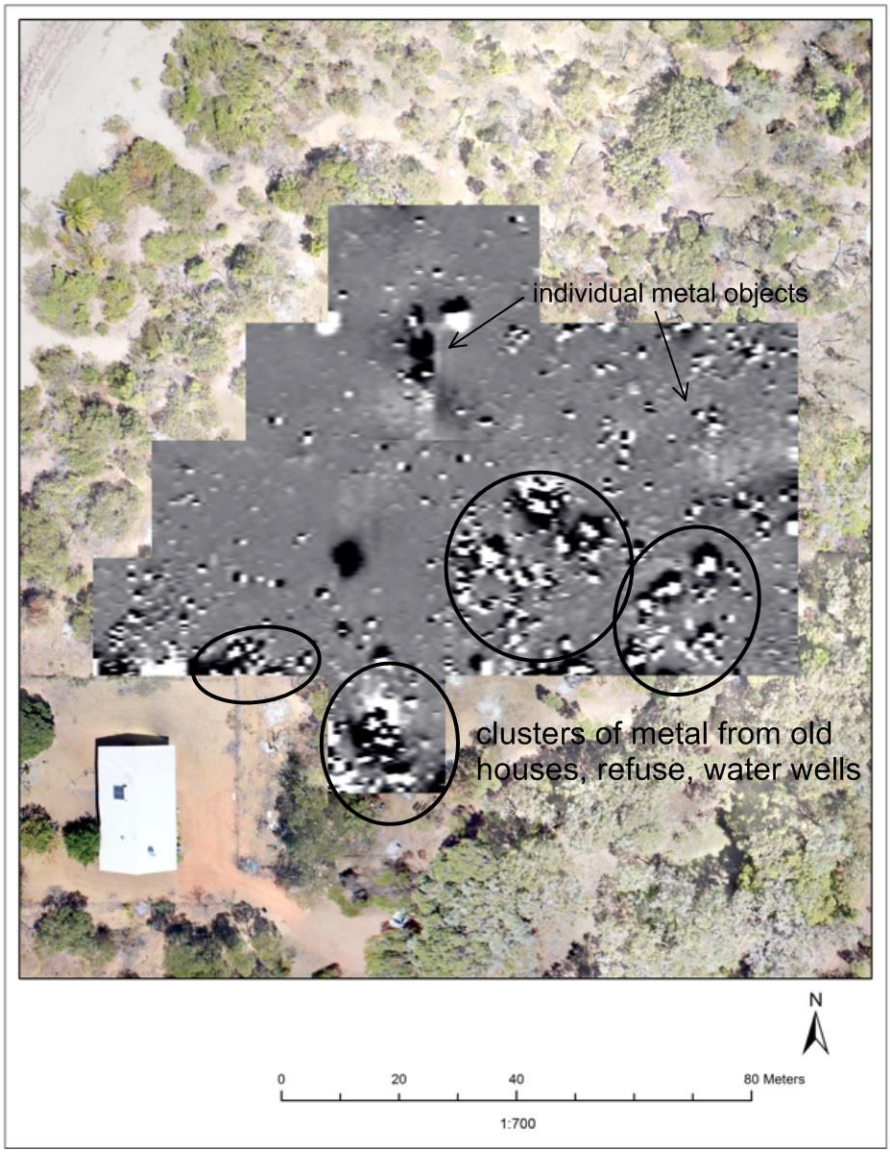


Figure 14: Magnetic gradiometry map overlain on the aerial photo. It shows clusters of metal from refuse, water wells and other metal objects.

The RTK GPS system was also used to collect survey points for elevations across the grids. From this data set a 5 cm contour map of the grids was produced to show the relative high and low areas across the surveyed area (Figure 15). This was helpful in adjusting some of the important reflection profiles for topography (eg. Figure 8) and interpreting the location of the higher elevation sand dunes and the "back dune" areas where the historic houses and trash dumping occurred.

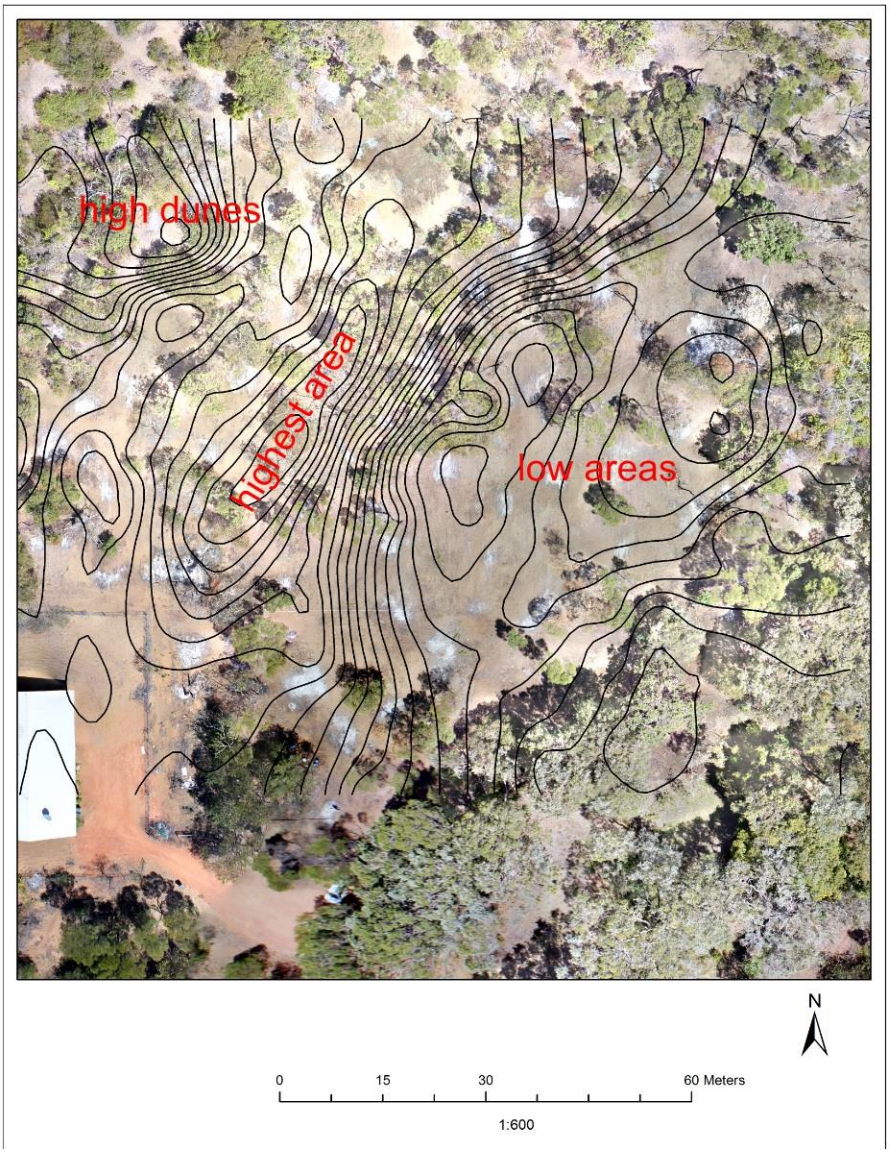


Figure 15: Topographic contour map showing the high and low elevation areas in the Mapoon Mission Cemetery area.

GPR Data Processing and Interpretation

Raw GPR reflection data are a collection of many individual traces, spaced at varying intervals, along two-dimensional transects within a grid (Conyers 2012: 26). Each reflection trace consists of a series of stacked waves received from certain depths in the ground at one surface location, which vary in amplitude depending on the amount and intensity of energy reflection that occurred at buried interfaces. When traces are stacked vertically, and in sequence, standard two-dimensional profiles are created showing the variations in amplitudes of reflected waves that vary along transects (Figure 8). They can be viewed much like profiles along vertical faces of excavations such as trenches. An analysis of the varying amplitudes in space can potentially show subsurface changes in stratigraphy and physical properties of burials, caskets and associated materials within the matrix of sediments and soils. The higher the physical contrast between the burial and the surround sediment, the greater the amplitude of the reflected wave generated at that contact (Conyers 2013: 59). When viewed in profile the higher amplitude

reflections are the areas of black and brighter shades of white visible within a gray-scale image, while neutral gray denote areas of little or no reflection (Figure 8).

When the GPR reflections were processed and viewed in standard reflection profiles reflections are collected from the dipping beds of the sand dune strata, tree roots, possible animal burrows, as well as the burials of interest. Some of the profiles collected in the lower topographic areas show strong linear reflections are visible toward the bottom produced by the contact of the sand with the bauxite layer (Figure 8). Graves located within the sand are distinctly visible as hyperbolic shaped reflections ranging in depth from 1.5-2.5 meters. They are typically visible as hyperbola-shaped reflections (Conyers 2006, 2012). This is because the radar energy moves out from a surface antenna in a cone, and therefore "sees" a burial prior to being directly over top of it, and then again as it moves away from it (Figure 16). At Mapoon it was found that as long as burials were in caskets or wrapped in some material that produces a velocity contrast with the surrounding sand, reflection hyperbolas were created. There are many variations in this general reflection feature, which are discussed below with each burial. In general, caskets that might still contain void spaces are more reflective than the textile wrapped interments. Older burials, which have largely decomposed still reflect energy that generates hyperbolic-shaped features, but the amplitude of the reflections is much less. These show up as "blurry" features in the reflection profiles, as will be discussed below in graves of this sort. Some very elaborate burials with intact coffins that were constructed with metal lining or contain other materials are highly reflective and can be identified by their strong hyperbolic reflections. There are also good examples of reflections from both the tops and bottom of caskets in some Mapoon graves, which indicate caskets that are still partially intact.

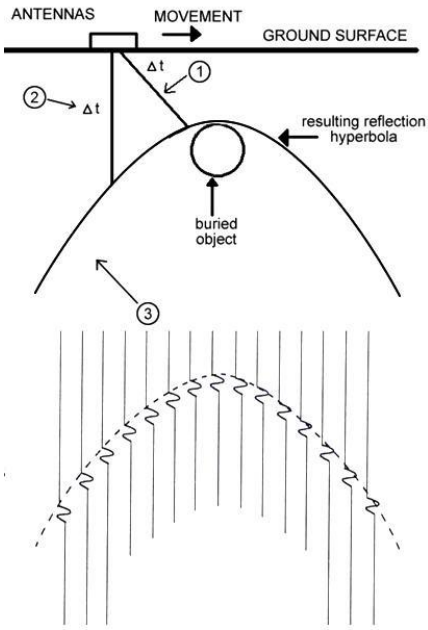


Figure 16: Generation of a reflection profile crossing a buried object such as a grave.

Tests have been performed on whether singular bones, and even concentration of bones will produce radar reflections (Solla et al. 2012). Those laboratory and field tests appear to indicate that bones by themselves do not contrast enough to yield reflections. Very old Indigenous burials in Australia have proven to be almost impossible to detect with GPR (Wallis et al. 2008). All that can be identified from these ancient burials that contain only bones are the

burial shafts themselves (Conyers 2012: 129). As part of this project very old burials were exceptionally difficult to identify, and were therefore not designated part of the "known" burials in this study.

The spatial location of reflection amplitudes in a three-dimensional volume can help greatly in subsurface interpretation when slice-maps at specific depths in the ground are produced. Maps of this sort are produced by re-sampling all reflection amplitudes in all profiles within a grid and then averaging the amplitudes in slices of a given thickness. Reflection amplitudes are then gridded and interpolated to provide a uniform placement of radar reflection strengths throughout the mapped area (Conyers 2013: 172). When viewed in map-form each slice can portray in plan-view the distribution of all reflected wave amplitudes at a desired depth, which were collected from burials (Figure 9). In these maps low amplitude variations within a slice denote little subsurface reflection and therefore the presence of homogeneous material while high amplitudes indicate significant subsurface discontinuities, in this case the presence of burials and associated objects. Degrees of amplitude variation in each amplitude slice can be assigned arbitrary colors along a nominal scale.

At the Mapoon Mission Cemetery slices were produced parallel to the ground every 30 cm deep in the ground (Figure 18) and the amplitudes were then correlated, compared and mapped. In the upper map from the ground surface to 30 cm depth only tree roots and some concentrations of trash are visible (Figure 9). Progressively deeper slices begin to produce images of the graves as the depth of 90 centimeters is reached (Figures 19 and 20). The more intact and elaborate burials are visible as red and yellow colored reflections, and the areas between graves that contain only sand are blue and white. In the eastern edge of the study area, in the topographically lower areas where the sand blanket is thinner, the deeper slices show very intricate banding of layers in the bauxite bedrock (Figures 3 and 4). In these deeper slices, the graves within the thicker portion of the coastal sand dunes are still visible.

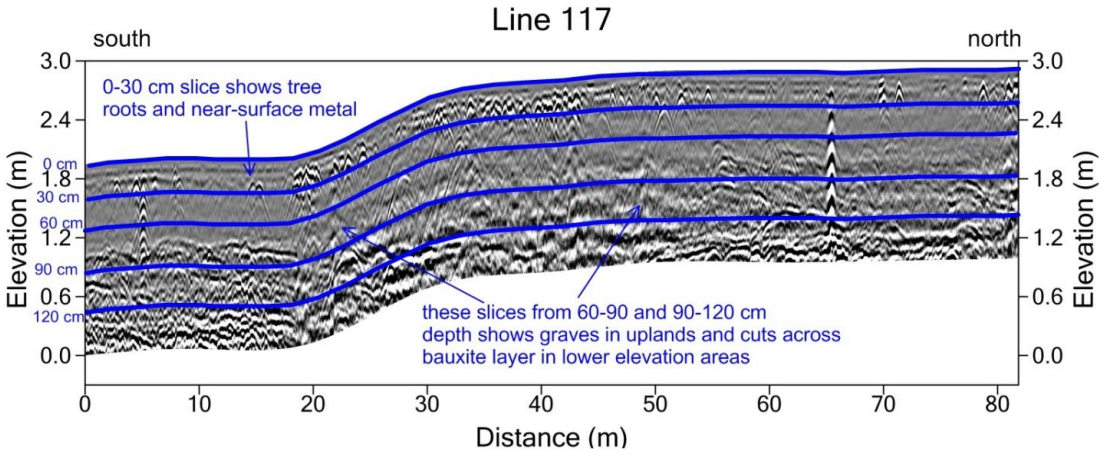


Figure 17: Generation of amplitude slice-maps parallel to the ground surface from reflection profiles.

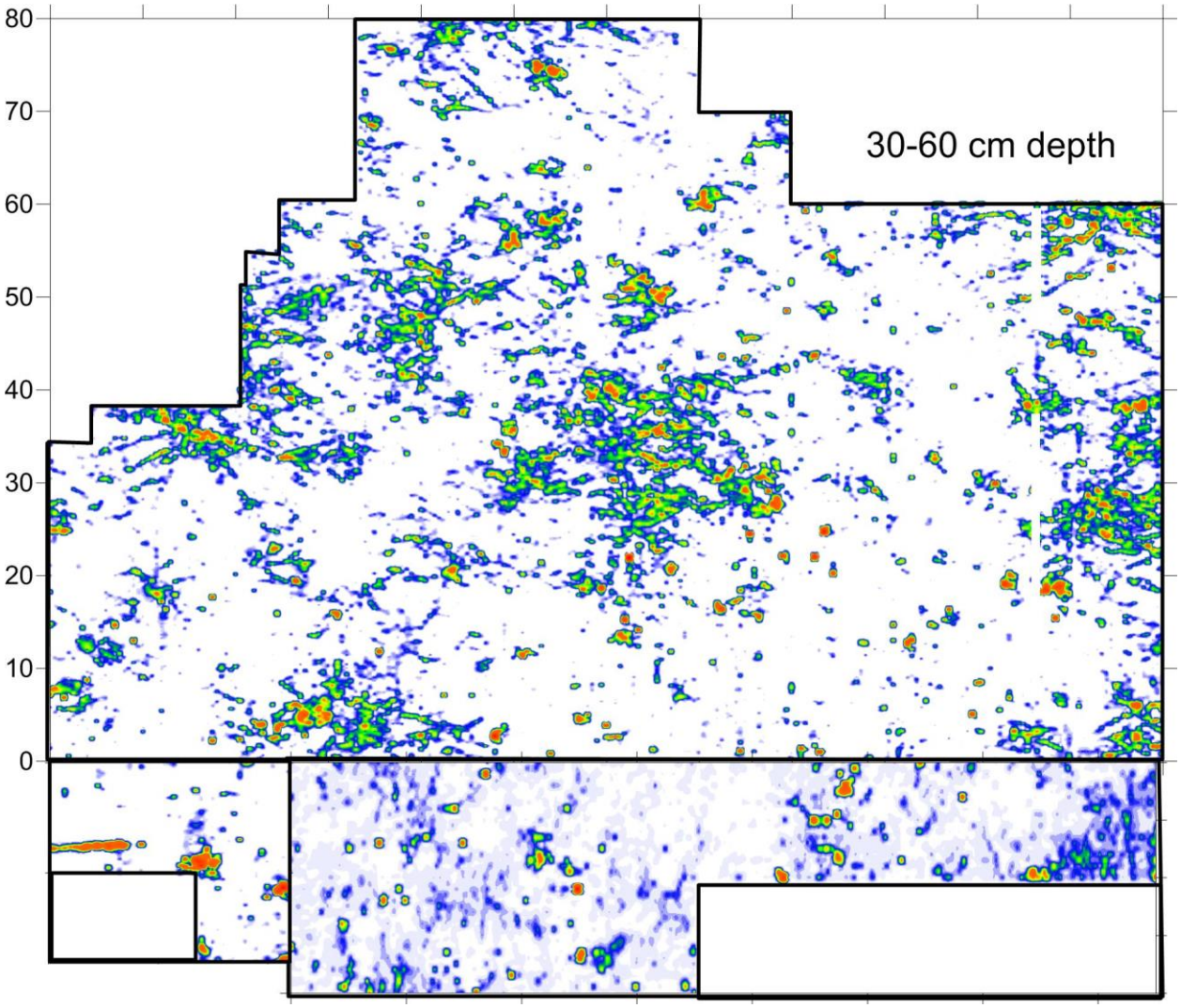


Figure 18: GPR amplitude map from 30-60 cm in the ground still showing many tree roots and animal burrows in the ground.

