MAPPING NENTHORN: TAKING ADVANTAGE OF EMERGING GPS AND GIS TECHNOLOGIES

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Introduction

The historic township of Nenthorn has sat in the hills of north-central Otago for just over 100 years, untouched since occupation in the late 1800s save for the occasional trample of sheep, intermittent trip from DOC personnel and archaeologists, and sporadic visits from tourists. This article focuses on using global positioning systems (GPS) and geographic information systems (GIS) to produce an accurate map of archaeological features visible at the surface during February of 2003 and how this data can assist in heritage management.

Site history

The site of Nenthorn, set in the rolling hills of east Otago (New Zealand Map Grid coordinates N 552233 E 2304690 500 m asl; approximately 20 km east of Middlemarch and the Rock and Pillar Range), was home to the last quartz goldmining rush in Otago (Hearn 1988). It experienced a rapid rise to prominence and equally rapid decline to desertion. William MacMillan discovered gold in quartz rock while rabbiting on the Stoneburn run in 1888. He applied for a prospecting claim to the Naseby Wardens court in November 1888. By March 1889 16 claims had been granted and the boom was on (*ibid*.: 7–9). There was much speculation in mining company shares. In some cases shares sold for hundreds of pounds, often in companies which had yet to put a spade in the ground. The township grew quickly on the back of this speculation and by mid 1889 had a population of approximately 350 (*ibid*.: 27). In reality gold production was patchy, with few mines producing enough gold to cover the costs of

Figure 1. Gordon Street, Nenthorn, 1889 (photo courtesy Otago Settler's Museum).

extraction, with the exception of the Surprise Company claim which produced 1½ – 2 ounces of gold per ton of ore for approximately 18 months.

As the town grew it attracted many businesses which opened shop along Gordon Street. At its peak Nenthorn boasted 4 hotels, 2 butchers, 2 bakers, 2 livery stables, 4 stores and 2 timber merchants. It even had its own newspaper, the Nenthorn Recorder (Hearn 1988: 27–29). The only surviving photograph of Nenthorn shows businesses lining both sides of Gordon street (Figure 1). On the basis of newspaper accounts and the surviving photograph it seems that most of the commercial buildings were constructed of corrugated iron and/or wooden weatherboards. Numerous small building sites show today as low raised earth outlines which suggests that most of the miners probably lived in small huts largely constructed of sod. Only two stone buildings appear to have been built, Philip Talty's St. Bathans Hotel, which was of rough and ready construction (Figure 2); and a dwelling of much better construction which may have never been completed. However, the lack of payable quantities of gold throughout the area led to general abandonment of the area by the late 1890s. As was the case with early ephemeral mining settlements once the gold returns began to fail businesses closed and the buildings were removed. Today all that is left of the town of Nenthorn are the ruins of the 2 stone buildings, a stone chimney, numerous

Figure 2. St. Bathans Hotel, February 2002.

building platforms and sod wall outlines and the wide formation of Gordon street.

The extent of previous research at Nenthorn is limited. A brief archaeological survey was conducted in 1984 (Jacomb and Easdale 1984). This five-day survey consisted of investigating features identified from an aerial photograph and selectively visited if they appeared threatened by pastoral development of the area. Over the past decade modern mining companies funded research to see if gold in payable quantities currently exists at the site—none were successful (S. Cox, Dunedin pers. comm. 2003).

Fieldwork

Preliminary site investigations involved an initial tour of the site by the authors on 3 February 2003. The main features of the former town as well as the major mining activity areas were identified on the ground. This tour allowed the senior author to develop a preliminary schedule of fieldwork. The fieldwork was scheduled to last five days and consisted of mapping visible features with a global positioning system (GPS) unit, specifically the Trimble GeoExplorer CE XT handheld (with sub-meter accuracy prior to differential correction). Features were located based on the initial site visit, the previous site survey conducted in 1984 by Jacomb and Easdale, and a foot survey by the senior author. Mapping was halted after five days in order to compare results using this new technology with the previous survey.

GPS surveys

Traditionally, the role of GPS & GIS in archaeology has been to map one or a few points to represent the location of a site within a regional context (Gamble 2001: 148). The ability of these technologies to document archaeological features at a finer scale (i.e., mapping features within sites) is recognized by many archaeologists, but has yet to come into prominent use (Renfrew & Bahn 2000: 88).

The increase in computational power of GPS receivers has permitted the collection of increasingly accurate data. The use of GPS for recording measurements at a fine scale (i.e., on the order of centimetres) has only recently become a reality. Therefore, few archaeologists have begun employing it for such. Branting (2002), among others, has used the advanced (and equally expensive) real-time kinematic (RTK) GPS units at the Kirkenes site in Turkey to demonstrate the accuracy of these more expensive (and cumbersome) units in his work to virtually re-construct an entire hilltop walled city. While the use of these units would be preferable for any development (simply because they can accurately record features to within centimetres), this project focused on using smaller units that are more often within the price range of individuals and small groups.

The first step to conducting a successful GPS survey requires the use of an almanac file. Almanac files are automatically collected by Trimble units every thirty days. This file records the positions of each satellite for the following month, allowing the user to pinpoint times of poor satellite service. Since each satellite makes two orbits around Earth in less than 24 hours the almanac must be updated every thirty days to account for this satellite drift. Remaining mindful of the different sources of GPS errors is vital to successfully completing a mapping project.

There are a number of different errors that can potentially alter accuracy and precision. There is a distinction between accuracy (how truthful to the real-world a coordinate is) and precision (level of measurement, such as metres or centimeters), and both aspects of GPS measurements are disturbed by errors. The number of satellites transmitting to a GPS receiver directly affects the accuracy of measurements recorded, the more the better. Another aspect of the GPS system that can cause errors is the angles of the satellites in relation to the horizon. The lower the angle, the more atmosphere the signal has to travel through, and the worse the error created. Telling the GPS unit to only use signals from satellites above a certain angle can compensate for this. These two types of errors are considered random. The other random error is called multi-path. This is perhaps the easiest type of error to understand. The radio waves that are transmitted by the satellites are sometimes bounced off stationary objects, and create a ghost signal, think of when your TV's reception is poor and you see double pictures, that is because one signal is a reflection and reaches your TV a fraction of a second later than the original signal. The most common source of multi-path error is reflections caused by buildings.

Fortunately, GPS units come with a built-in ability to predict the amount of error present from moment to moment. This capacity is referred to as Dilution of Precision (DOP), which measures the amount of error (uncertainty) at the moment GPS measurements are recorded. There are two main types of DOP values, the horizontal dilution of precision (HDOP) and the position dilution of precision (PDOP). HDOP gauges accuracy in two dimensions, horizontally, it relates to the x, y coordinate measurements. PDOP gauges accuracy in three dimension, is most often used, and relates to x, y, z coordinate measurements. In Figure 3, the large spikes at 13:00 and 17:00 hours demonstrate PDOP values that are too high to use for accurate recording. As a general rule, the lower the PDOP, the more accurate the measurement; a PDOP of 4 or less is ideal.

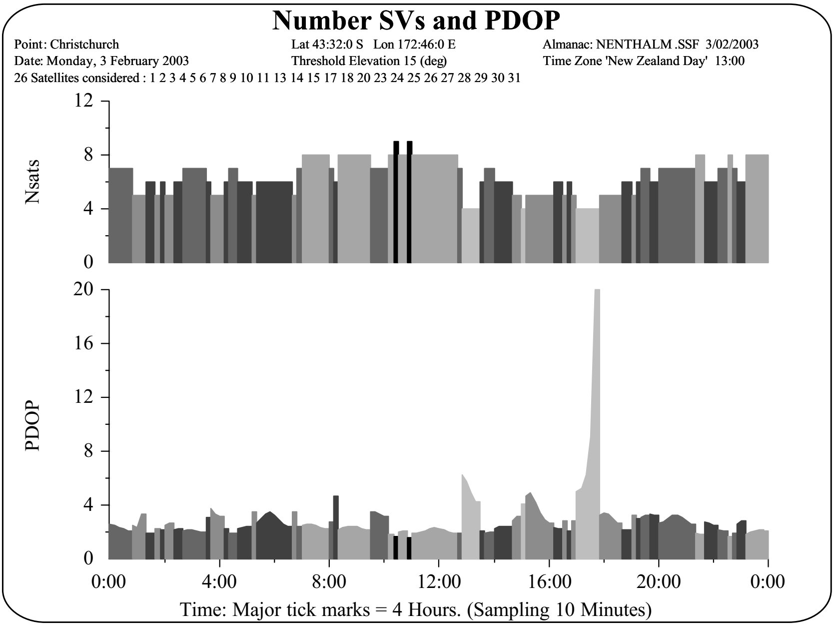

Figure 3. PDOP and Number of Satellites for February, 2003.

Mapping features using a GPS receiver involves placing the antennae over the point one wishes to have coordinates for. Measurements are then recorded and stored within the receiver. If the operator wants to record a point, the receiver is positioned and multiple measurements recorded (to be averaged together). To map lines and polygons (areas), the user mentally divides the feature into a series of nodes, and proceeds to record a single measurement at each node. The newer models of GPS units allow for real-time comparison of collected measurement with a map function. The experienced GPS user will make heavy use of this utility to guarantee that the data collected closely conforms to the features mapped. As with most new technologies it appears that the best way to develop expertise in using GPS is simply through practice.