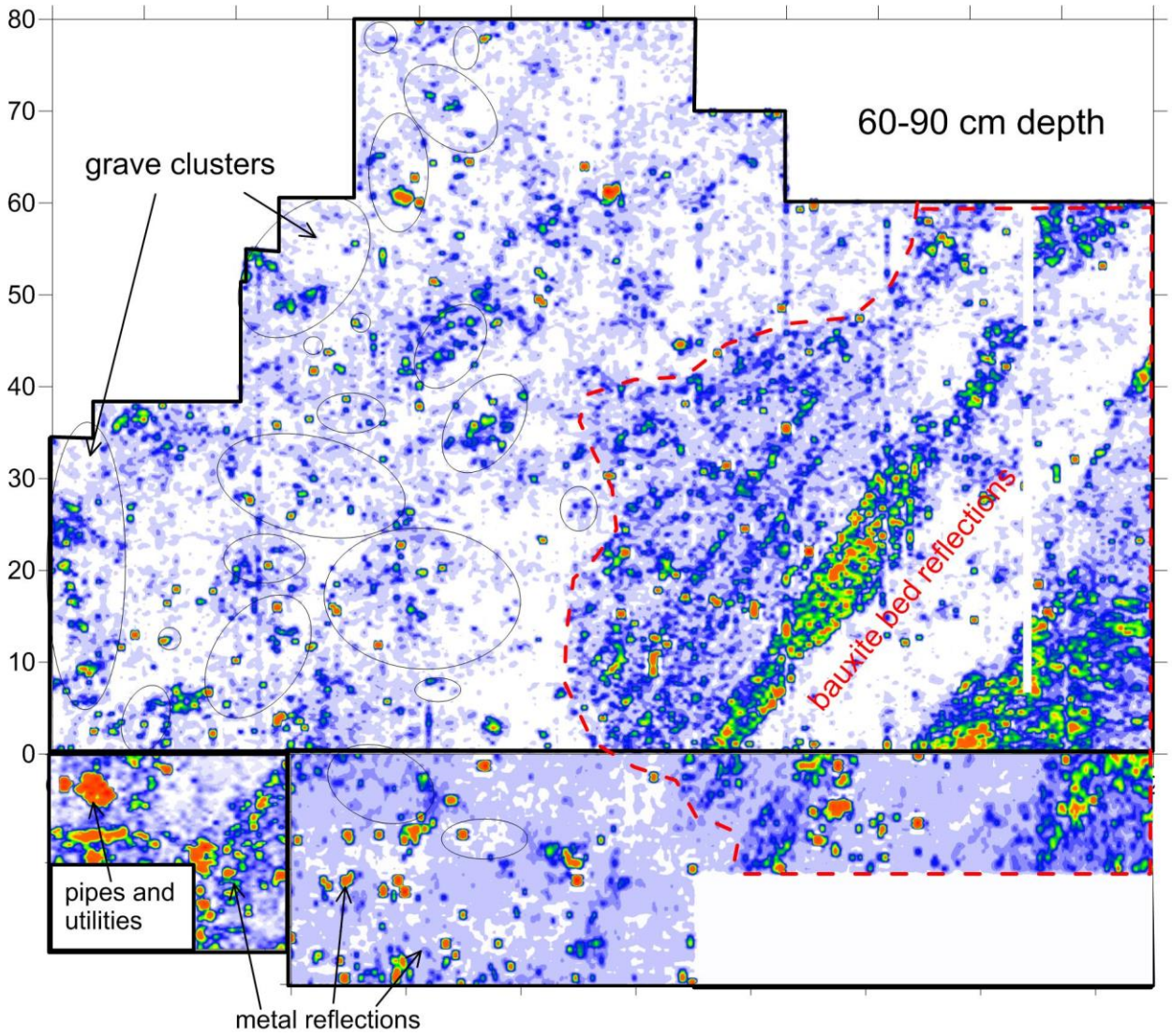


Figure 19: GPR amplitude maps from 60-90 cm in the ground showing some buried utilities around Auntie Harriet's house, clusters of graves (circled) and some metal reflections. In the eastern portion of the grid, where there is less sand dune overburden, the bauxite beds are imaged as linear bands.

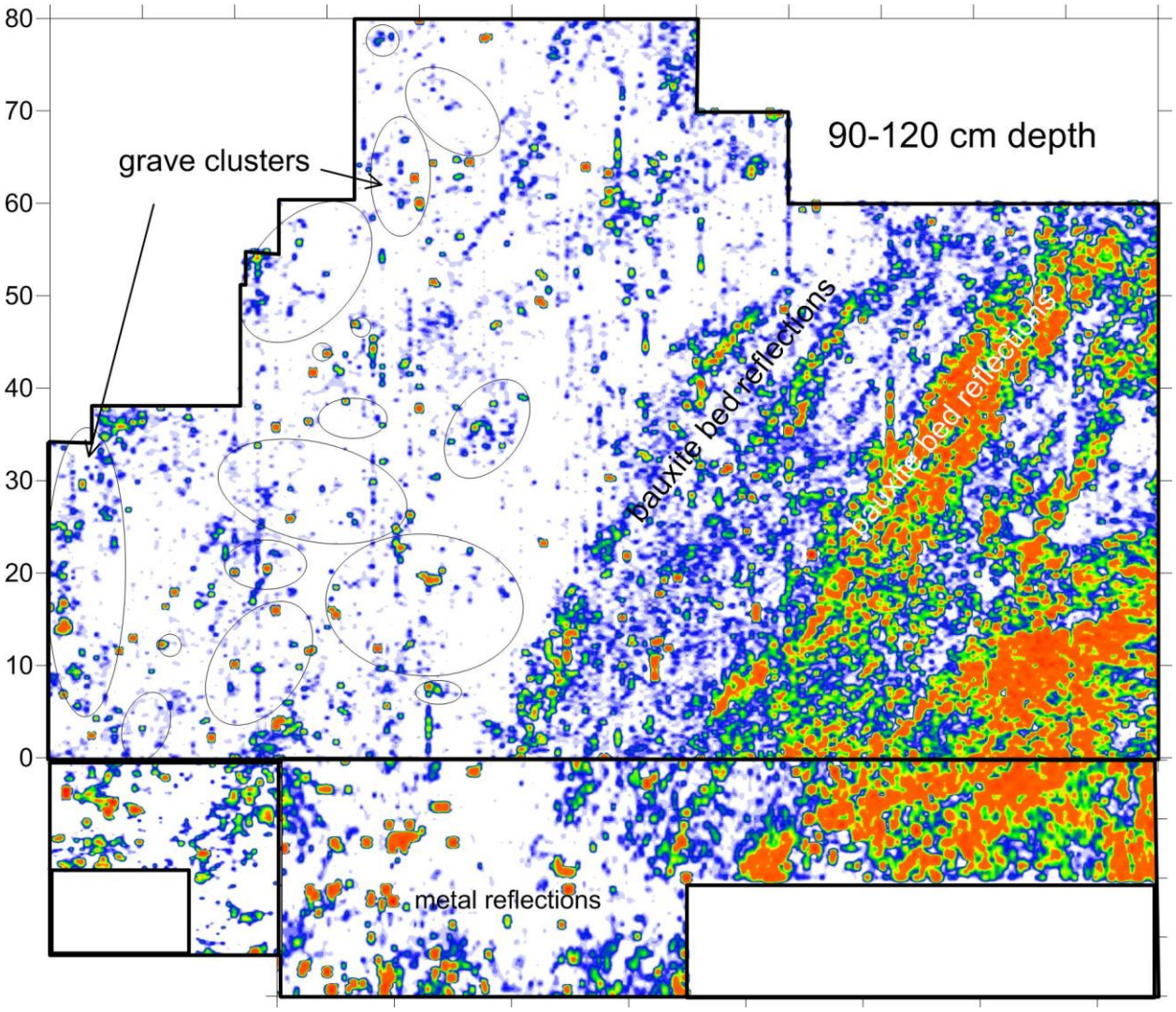


Figure 20: GPR amplitude map from 90-120 cm depth showing grave clusters.

The amplitude maps were used as a guide to the location of graves, and a way to map concentrations spatially. Confirmation of graves, however, necessitated analysis of each individual reflection profile. The location of graves that came from an analysis of both types of images shows that there are "clusters" of graves in certain locations. There are very few graves in the Mapoon Mission Cemetery that are "lone burials". This suggests that burial locations and "plots" were well mapped out and known to people over the decades that the cemetery was actively receiving burials. Those clusters have arbitrarily been designated numbers 1 through 10 (Figure 21). The clusters were also delineated by the "grave type" visible using GPR. For instance, almost all the graves in Cluster 1 contain "European-style" graves, which are oriented east-west along orderly rows on the highest topographic sand dunes in the cemetery. Other clusters identified contain "traditional Aboriginal-style" graves that lack the east-west orientation and produce single reflection hyperbolas that would be expected from fabric wrapped remains. Each cluster of graves will be discussed in order below, with an analysis of each individual grave within the clusters.

Figure 21: Map of arbitrary grave clusters visible in the GPR amplitude maps, all of which are discussed individually below.

All graves were then plotted directly on the aerial photos and given numbers (Figure 22). These numbers are totally arbitrary, and were named in the order they were discovered during data analysis. They are tabulated with regard to grid number and profile number in Appendix 1.

Figure 22: Map of all discovered graves with their grave numbers.

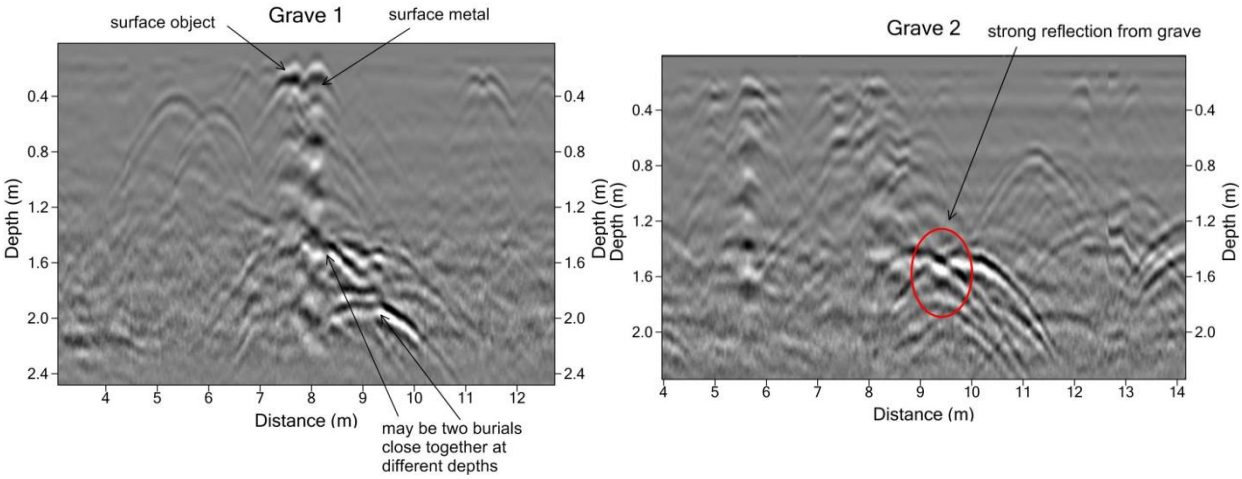
The European-style burials are very distinct as to their radar reflections and orientations. They produce high amplitude hyperbolas, sometimes from both tops and bottoms of caskets, and are oriented east-west. The more traditional "Aboriginal-style" graves always produce a single hyperbolic reflection and are lower in amplitude. They are found in clusters where graves do not follow a single orientation. There may be very old pre-mission burials in some areas, as some very low amplitude graves were identified. The low amplitudes are likely a result of a high amount of deterioration brought about by a long time in the ground. It is impossible to differentiate "very old traditional" burials from those that are younger. Each is discussed with respect to how strong the reflections are, which may indicate age, but these are very inaccurate measurements of time in the ground as other factors might cause this difference in radar reflectivity. Those factors may be depth of burial, amount of water in the ground, associated burial materials, whether the remains were mummified, cremated or not altered at all prior to burial.

Analysis of Individual Graves by Cluster and Number

Cluster 1: Graves 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,95.

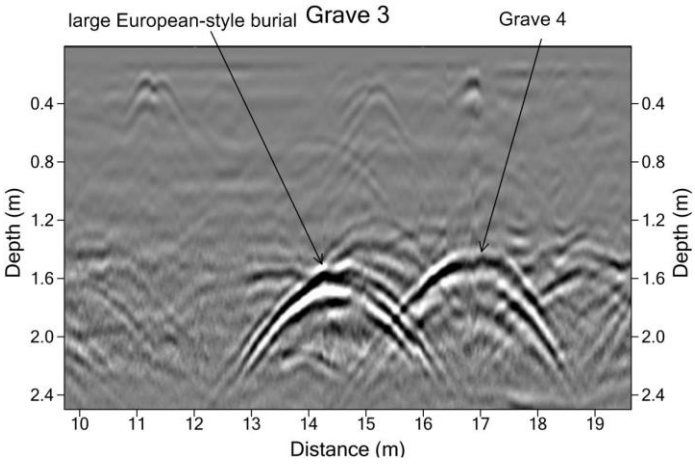
This cluster of graves is found along the southeastern portion of the cemetery on a ridge of sand dunes. In general they include mostly European-type burials, with some older, deeper interments. Some are close together and appear to have been organized in rows. There are no surface markers in this area of the cemetery, suggesting these may be the oldest of the mission-period graves, perhaps from the early part of the 20th Century. Almost all the European graves are aligned east-west also suggesting this Christian influence. They may be burials from many different years or even decades, as some are more deteriorated than others. There is also a possibility that multiple burials occur in the same grave shaft. In this same general area there are also traditional Aboriginal-style interments, which points to this area of the cemetery having a long and varied burial history.

Grave 1 is possibly two burials in one shaft that are very close to one another. They are located at different depths, which suggest they were put in the ground at different times, but still very close together. The



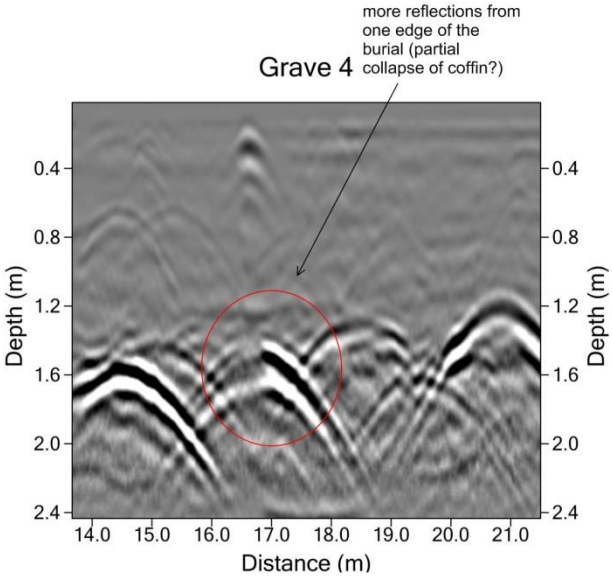
GPR profile of Grave 1 shows the affect surface metal has on the reflections, with the typical " barber pole" type reflection feature as the reflections from the metal "ring" down through the time window.

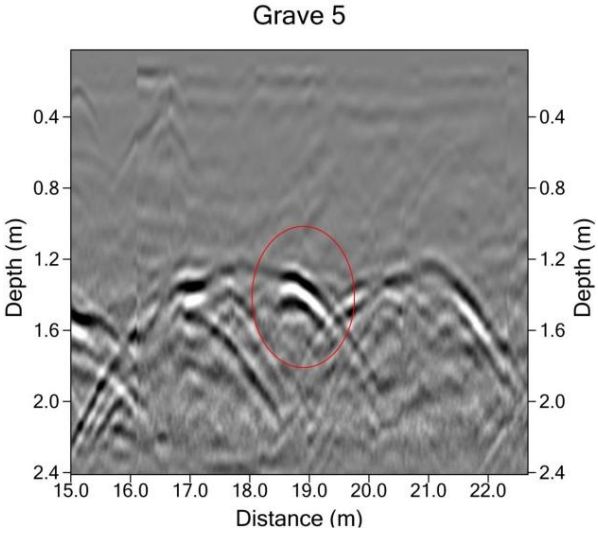
Grave 2 shows a European-type grave with a strong reflection, indicating a casket that might still have some void space in it. This is a complex reflection pattern as there are also reflections from other portions of the casket.