Data integration and computer aided design

After correcting the raw GPS data to increase its accuracy, files were converted to a format that could be read by ArcMap. ArcMap, as the main work space for the ArcGIS suite of programs, allows the user to layer multiple datasets. The main idea can be illustrated by drawing different maps on clear sheets of plastic and then overlaying them on top of one another. These layers can take the form of vector (line) data such as archaeological features (e.g. building remains and tramways) and raster (continuous) data like aerial photographs. ArcGIS goes beyond this simple aspect of multi-layer mapping to include advanced spatial analysis (such as watershed analysis derived from topographical data) and recently into the world of 3D design.

In the GIS a large amount of secondary data was gathered, this included aerial photographs and contour data obtained from the Land Information New Zealand website. The geo-referenced aerial photographs, besides allowing the viewer to easily visualize the site, had the added benefit of verifying locations of features (e.g., roads, building, mineshafts, etc.), further demonstrating the accuracy of the GPS unit. Simon Cox, at the Institute of Geological and Nuclear Sciences, provided GIS data layers that included historic mining claims and current investigations by mining companies. The exercise of including these various forms of data showcases the value of GIS to historical researchers and the public. For example, the inclusion of boundary data for mining licenses at Nenthorn will allow future researchers who work at the site to immediately determine which company or individual worked plots of land. Also, if Nenthorn is further developed into an interpretive site, the map created will help support public centered documentation (e.g., tourist brochures, interpretation panels).

Recently GIS technology "has enabled three-dimensional modeling and visualization to occur not just in the graphic design domain but also in the geographic information system domain" (Helm 2001: 115). Archaeologists have

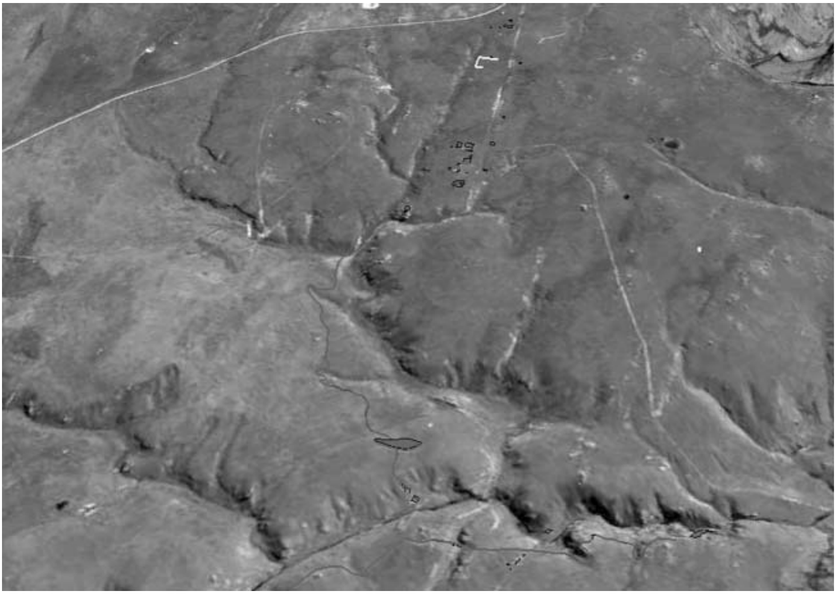

Figure 4. 3D picture showing Nenthorn.

commented on the ability of 3-D recreations and how they might "have a tremendous impact on the science" of archaeology (Bawaya 2003:38). These types of reconstructions are well-suited for interpretive centers and informational websites. Once data was added, including the features mapped by the GPS units, the 3D capabilities of ArcGIS were explored. At first only a still 3D picture of the site was created (Figure 4), which might have proved useful as an introductory photograph for reports or websites. After enrolling in Spatial Information Systems and Surveying papers at the University of Otago, the animation potential of ArcGIS was explored. The output of using these animation features was impressive, considering that these capabilities were easy to learn and quick to utilize. This new 3D capability of ArcGIS was used to create a 12 second introductory video for an interpretive website. While the 12-second fly-through video of Nenthorn used on the website serves basically the same purpose as would a still picture (to introduce the site), the reaction from audiences at talks has been much more exciting than from the simple still pictures.

Dissemination

The importance of disseminating information gathered while conducting archaeological work cannot be underestimated. Fortunately the electronic format of GIS lends itself ideally to creating a variety of methods to share information. Using the GPS data gathered two forms of presentations were designed. An archaeological map was created using ArcMap (Figure 5), the features of ArcGIS allow quick re-sizing, useful for publishing the map for a variety of purposes (e.g., reports, field maps, posters, etc.). Also a website to function as a virtual tour was created. This included many example photographs from the GIS (Figures 6 and 7), brief histories of the site, and hyperlinks to historic and modern photographs, helping to explain the site visually. The use of linked photographs in the GIS site map allows interested persons to explore the site virtually. This process allows other researchers to learn more detailed information concerning features from afar and also serves the possible tourist function of enticing the public to explore the site in person.