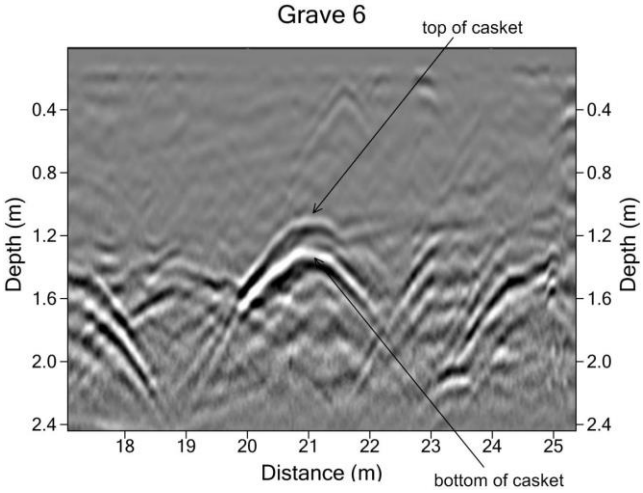
Graves 3, 4, 5 and 6 are all in a north-south row and all show European-like characteristics with very strong reflections from substantial caskets. They were likely interred about the same time and marked on the surface to produce this orderly an alignment. There are no surface indications of these graves today.

Grave 4 can also be seen in its entirety in the profile labeled Grave 3, but in the one labeled Grave 4 only half of the standard reflection profile is displayed. This is caused by Grave 3 "blocking" the hyperbola axis on one side and not allowing energy to reflect from one side of the casket. The same phenomena can be seen in the profile displaying Grave 5.





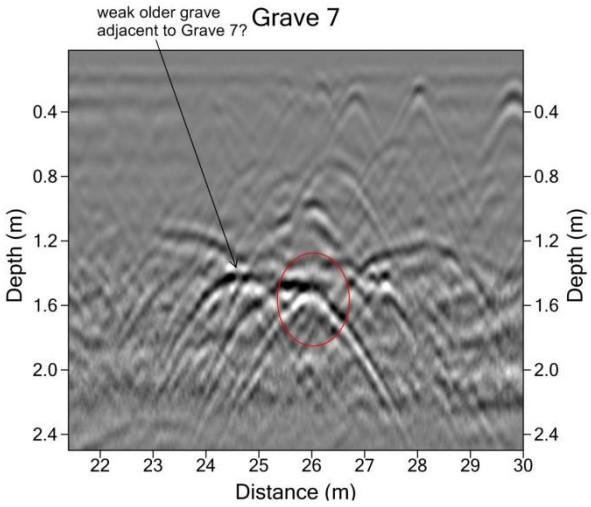
Grave 6 is particularly interesting as it displays reflections from the both the top and base of the casket, showing that a good deal of work went into building this vessel, which has withstood the elements over time.

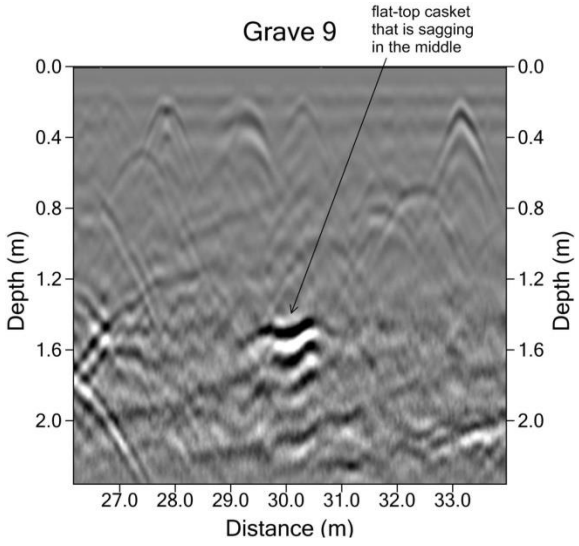


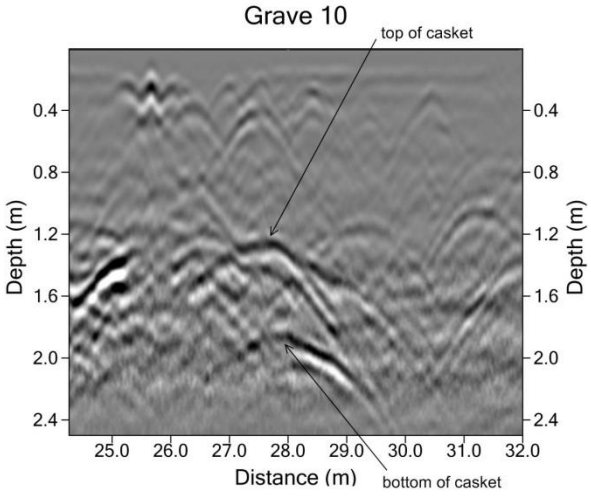
Reflections from other nearby caskets can be seen also in all these profiles, as they are very much intact and reflect a large amount of radar energy.

Graves 7, 9, 10, 11, 21, 22 and 95 are tightly grouped in the northern portion of Cluster 1. All but 11 and 95 appear very old and more traditional, with no clear casket reflections or other reflection features of high amplitude that are common in the European-style graves. They are closely packed with older graves adjacent to younger ones. Graves 11 and 95 are very European-like, but because they are located in this area very closely interred with more traditional graves, they may be the interments of Indigenous people who were placed near their relatives, but buried in a mission-influenced Christian way.

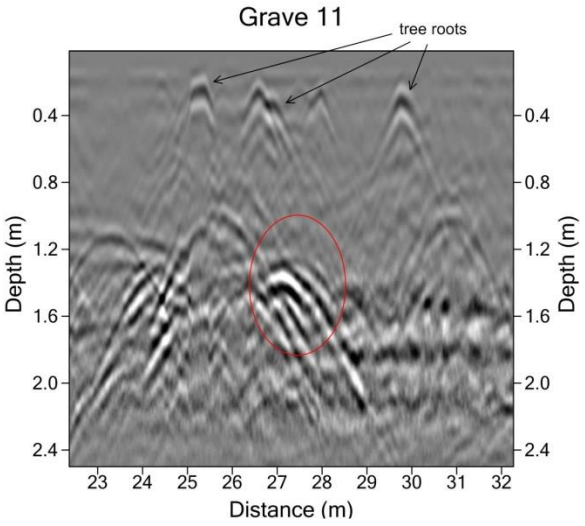
There are two reflections that make up Grave 7, which are very close to each other. Perhaps Grave 7 was placed very close to an older burial, producing this signature. It is hard to differentiate the two. Grave 9 is probably a casket, which has deteriorated and collapsed in the top, showing the sagging reflection and no reflections from the sides or top edges, which would have produced the more common hyperbolic shaped reflection.



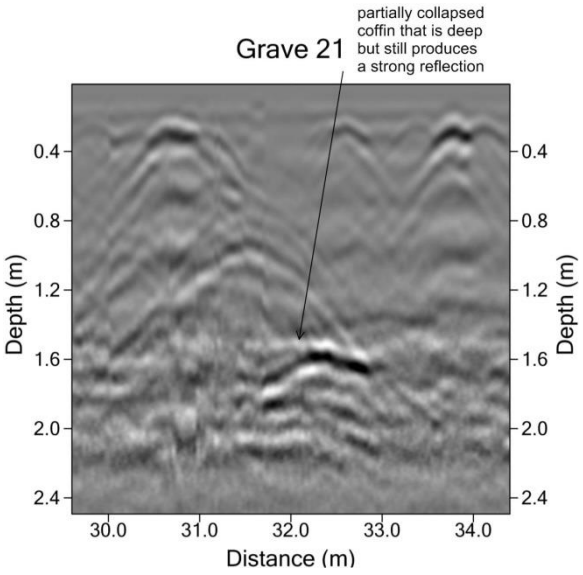


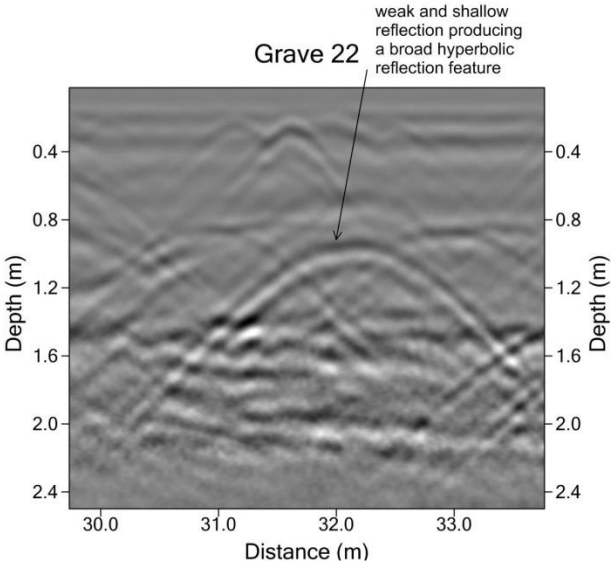


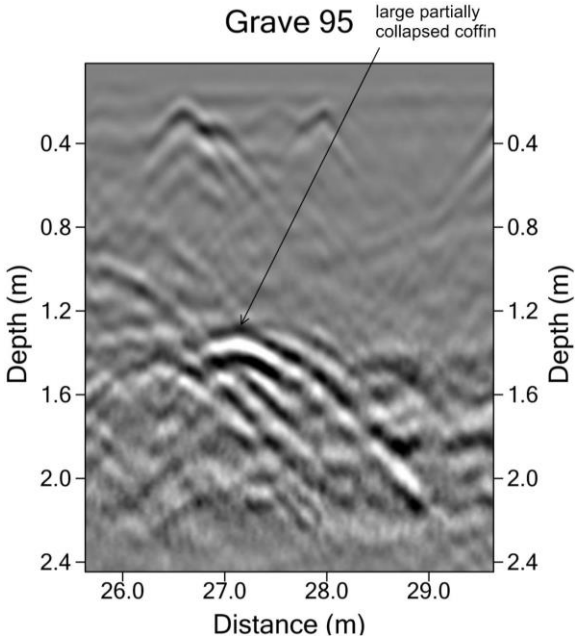
Grave 10, also in this northern grouping in Cluster 1 produced a weak reflection, probably from a deteriorated casket. It still exhibits top and bottom features. The Grave 11 shows nicely what the surface roots look like in a GPR reflection profile. The grave itself looks very European with a strong casket reflection from the top.



Graves 21, 22 and 95, also in this grouping in Cluster 1 show weak reflections from deteriorated caskets, or very weak reflections from bundles. Grave 21 is only preserved as a flat surface to reflect some radar energy.

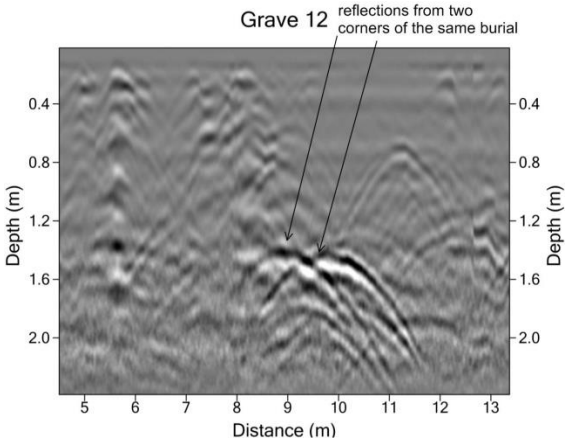




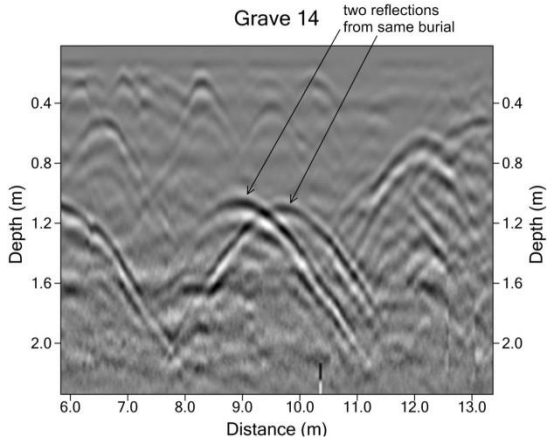


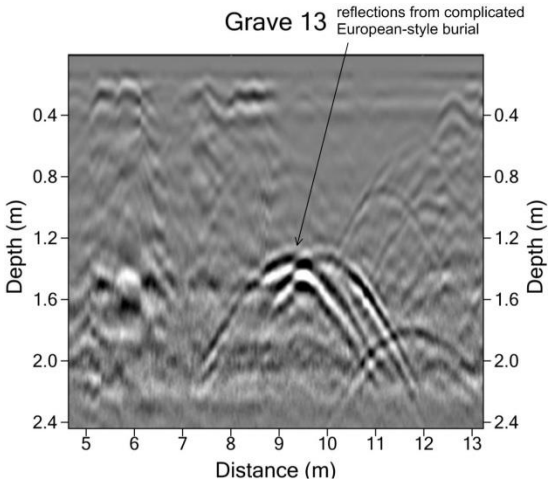
Grave 95 was at one time a well-developed European-like casket, which has partially collapsed.

Just to the east of the very formal line of European-type burials in Cluster 1, which are Graves 3, 4, 5 and 6 is another row of less formal burials, most of which also appear to be European-like also. But in that area of Cluster 1 it is more complex as there are also deep, older Indigenous type burials, younger European-influenced interments and also more recent still-intact European ones. Graves 12, 13, 14, 15, 17 and 18 are definitely European with strong hyperbolas and therefore more recent, while 16 and 19 are significantly older and exhibit weak reflections with no indications of caskets that have any intact void spaces.

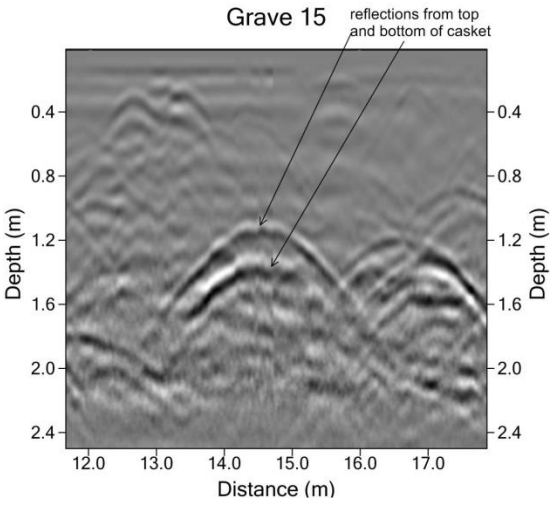


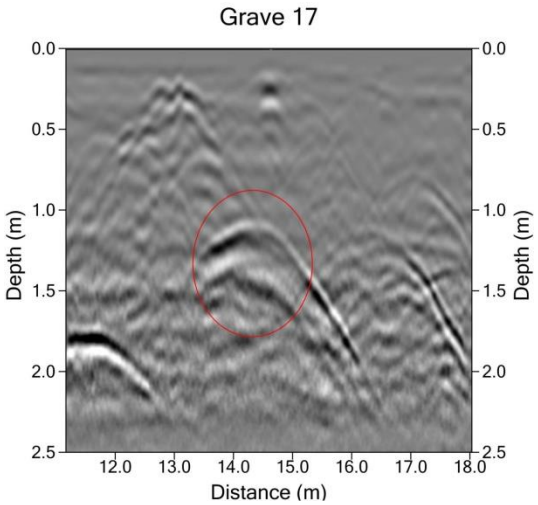
Grave 12 is interesting because it appears to have two burials, but really is just two reflections from the same coffin (perhaps edges). The interment in Grave 13 is also complicated as it does not have one coherent reflection from the coffin top, but is truncated. This may be caused by partial collapse of the top.



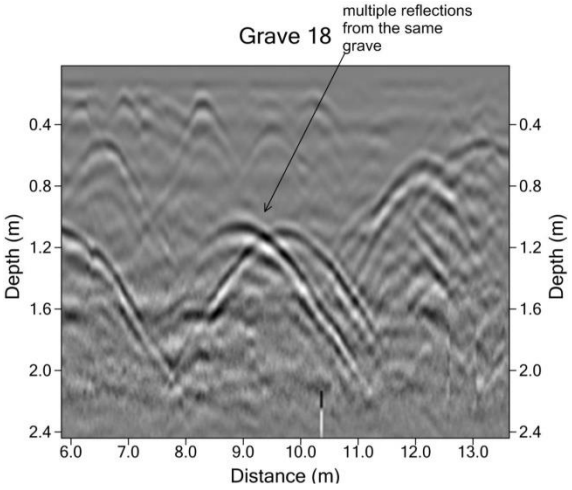


The same complex reflections occurred from the edges of a European-style coffin in Grave 14. The caskets in Graves 15 and 17 are both deteriorated but still partially intact and produce reflections from both the top and bottom.

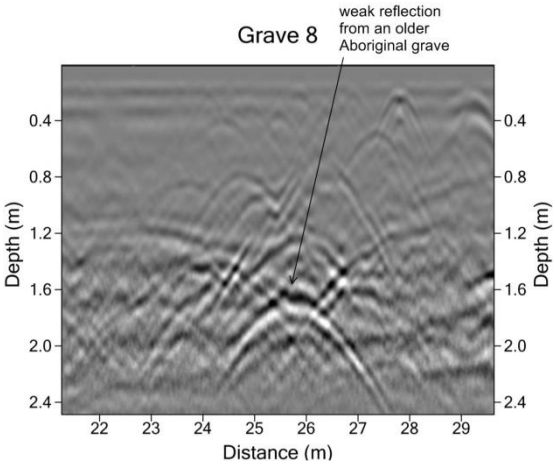


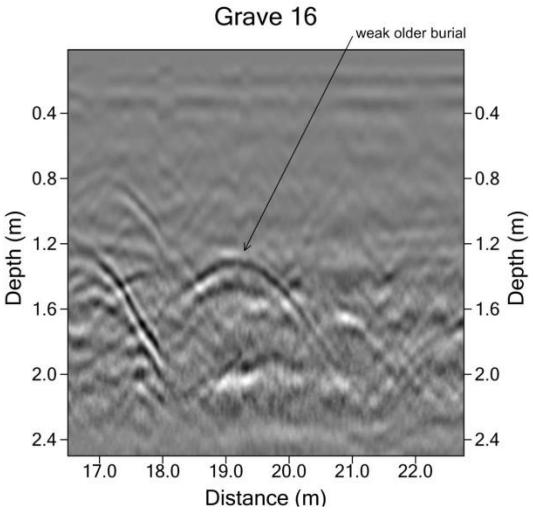


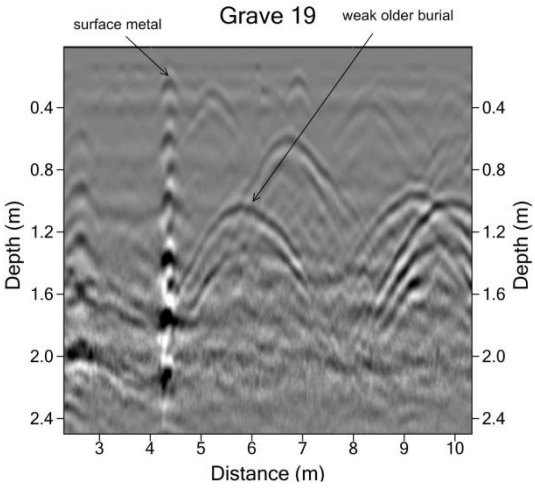
The interment in Grave 18 fits the same general characteristic for other European-style graves in this area of Cluster 1, with multiple reflections from a partially intact casket.

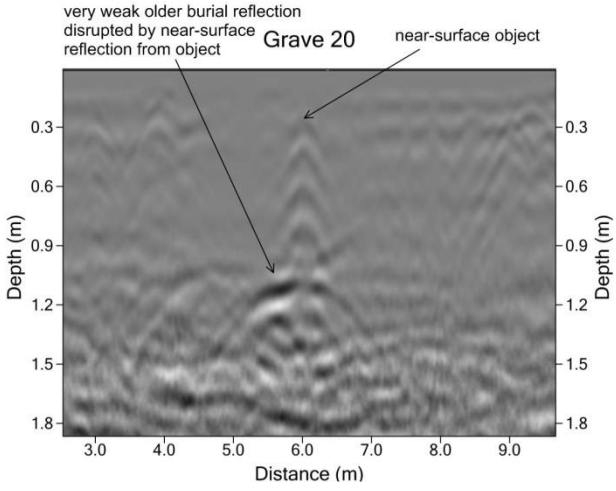


Graves 8, 16 and 19, also located in this same general area of Cluster 1 are much different than the others. All are very weak reflection features that appear to be old and are likely traditional graves. These three are probably the oldest graves in this burial area.





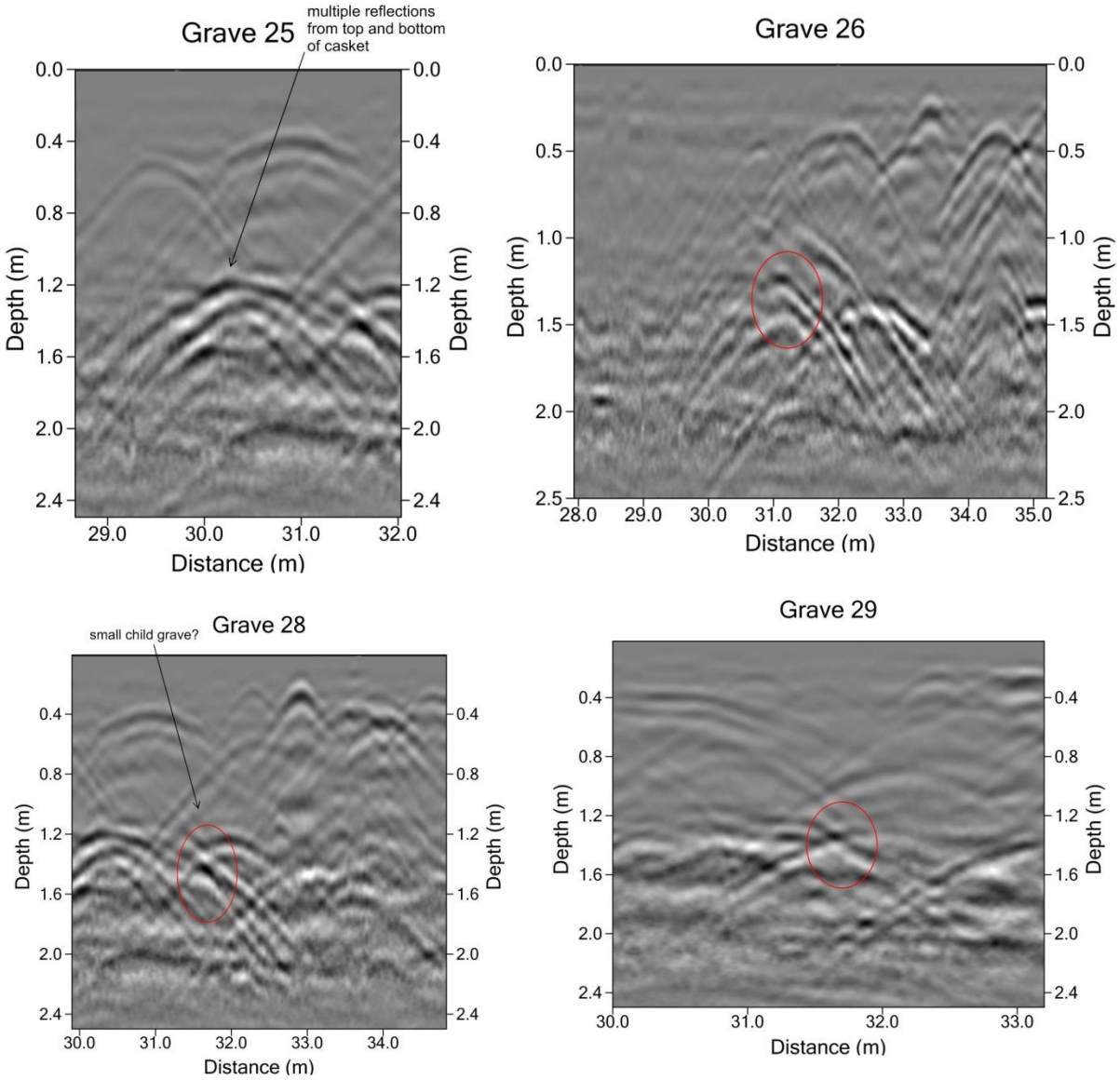




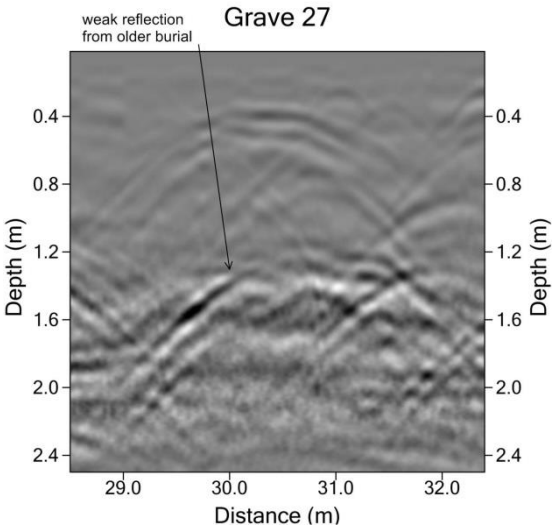
Grave 20 is really not part of the cluster of European and older traditional Aboriginal graves and sits by itself to the east at a very different orientation than the others. It appears to be one of the oldest in the cemetery, and was probably unmarked or its markers had been destroyed prior to the burial of the others in this area and therefore did not have any subsequent burials near it from a later date.

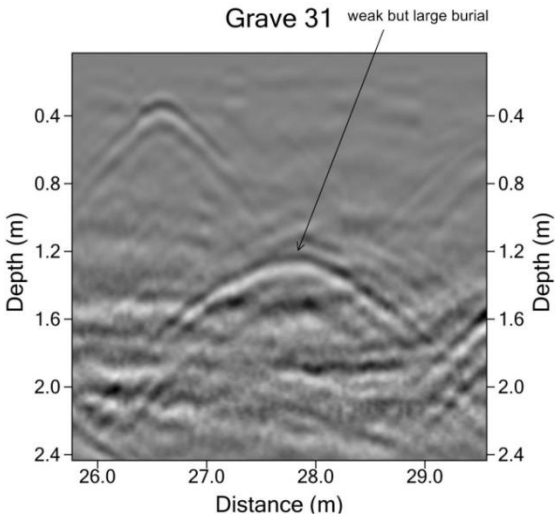
Cluster 2: Graves 25, 26, 27, 28, 29, 31, 41, 47, 48, 50, 57, 51and 59

All the graves in this cluster are very traditional Aboriginal-style burials. They are a little deeper than the European graves seen elsewhere, contain no well-defined coffins and produce only very weak reflections. One small concentration of graves are numbered 25, 26, 27, 28 and 29. In this area Grave 25 appears to have a casket, but it is very deteriorated while still reflecting radar waves from the top and bottom. The others here are much weaker, and possibly older and are barely visible.

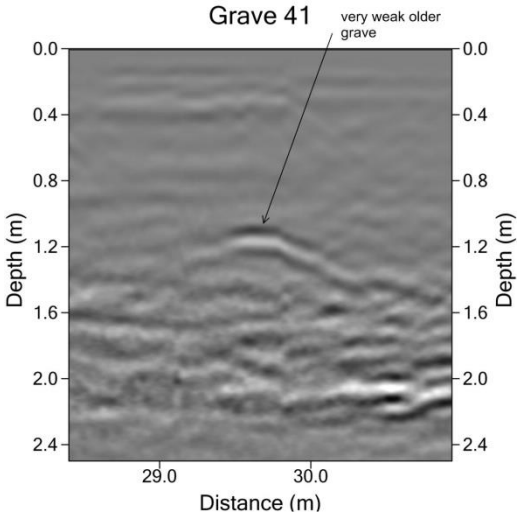


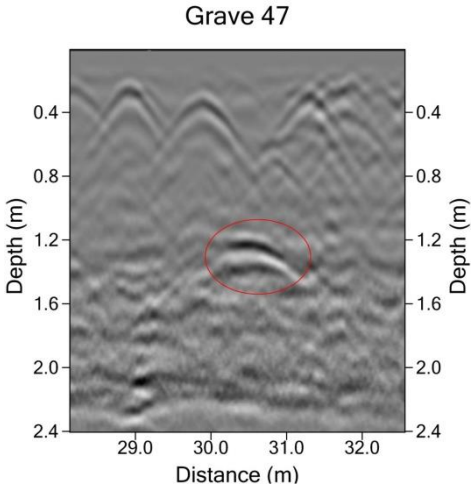
Within this concentration of graves are two sad stories, very small burials in Graves 28 and 29, which appears to be small child interments

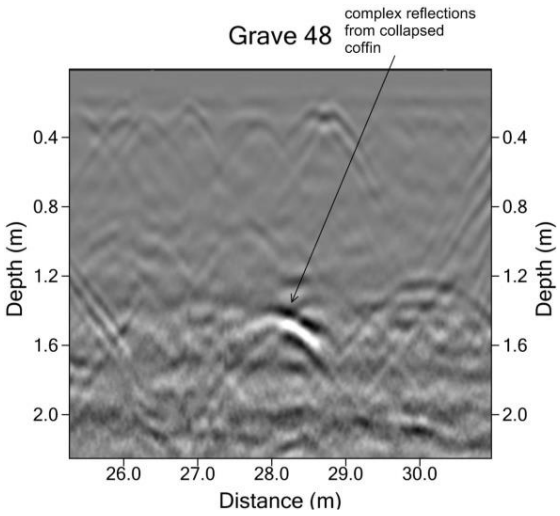


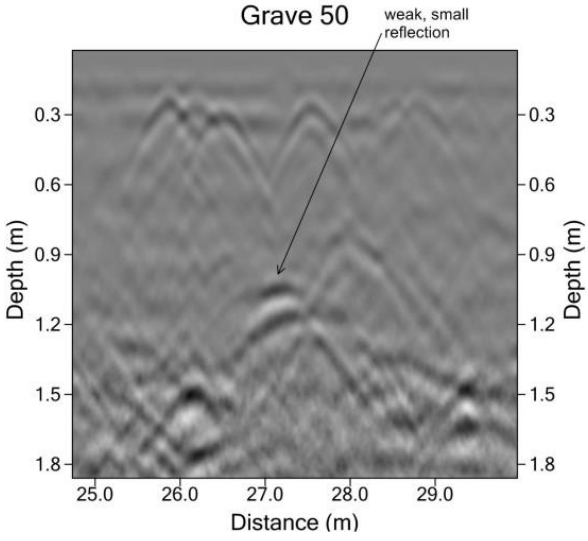


Grave 27 is a deep older burial that is very deteriorated. Grave 31 is just to the south of the concentration of graves discussed above. It is large and probably the grave of an adult, but buried in the traditional manner with no casket. Graves 41, 47 and 48 are a separate burial area in this cluster are all old and produce very weak reflections.

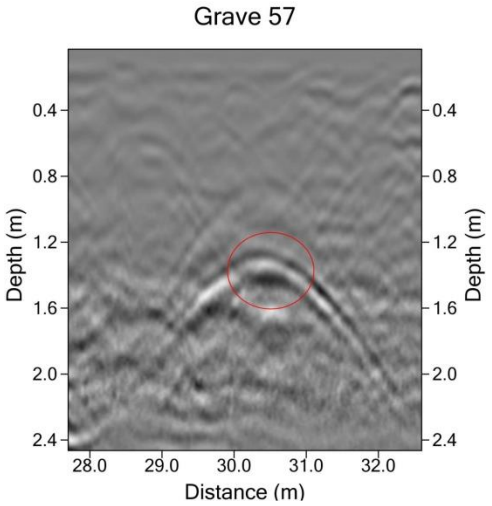




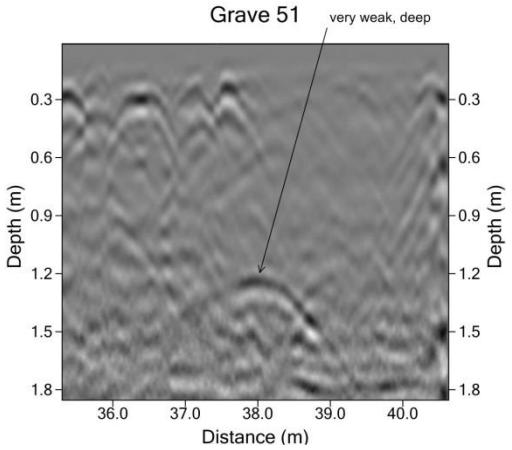


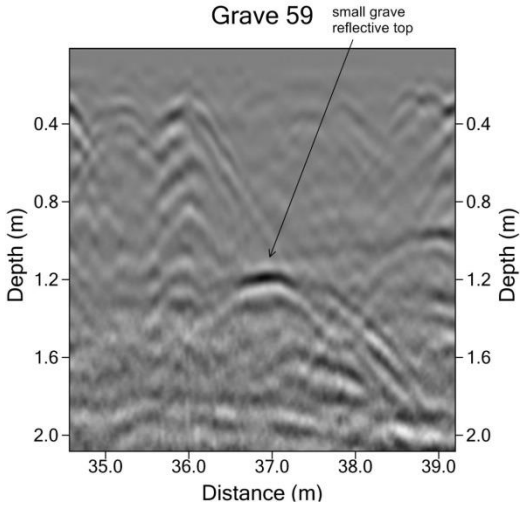


There is a small grouping containing Graves 50 and 57, also very weak and old.



A separate small burial area in this cluster contains two traditional graves to the northeast of the other interments with Graves 51 and 59. Both are very old and produce only weak reflections.

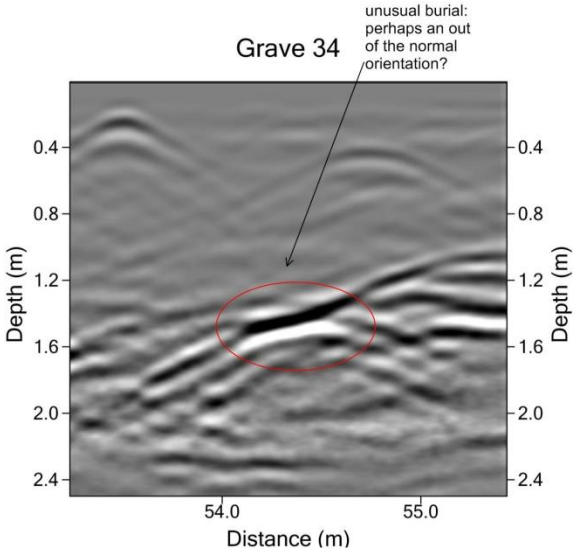


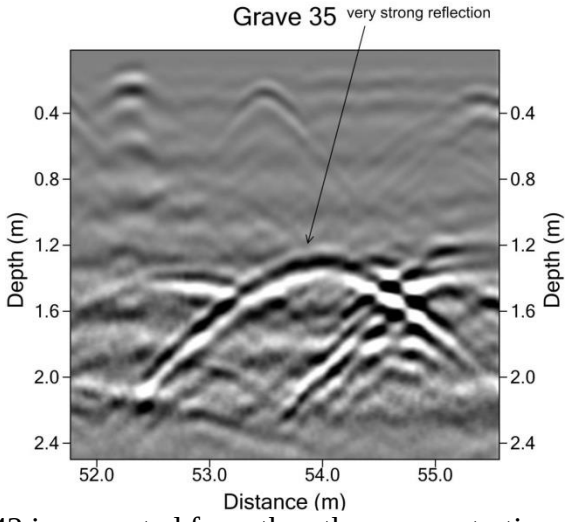


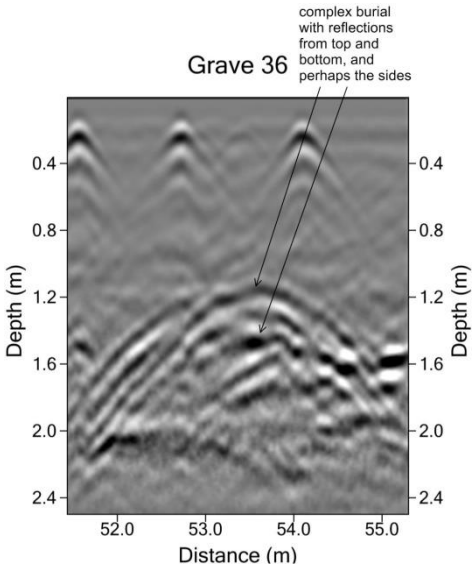
Cluster 3: Graves 34, 35, 36, 37, 42, 43, 44, 45, 46, 49, 52 and 62

This cluster of graves is north of Clusters 1 and 2 and contains a mixture of older traditional graves and typical European-style burials. The concentration of some of them in tight arrangements where the burial type is the same is suggestive of either burials at the same time, or perhaps "family" or "group" plots that were at one time marked so that people knew who was buried where. The grouping of Graves 34, 35, 36 and 37 are all European-style graves as are 43, 44, 45 and 46. There are two more traditional burials that are separated from those concentrations (Graves 42, 49 and 52), which may be earlier burials or individuals who were not related in some way to those that were concentrated here. One very notable grave is 62, which I have included in this cluster only because it is nearby. Grave 62 is one of the most distinct and well-preserved burial in the Mapoon Mission Cemetery, and is located by itself with no surrounding burials. All these graves are located on a topographically distinct sand dune.

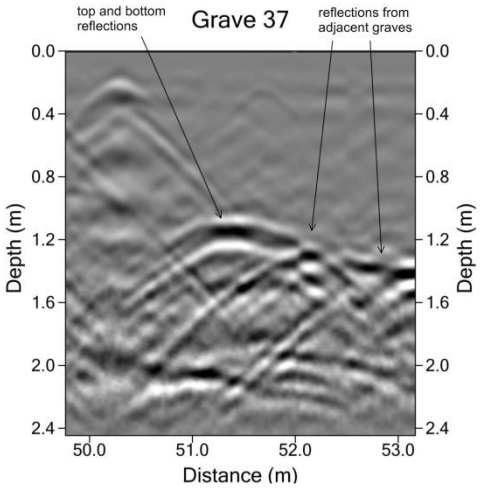
The tightly grouped graves (34, 35, 36, 37) all have the same general characteristics. They are European-style caskets with high amplitude radar reflections and in some cases reflections from the top and bottom of caskets.

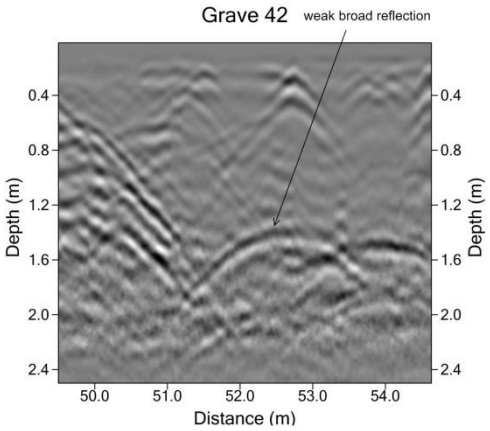




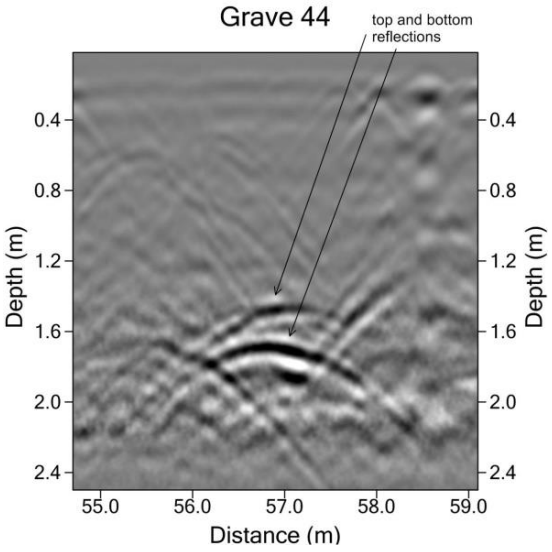


Grave 42 is separated from the other concentrations and has generated a very weak but broad reflection, which is showing this is a large adult, but one who was buried in a traditional way.

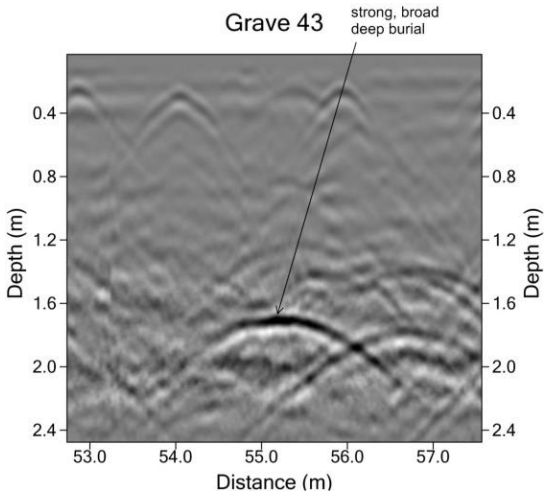


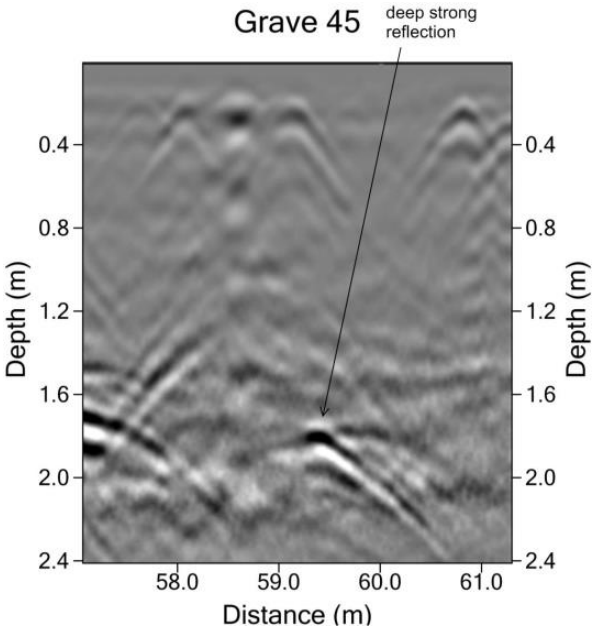


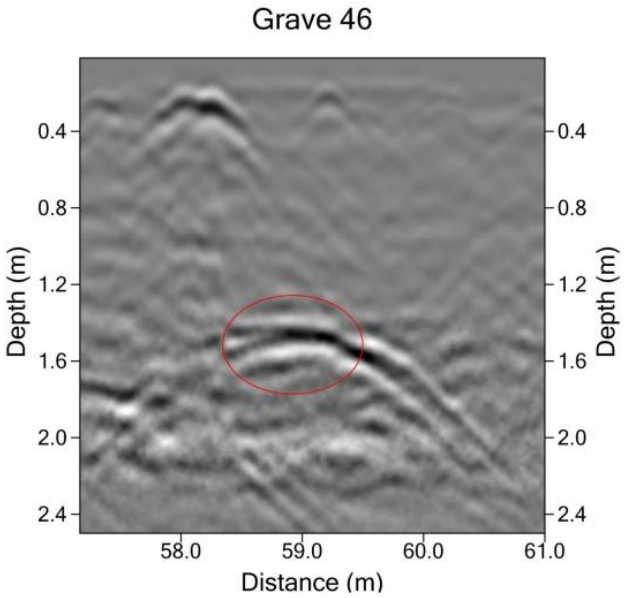
The other concentration of burials in this cluster (43, 44, 45, 46) have generated strong reflections of various sizes, all consistent with

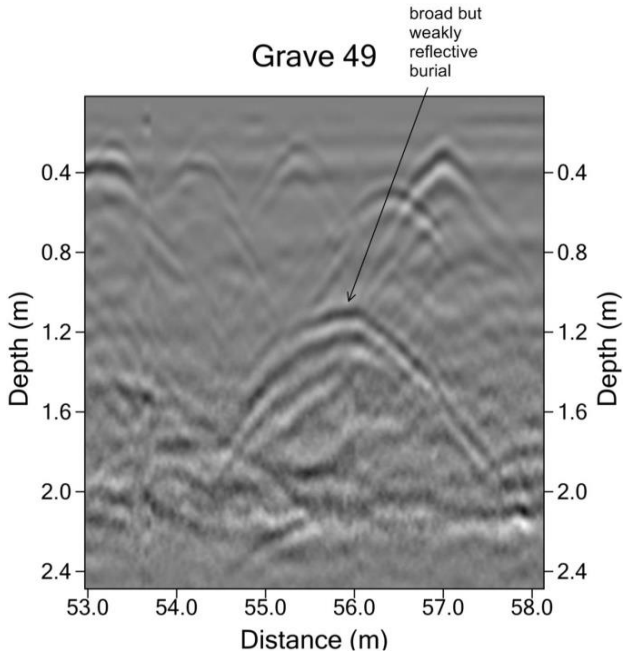


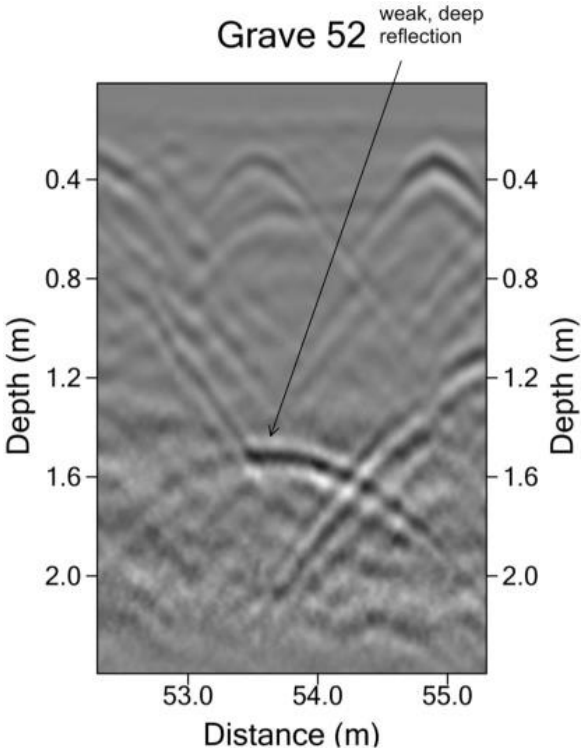
European-style graves. Grave 44 still retains a top and bottom of the casket and generated two reflections. Numbers 43 and 46 are large, but somewhat deteriorated caskets, while Grave 45 is small (a child perhaps?), but in an intact casket that produces a strong reflection.

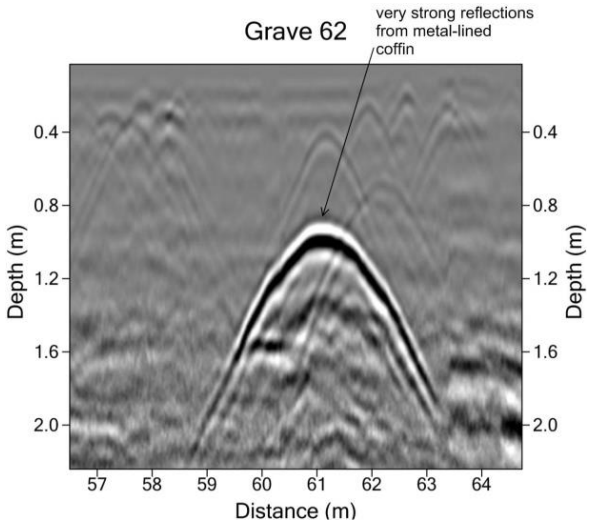










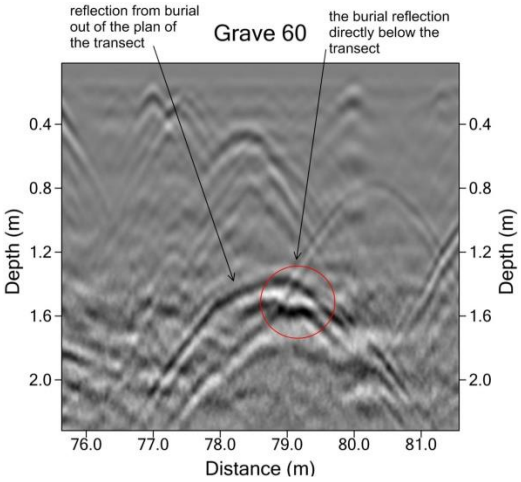


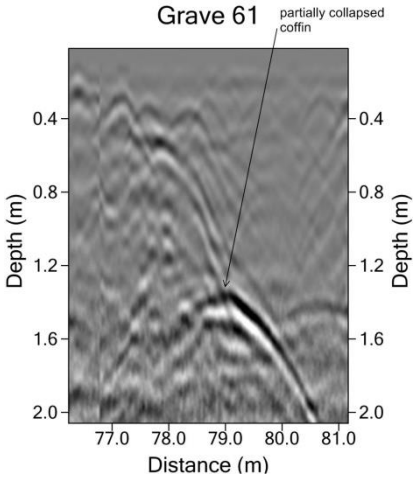
Grave 49 sits by itself and has generated a broad, but very weak reflection. It may be a traditional burial, or a European one, which has just deteriorated. The same is true for Grave 52, which is also broad but weak, and possibly older than the others in this general area.

The most extraordinary burial in this cluster is Grave 62 which has generated a perfect hyperbolic-shaped reflection. This burial is separated from the others in this cluster, but still located on the topographically high sand dunes. It has generated such a strong reflection because it is a coffin that is lined, or at least has a cover, which is metal. In the early part of the 20th century it was common to burial notable or wealthy people in lead-lined coffins. This may be what makes this burial so strong. The fact that it sits by itself with no surrounding graves brings to mind a number of questions as to who might be buried here. Whoever occupies this burial location was wealthy or important enough (or had relatives or others who were wealthy and important to organize this burial) to have this kind of a coffin. It was likely marked in some fashion, but there is no surface indication of this today. Why are there no other burials nearby? Did this person not have relatives or associates who were considered as joint-occupants of this burial location? Was there a reason why this lone-burial area was thought to be special or exclusive in some reason? These are all interesting questions, with no answers unless they reside in historical documents that have not been preserved or yet come to light.

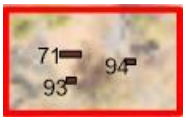
Cluster 4: Graves 60 and 61

These two graves are the northernmost burials in the cemetery and located next to one another. Both are European-style and located at about the same depth. Why are they located so far away from all the others in this cemetery? This area is still on the high sand dunes, as are most of the other European-type burial locations. The two buried here were likely related in some way, but it is interesting to speculate why they are separated from the other clusters.

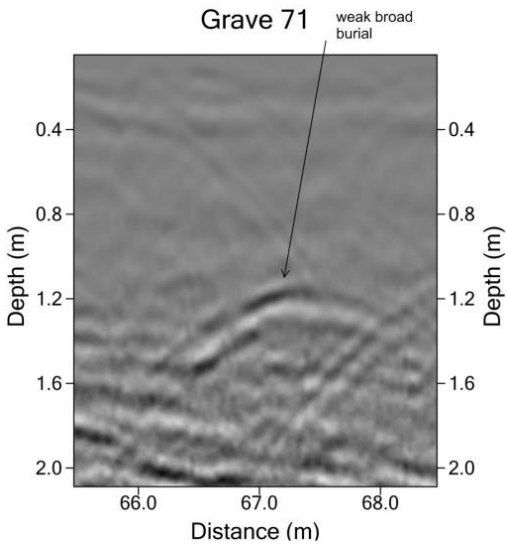


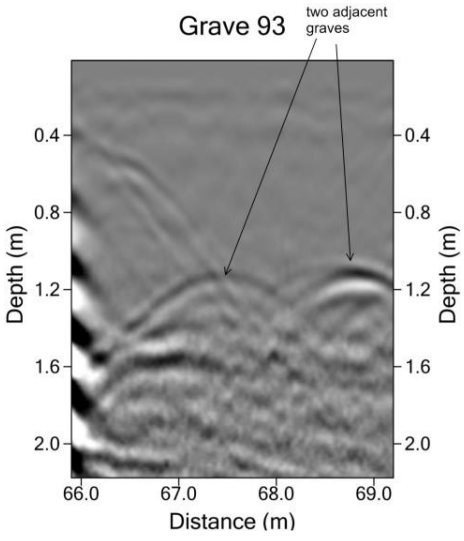


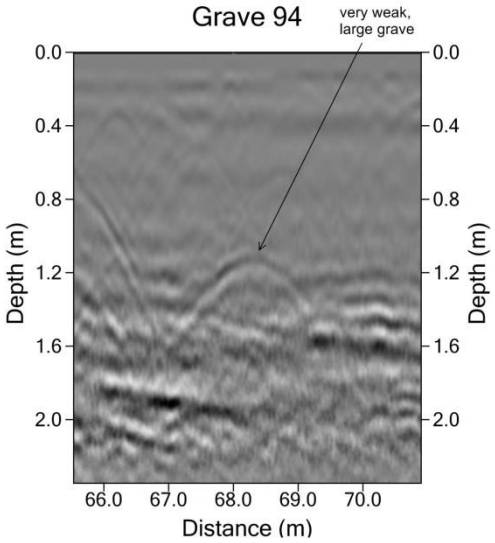
Cluster 5: Graves 71, 93 and 94



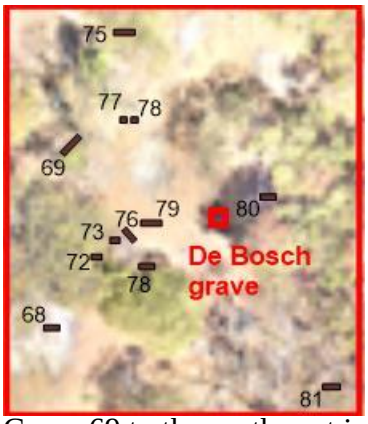
These three graves are also separated from the majority of the others in the Mapoon Mission Cemetery, and located on a small sand dune in the northern portion of the area. All three have produced very weak reflections, which suggests traditional Aboriginal-style burials. They are large, which suggests adults. Grave 93 is interesting as it may contain two burials. I have included them as one, as I cannot find one of them in the adjacent reflection profile. So this might be one or perhaps two graves.





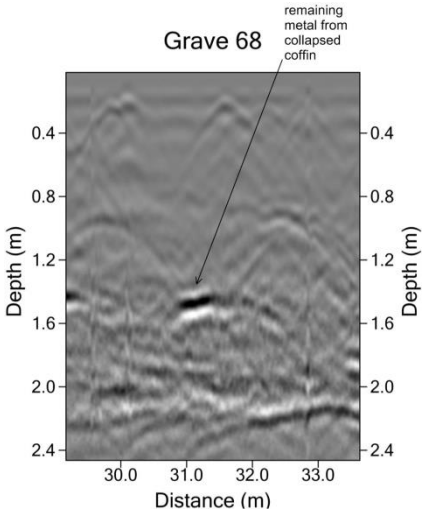


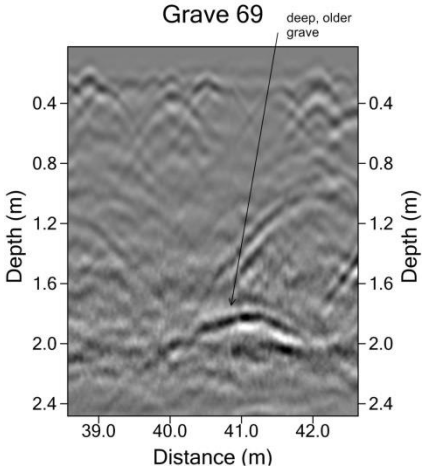
Cluster 6: Graves 68, 69, 72, 73, 75, 76, 77, 78, 79, 80 and 81

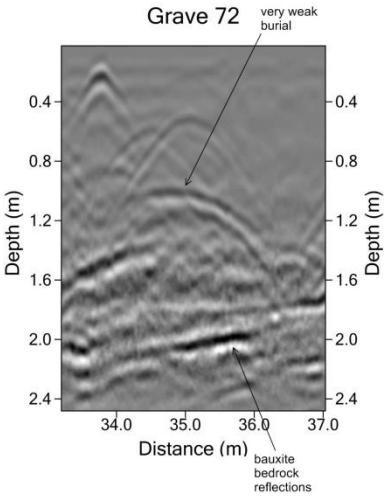


This cluster of graves is located near the De Bosch grave, the only grave with an extant surface marker in the Mapoon Mission Cemetery (Figure 4). Grave 68 was at one time a complete coffin, which has collapsed. Some small amount of metal that remains in the top has reflected energy, but the remainder of the coffin has disintegrated. Number 68 sits by itself in an open area.

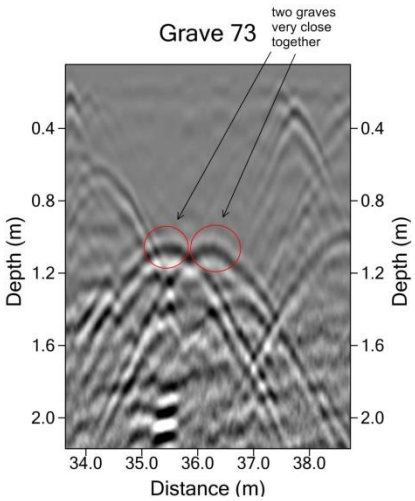
Grave 69 to the northwest in this area is broad and deep, but also highly weathered with little remaining to reflect radar waves.



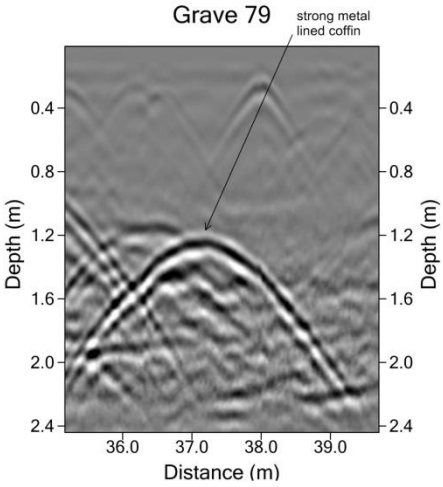




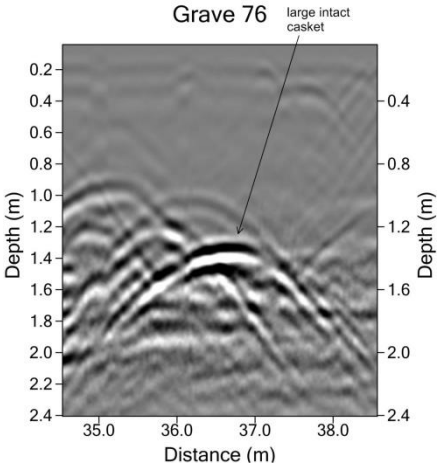
Graves 72, 73, 76, 78, 79 and 80 are located very close to the De Bosch grave. All are European in style. Some produce only very weak reflections, such as Grave 72.



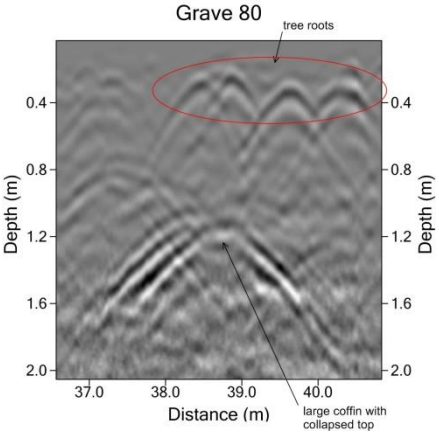
Grave 73 is complicated, and while I have given it only one number, it might be two burials very close to one another, at the same depth and likely buried at the same time in the same shaft.

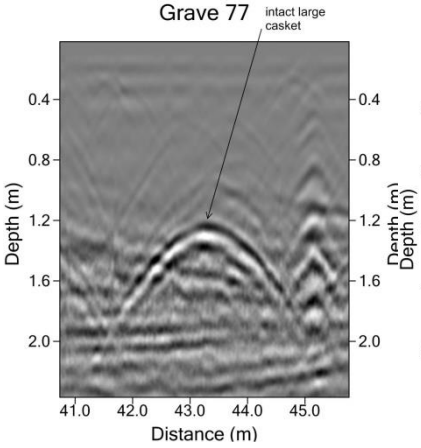


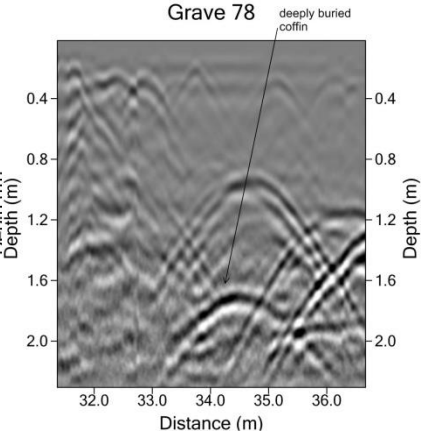
Grave 76 produced a very strong reflection from a largely intact casket, which must be composed of very substantial material. Number 76, is perhaps made of material that has weathered more and is therefore less reflective. Grave 79 is also a very substantial burial and has produced a perfect reflection hyperbola, which would happen if the casket is mostly intact and composed of reflective materials.



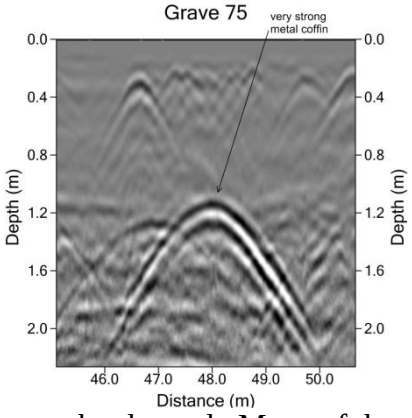
Grave 80 was at one time a substantial European-style grave, but the top of it has collapsed, and only its sides and edges reflect radar waves. This burial is located just to the east of the De Bosch grave.



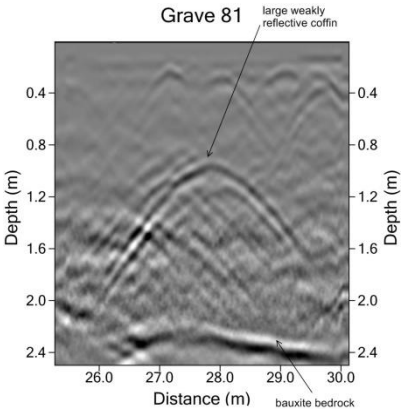




To the north of the concentration of graves near the De Bosch surface monument are the two burials directly next to each other, Graves 77 and 78. Both are European-style burials with very strong reflections.



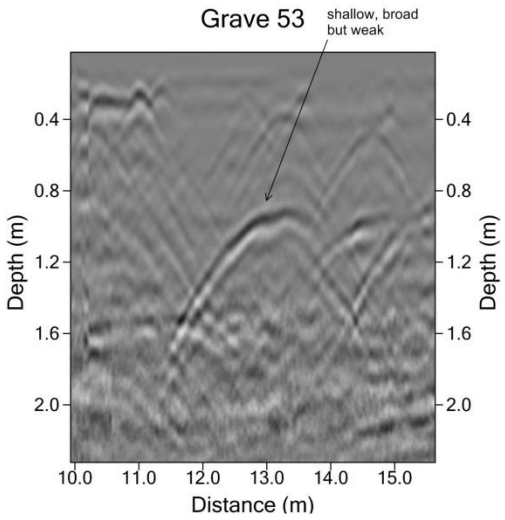
To the far north in this cluster, all alone, is a very strongly reflective European grave, number 75, which reminds me of the lone grave in the farthest north of the cemetery (Grave 62). This lone grave holds a substantial casket composed partially of metal or very hard wood. Many of the same questions about who was buried here, and why this person received such a substantial casket, but is located far away from all other burials is applicable to

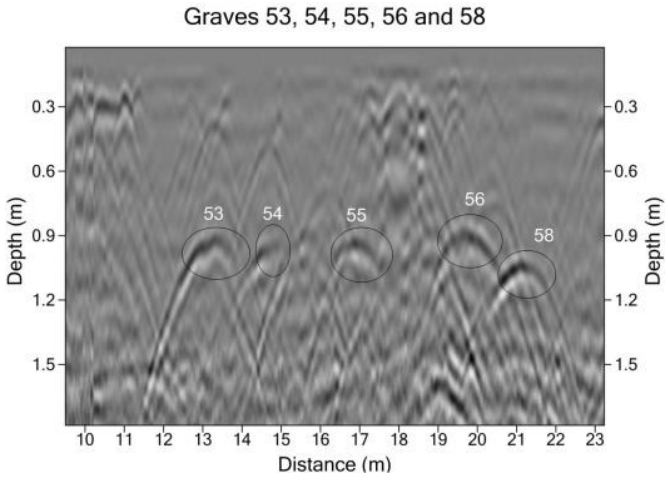


this interment also. Grave 81, far to the southeast of the rest of the burials in this cluster is also European-like, but the casket is composed of much less substantial material and produced a very weak reflection. This grave is located in a low area, where the bauxite bedrock is much closer to the surface than on the sand dunes, where most of the burials are located.

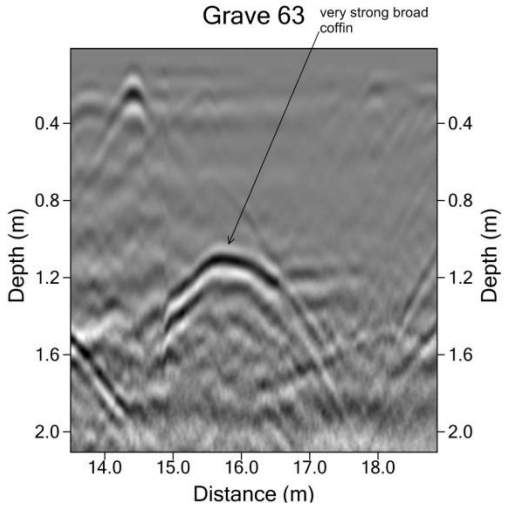
Cluster 7: Graves 53, 54, 55, 56, 58, 63, 67, 70 and 74

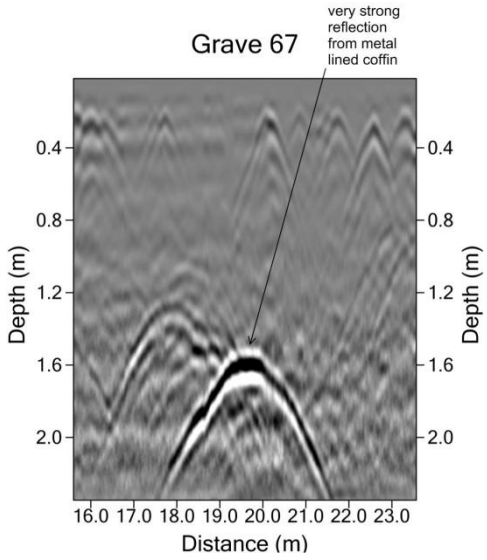
This cluster of graves, south of the De Bosch grave cluster contains all European-style burials, except for Grave 74, to the east of this area, which is a very old, deep, traditional burial. One organized area on the western side of the cluster has 5 graves in a north-south row, which are oriented for the most part east-west (except for Grave 56, which is at an angle). These graves all contain well-developed hyperbolic reflections, but most are very weak, indicating coffins that have mostly deteriorated. Graves 63 and 67 are "lone graves" that are not associated with the others, at least as closely placed in some of the



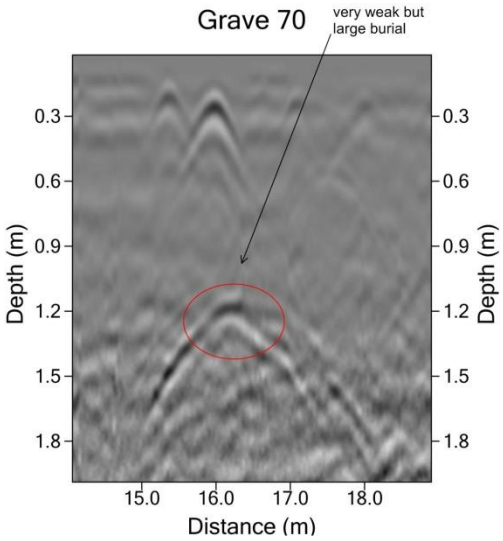


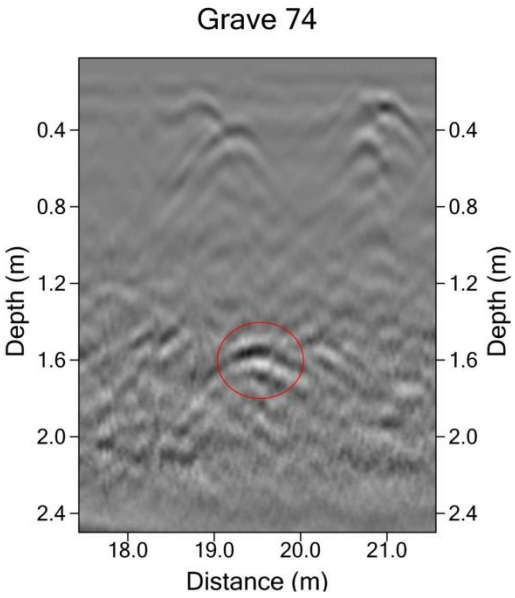
other areas of the cemeteries. In analyzing these burials in order, it now becomes apparent that the best preserved European-style graves that contain coffins with perhaps metal lining, or made of wood that has held up from the elements, are not in organized areas of the cemetery where the graves are all in rows. This is interesting, as the burial locations that people whose relatives or associates could afford a "very special" type of burial are all separated and by themselves. I am not sure how to interpret this. But in this cluster Graves 63 and 67 are very much like Grave 62, all singular burials. Burial 70 is near these two distinct singular burials, but it is low amplitude, and the coffin here was presumably constructed of materials that have mostly decomposed. This burial is also European-like.





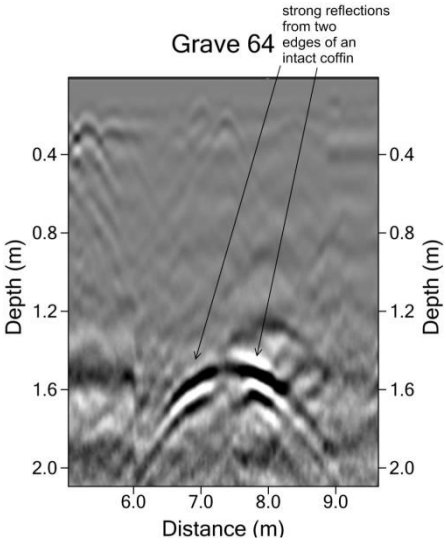
To the east of this grouping of European-like burials is one lone traditional burial, Grave 74, which is buried deeper than the others. It is oriented at an angle to the cardinal directions, which is much like other Aboriginal-style burials. It has produced a very weak reflection, and has likely mostly decomposed.

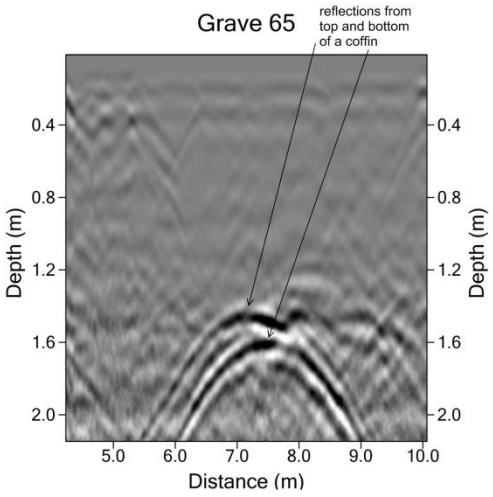


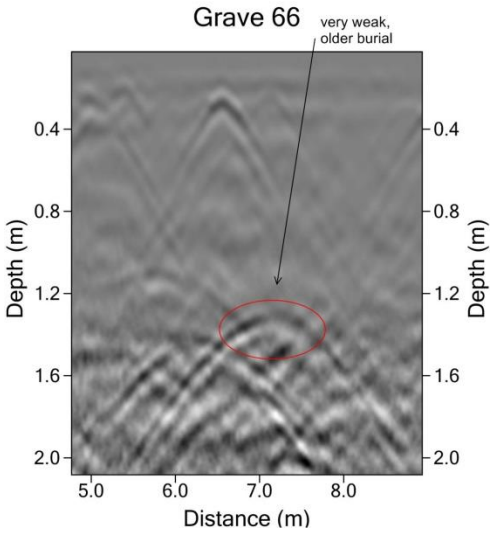


Cluster 8: Grids 64, 65 and 66

This small cluster of burials contains all European-style burials that are all very close to each other. Grave 64 contains a coffin that reflects energy from its edges only, but not from the top, which shows that the top portion of the container has collapsed. Grave 65 is more intact and still produces reflections from both the top and bottom. Grave 66 generates only a very weak reflection, and might be older than the other two in this cluster.

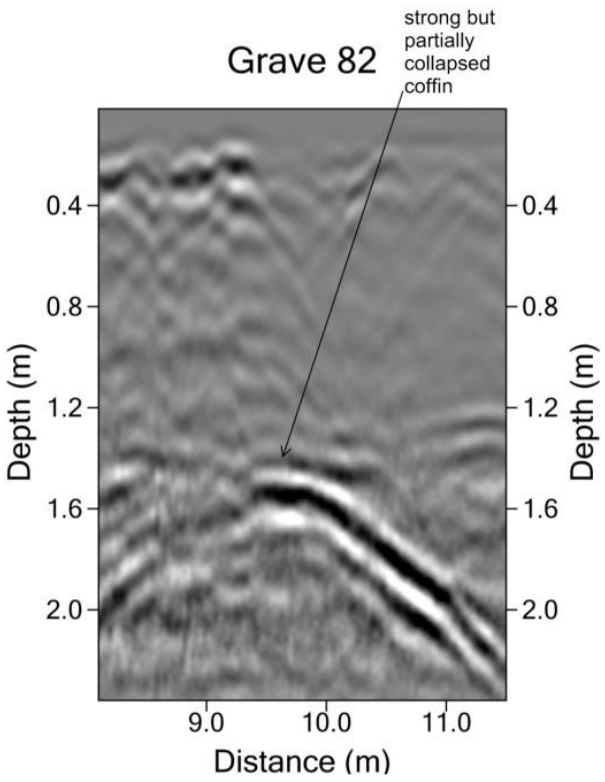


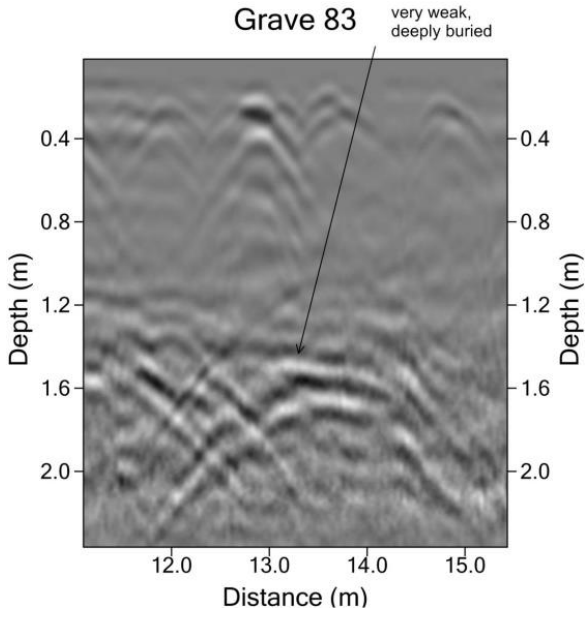


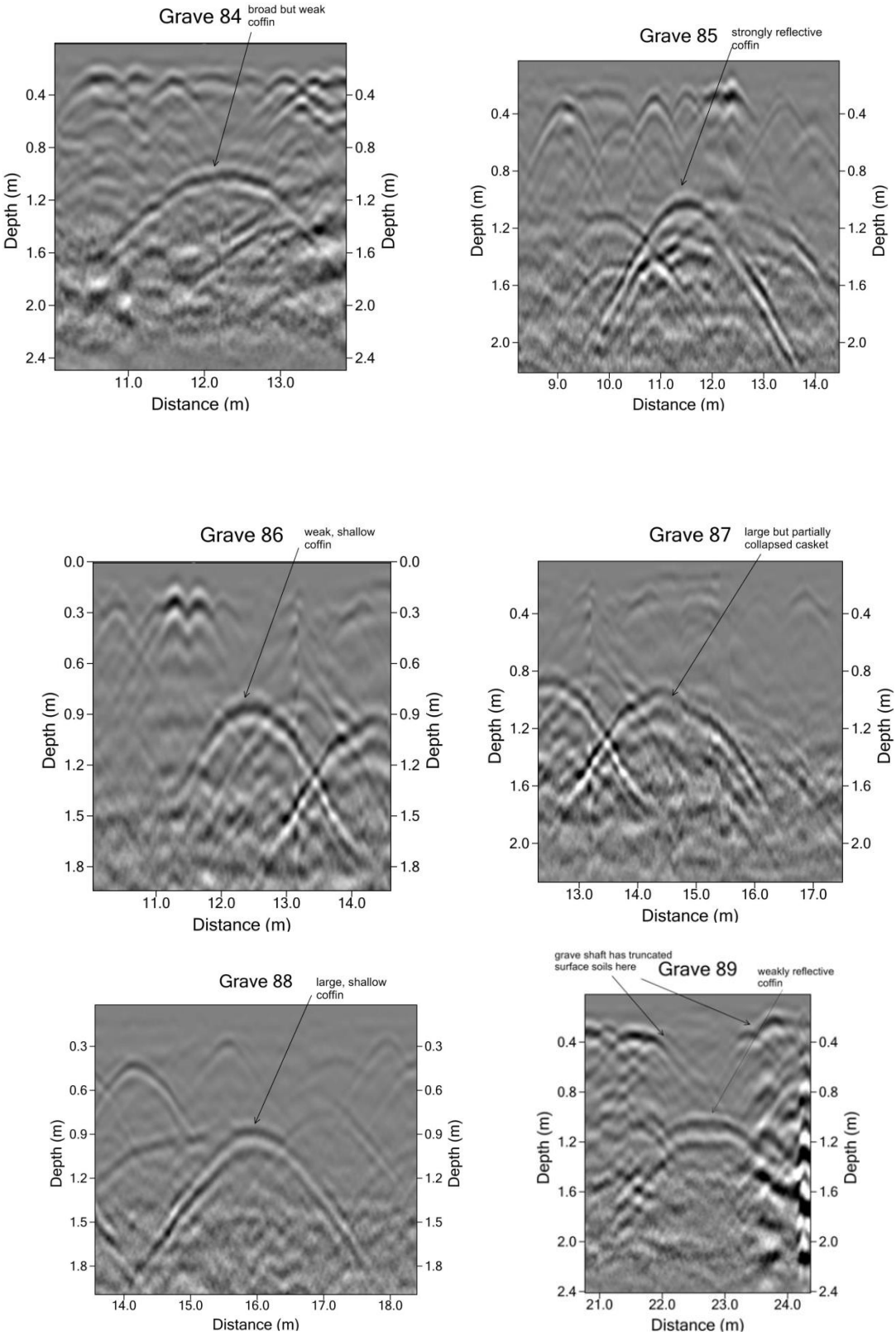


Cluster 9: Graves 82, 83, 84, 85, 86, 87, 88, 89, 90 and 91

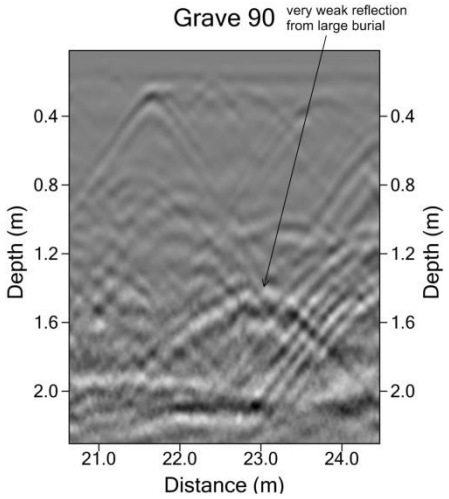
This cluster of graves contains all European-style burials with two distinct concentrations of graves. These graves all contain adults of various ages or coffin types, as some are more reflective than others. They are all variations on the same basic hyperbolic reflections from coffins.

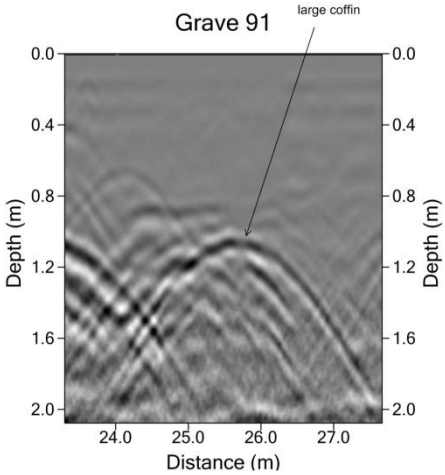






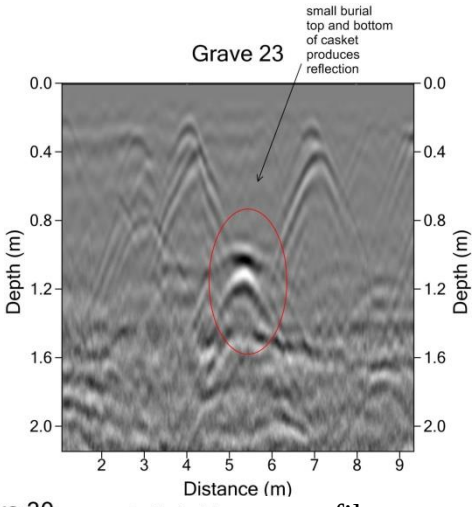
Grave 89 is one of the more interesting with regards to its GPR signature, as the ground in this area is well stratified, and the grave shaft is visible as a distinct truncation surface. The coffin is very deteriorated in this shaft. Most of the other burial areas in the Mapoon Mission Cemetery were placed in loose sand, which does not contain layers that are reflective. Therefore bedding truncation surfaces such as in Grave 89 are not common.

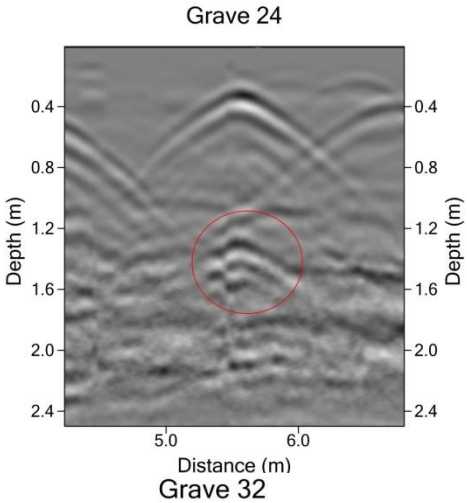




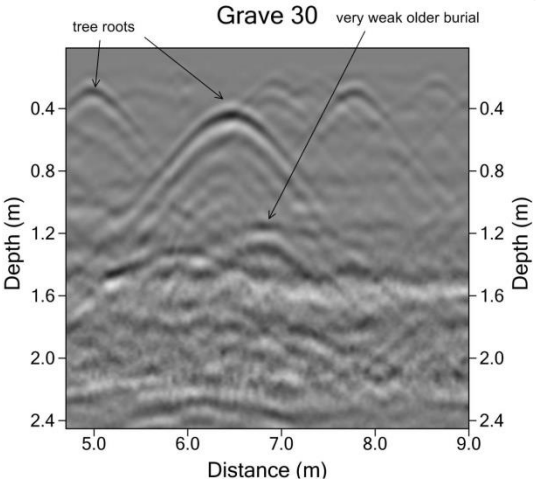
Cluster 10: Graves 23, 24, 30, 32, 33, 38, 39, 40 and 92

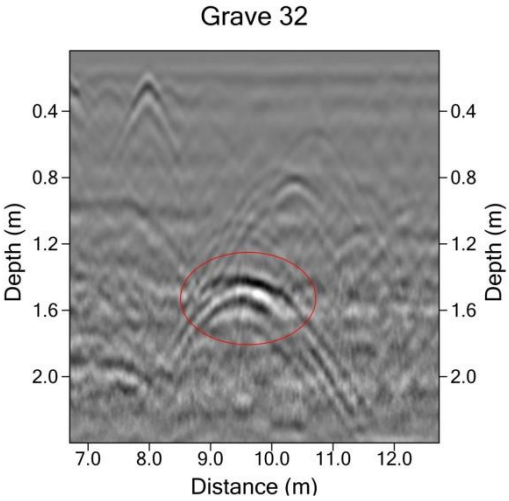
These graves are just to the east of Cluster 1 in an open low area that slopes to the east. This area contains a mixture of grave types with some old traditional burials, a few European types, and two locations where there appear to be children burials.





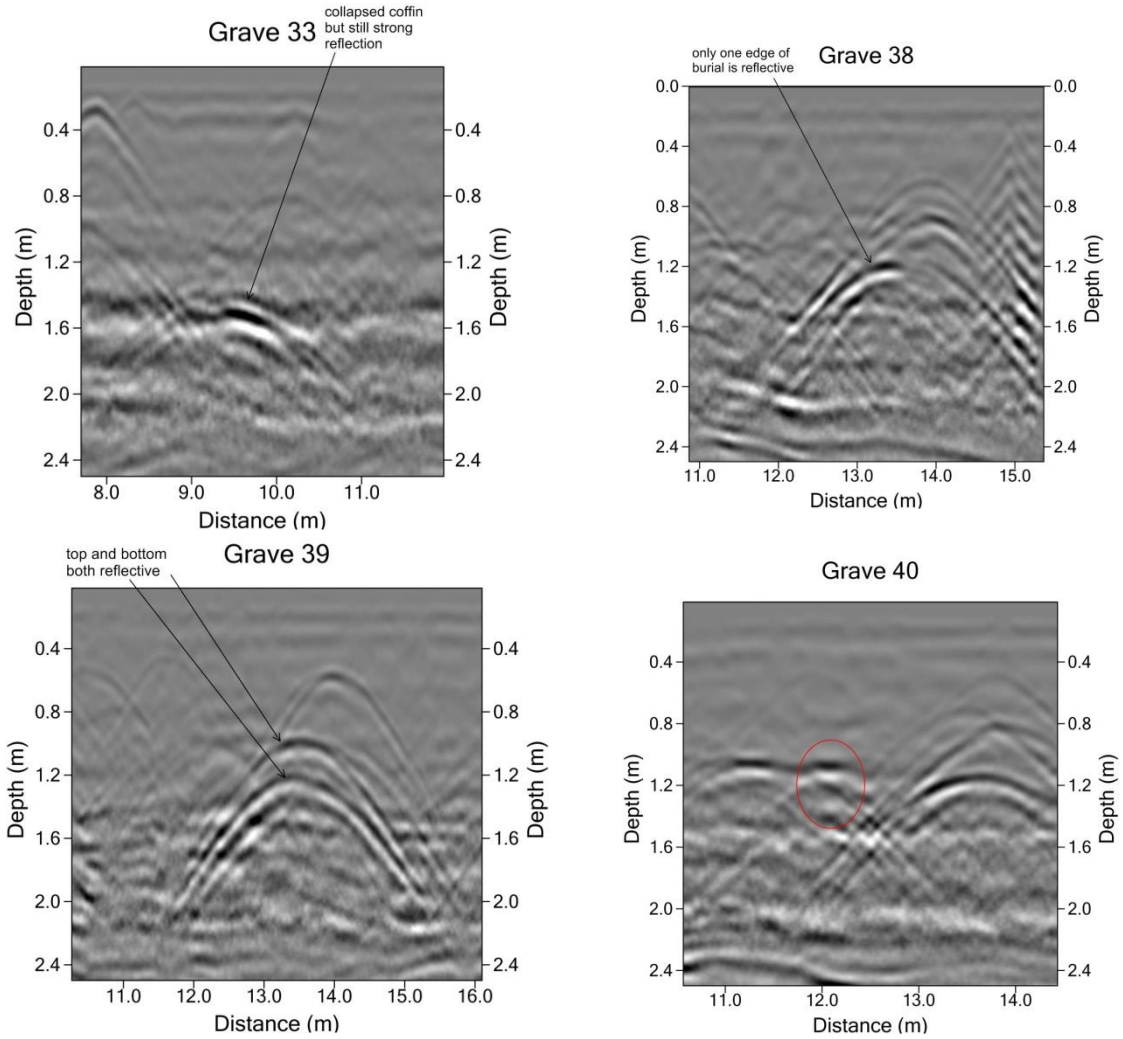
Grave 23 is a small burial in a distinct shaft, where both the top and bottom of the casket is visible in the reflection profile. Grave 24 directly adjacent to it is also very small, and could also be a child. Could this small area be the place where two



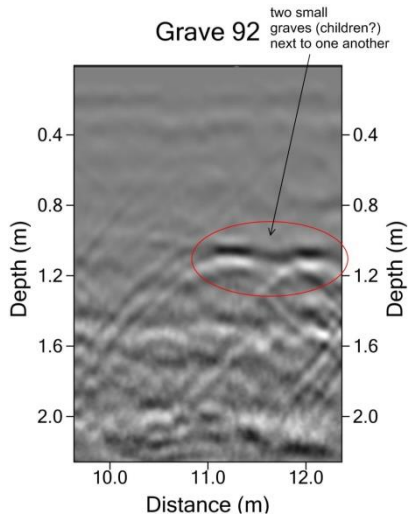


children who died at one time were interred, or a designated children's plot in the cemetery?

Grave 30 just northeast of the possible child burials is a deep, very old burial that is likely Aboriginal. The tree roots are also visible in the shallow part of the reflection profile in this grave. The concentration of the remainder of the graves in in this cluster are very different, and all appear to be European-like. Grave 32 is a typical European-style coffin, and 33 looks much the same, but has partially collapsed on one edge. The coffin in Grave 38 has also partially collapsed, and only one edge of it is capable of reflecting radar energy.



Grave 39 also appears to be European-like with a coffin that shows reflections from both the top and base. However, right in the middle of this concentration of burials are two others that both appear to hold two children buried at the same time (Graves 40 and 92). Both have strong reflections off of what appears to be collapsed coffins, which still generate hyperbolas. This is further evidence that this portion of the Mapoon Mission Cemetery holds children's graves, a very sad and untold story in the history of the mission.



Conclusions

There are a number of very interesting variations within the Mapoon Mission Cemetery. The most formal burial area is in Cluster 1 on the western edge of the study on the high dunes. In this area there are what appear to be formal rows of burials, none of which were marked on the surface. They are uniformly oriented east-west, which is typical of Christian graves. This area has a mixture of European-style burials, but also a few deeper old Aboriginal-style graves. Perhaps this cluster of burials contains the oldest area of the mission cemetery where people knew and understood where the "ancient" burials were, and placed the newly deceased in this area also, but using European-burial methods. That there are no surface markings at all in this cluster shows that it is very old and therefore wooden or coral markers have long ago disintegrated or disappeared.

Throughout the cemetery there are many European-style burials that were interred in substantial wooden coffins, as the historical records show. Many of those still retain tops and bottoms, and radar reflections can be seen from both interfaces. Often tops have collapsed or edges of coffins have deteriorated, and only produce reflections from a portion of the existing burial containers.

There are two clusters that appear to contain primarily Aboriginal-style graves, Clusters 2 and 7. The graves in these two clusters are not oriented east-west, as Christian graves are. The clusters here suggest family or kin groups knew of the grave locations of their elders by markings, and newly deceased were placed in these same areas. The coral stones still visible on the ground surface are generally located in these areas, but there is little correlation between today's coral and wooden grave markers and the burials below the surface. Horses and people, as well as other natural elements have moved these markers some distance, but they generally are locating the areas of these traditional graves.

I was very interested in the very reflective graves that appear to contain metal linings to the coffins and which are in all cases very substantial. Three of these graves 62, 67 and 75 sit by themselves and are not surrounded by other burials. The fourth substantial grave, number 79 is very near the De Bosch grave and perhaps related to that person, or buried in this area about the same time. Other substantial coffins are found in the organized rows in Cluster 1.

There are two concentrations of child graves, numbers 28 and 29 in Cluster 2 and 23, 24, 40 and 92 in Cluster 10. These areas hold the remains of children and hint at some very sad stories in the history of this region.

Most of the graves in the cemetery area are European-style graves. Only about 20% appear to be traditional interments, some of which may pre-date the mission's founding in this area. It is also likely that people were still buried in a traditional Aboriginal way in this cemetery, after the mission's influence.

The area east of the sand dunes contained no graves. All radar reflections studied in this lower topographic area were produced by buried and surface metal associated with the historic dwellings that were located in this area until just recently. All the human graves appear to be located on the higher sandy areas, with only a few in the somewhat lower sandy areas.

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Appendix 1: All graves found with their number, the GPR grid and file number, where they sit in space within the Grid (x and y coordinates) and where they sit in space within the site grid (x and y), with depth in time (nanoseconds of two-way radar travel time).

Grave #	Grid	File	Grid X (m)	Grid Y (m)	Site X (m)	Site Y (m)	Depth in Time (ns)
1	1	1	0	8	0	9	19
1	1	3	1	8	1	9	20.5
1	1	2	0.5	9	0.5	10	25
2	1	6	2.5	9	2.5	10	19.5
3	1	5	2	17	2	16	18
3	1	6	2.5	17	2.5	16.5	16.5
3	1	2	0.5	15	0.5	15	22
3	1	3	1	15	1	16	21
3	1	4	1.5	15	1.5	16	20
4	1	1	0	17	0	19	20
4	1	3	1	17	1	19	18.5
4	1	4	1.5	17	1.5	19	19
4	1	5	2	19	2	19	17
4	1	2	0.5	19	0.5	19	20
5	1	4	1.5	19	1.5	21	17
5	1	2	0.5	21	0.5	21	20.5
5	1	5	2	21	2	21	17
6	6	3	1	21	1	23.5	15
6	1	2	0.5	23	0.5	23	18
6	1	5	2	23	2	23	16
6	1	4	1.5	24	1.5	23	15
7	1	6	2.5	25	2.5	27	17.5
7	1	7	3	25	3	27	18.5
7	1	7	3	26	3	27.5	19
8	1	8	3.5	26	3.5	22	17
8	1	9	4	22	4	22	16.5

Grave #	Grid	File	Grid X (m)	Grid Y (m)	Site X (m)	Site Y (m)	Depth in Time (ns)
9	1	7	3	28.5	3	29	19.5
9	1	8	3.5	30	3.5	29	16.5
10	1	5	2	28	2	31	17
11	1	7	3	31	3	31	18.5
12	1	6	2.5	10	2.5	11.5	19
12	1	7	3	10	3	11.5	17.5
13	1	7	3	9.5	3	11	18
13	1	8	3.5	9.5	3.5	11	16
13	1	9	4	9.5	4	11	15
14	1	10	4.5	10	4.5	10	14.5
14	1	11	5	10	5	10	13.5
14	1	12	5.5	10	5.5	10	13.5
15	1	7	3	14.5	3	16	15
15	1	8	3.5	16.5	3.5	16	14.5
16	1	7	3	15	3	19	16
16	1	8	3.5	19	3.5	19	16.5
17	1	8	3.5	14.5	3.5	15	23.5
17	1	10	4.5	15.5	4.5	15	16
18	1	10	4.5	9	4.5	9	14
18	1	11	5	9	5	9	13
19	1	11	5	6	5	6	14
19	1	12	5.5	6	5.5	6	15
20	1	22	10.5	5.5	10.5	5.5	14.5
20	1	24	11.5	6	11.5	6	14
21	1	13	6	32	6	31.5	12.5
22	1	17	8	31.5	8	32	12.5
23	1	39	19	5.5	19	5	13
24	1	40	19.5	5.5	19.5	5.5	16
25	1	40	19.5	30.5	19.5	30.5	15.5
26	1	39	19	31	19	31	16
27	1	41	20	30	20	30.5	18
28	1	40	19.5	32	19.5	32	16
29	1	41	20	31.5	20	31.5	17
30	1	42	20.5	7	20.5	7	15.5
30	1	43	21	6	21	6	17
30	1	44	21.5	5.5	21.5	5.5	17.5
31	1	41	20	28	20	28	16.5
31	1	42	20.5	27.5	20.5	27.5	16
31	1	43	21	28	21	28	16.5
31	1	44	21.5	28	21.5	28	16.5
32	1	44	21.5	10	21.5	10	17.5
32	1	45	22	10	22	10	8.5
33	1	46	22.5	9.5	22.5	9.5	19

Grave #	Grid	File	Grid X (m)	Grid Y (m)	Site X (m)	Site Y (m)	Depth in Time (ns)
34	1	45	22	54.5	22	54.5	15
35	1	46	22.5	54	22.5	54	17
36	1	47	23	54	23	54	15.5
36	1	48	23.5	54	23.5	54	15.5
36	1	49	24	53.5	24	54	15
37	1	43	21	51.5	21	51.5	14.5
37	1	44	21.5	52.5	21.5	52.5	15
38	1	51	25	13.5	25	14	16
38	1	47	23	14	23	14	13.5
38	1	49	24	13.5	24	13.5	15
38	1	50	24.5	13.5	24.5	14	15.5
39	1	52	25.5	13.5	25.5	13.5	12.5
39	1	53	26	13.5	26	13.5	13
40	1	49	24	12	24	12	14
40	1	50	24.5	12	24.5	12	14.5
41	1	51	25	29.5	25	29.5	15
41	1	52	25.5	30	25.5	29.5	14.5
42	1	52	25.5	52.5	25.5	52.5	18
42	1	54	26.5	52	26.5	52	20.5
42	1	55	27	52	27	52	20
43	1	54	26.5	55	26.5	56.5	23.5
44	1	55	27	56.5	27	56.5	21.5
44	1	56	27.5	57	27.5	57	22.5
45	1	55	27	59.5	27	59	23.5
46	1	56	27.5	59	27.5	59	18
47	1	57	28	31	28	30	16
47	1	58	28.5	30.5	28.5	30	16.5
48	1	56	27.5	28	27.5	28	15.5
48	1	60	29.5	28	29.5	28	18.5
49	1	64	31.5	55.5	31.5	55.5	15.5
49	1	65	32	56	32	55.5	15
50	1	62	30.5	27	30.5	27	14
50	1	65	32	27.5	32	27.5	15.5
51	1	62	30.5	38	30.5	38	16.5
51	1	65	32	38	32	38	15
52	1	66	32.5	53.5	32.5	53	20
52	1	67	33	54.5	33	54	19.5
53	1	69	34	13	34	13	12.5
53	1	70	34.5	13	34.5	13	12.5
54	1	69	34	14.5	34	14.5	12.5
54	1	70	34.5	14.5	34.5	14.5	13
55	1	69	34	21	34	21	13.5
55	1	70	34.5	21	34.5	21	14

Grave #	Grid	File	Grid X (m)	Grid Y (m)	Site X (m)	Site Y (m)	Depth in Time (ns)
56	1	69	34	17	34	17	12.5
57	1	68	33.5	30	33.5	29.5	16.5
57	1	69	34	30.5	34	30	17
58	1	64	31.5	20	31.5	20	11
58	1	65	32	20	32	20	11.5
58	1	66	32.5	20	32.5	20	12
58	1	68	33.5	20	33.5	20	12.5
58	1	67	33	20	33	20	12
58	1	69	34	20	34	20	11.5
59	1	69	34	37	34	37	16
59	1	70	34.5	37	34.5	37	15.5
60	1	72	35.5	79	35.5	78.5	14.5
60	1	73	36	79	36	78	17.5
60	1	74	36.5	78	36.5	78	17
61	1	75	37	78.5	37	78	18
62	1	76	37.5	61.5	37.5	61	12
62	1	77	38	61.5	38	61	12
62	1	78	38.5	61.5	38.5	61.5	12
63	1	79	39	16	39	16	15
63	1	80	39.5	16	39.5	16	13.5
64	1	83	41	7.5	41	7.3	19.5
64	1	84	41.5	7.5	41.5	7.5	18.5
65	1	85	42	7	42	7	19.5
65	1	86	42.5	7	42.5	7	21
66	1	88	43.5	7	43.5	7	17.5
67	1	83	41	19.5	41	19.5	20.5
67	1	84	41.5	20	41.5	19.5	20
67	1	85	42	20	42	19.5	20
68	1	84	41.5	31.5	41.5	31	19
68	1	85	42	31	42	31	18.5
69	1	85	42	41	42	41	23.5
69	1	88	43.5	42	43.5	42	16
70	1	87	43	16	43	16	15.5
70	1	88	43.5	16	43.5	16	16.5
71	1	91	45	69	45	68.5	16
71	1	92	45.5	69	45.5	68.5	15
71	1	93	46	67.5	46	68.5	14.5
72	1	90	44.5	35	44.5	35	14
73	1	92	45.5	36	45.5	36	14
74	1	101	50	20	50	20	18
74	1	102	50.5	19.5	50.5	19.5	20.5
75	1	92	45.5	48	45.5	48	15
75	1	93	46	48	46	48	15

Grave #	Grid	File	Grid X (m)	Grid Y (m)	Site X (m)	Site Y (m)	Depth in Time (ns)
76	1	93	46	36.5	46	36.5	17
76	1	94	46.5	36	46.5	36	16
77	1	93	46	43	46	43	16.5
78	1	94	46.5	43	46.5	43	16.5
78	1	95	47	34.5	47	34.5	22
78	1	96	47.5	34.5	47.5	34.5	22
79	1	95	47	37	47	37	16
79	1	96	47.5	37	47.5	37	15
79	1	97	48	37	48	37	15
80	1	109	54	38.5	54	38.5	15.5
80	1	110	54.5	38.5	54.5	38.5	15.5
81	1	116	57.5	27.5	57.5	27.5	13
81	1	117	58	27.5	58	27.5	13
81	1	118	58.5	27.5	58.5	27.5	16
82	2	242	0	10	35	0	19
82	2	243	0.5	10	35	-0.5	18.5
83	2	244	1	13.5	38.5	-1	18.5
83	2	245	1.5	13	38	-1.5	21.5
84	2	250	4	12	37	-4	13.5
85	2	246	2	11.5	36.5	-2	16
85	2	247	2.5	11.5	36.5	-2.5	13.5
85	2	248	3	11.5	36.5	-3	13.5
86	2	251	4.5	12.5	37.5	-4.5	12
86	2	252	5	12.5	37.5	-5	11
87	2	251	4.5	14.5	39.5	-4.5	13
87	2	252	5	14.5	39.5	-5	12
88	2	252	5	16	41	-5	12
88	2	253	5.5	16	41	-5.5	12
88	2	255	6.5	16	41	-6.5	15
89	2	258	8	23	48	-8	13.5
89	2	259	8.5	23	47.5	-8.5	13
89	2	260	9	23	48	-9	14.5
90	2	261	9.5	23	48	-9.5	16
90	2	262	10	23	48	-10	18.5
91	2	258	8	25.5	50.5	-8	14
91	2	259	8.5	25.5	50.5	-8.5	14
92	1	50	24.5	11	24.5	11	14
93	1	92	45.5	67.5	45.5	67	15
94	1	99	49	68	49	68	15
95	1	6	2.5	27	2.5	30	17