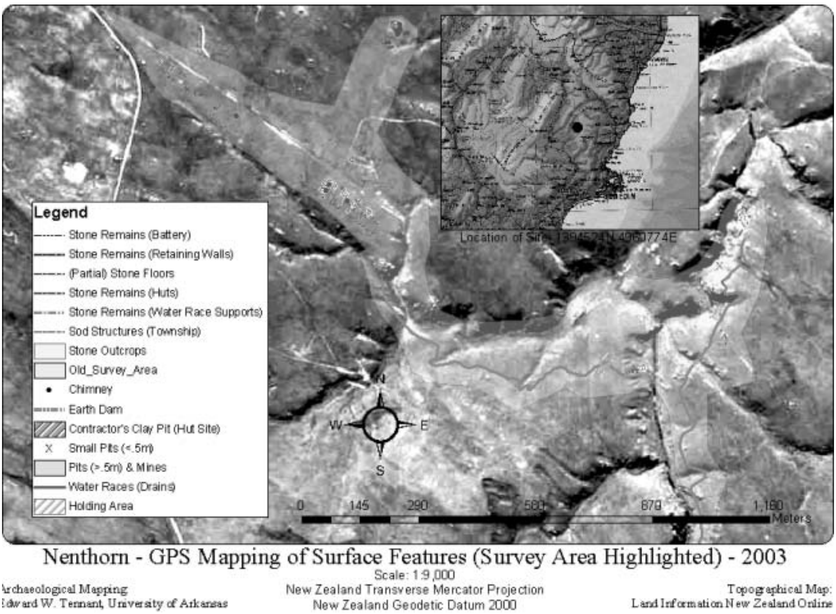

Figure 5. Archaeological map of Nenthorn township created with ArcGIS.

Figure 6. Nenthorn showing GPS survey.

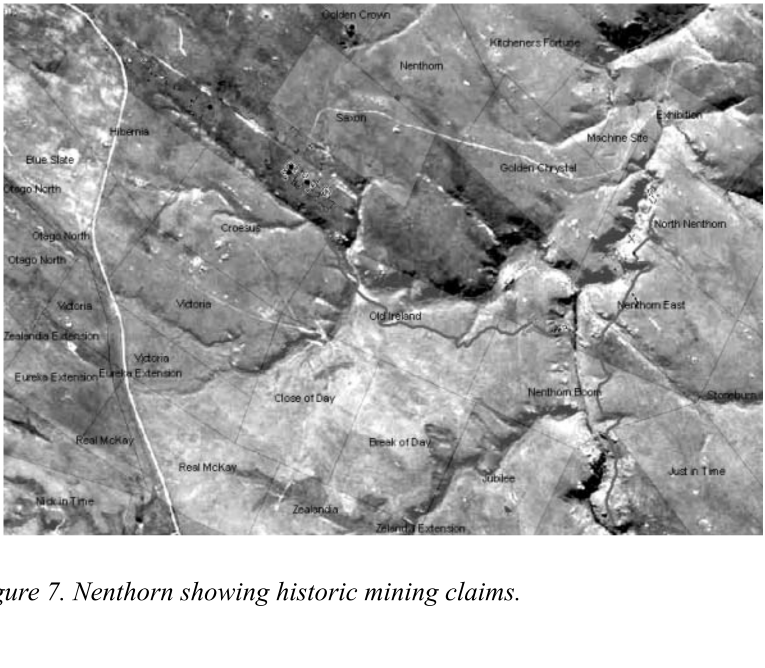

Figure 7. Nenthorn showing historic mining claims.

Benefits

Numerous advantages became apparent during the course of this project. The ability to accurately map features (many of which were verifiable through aerial photographs) and the overall speed was the most visible benefit. The fieldwork was scheduled to last five days for comparison with the amount mapped using a traditional survey scheme (via the Jacomb and Easdale survey). Approximately twice as much area was surveyed in the same amount of time (Figure 8). Also, since the features were mapped with a GPS, spatial relationship within the site is automatically recorded.

The creation of a GIS allowed many types of data to exist concurrently in an increasingly user-friendly environment. The migration of this data from the GIS to a web-friendly setting allowed for the material to exist in a format that lends itself to public consumption more readily than many traditional forms of publication (e.g., site reports, archaeological journals, etc.). Also, the GIS shows the full extent of the area surveyed, and since the entire area was not surveyed, this has value for any future work where researchers can quickly determine the amount of land that might still require work.

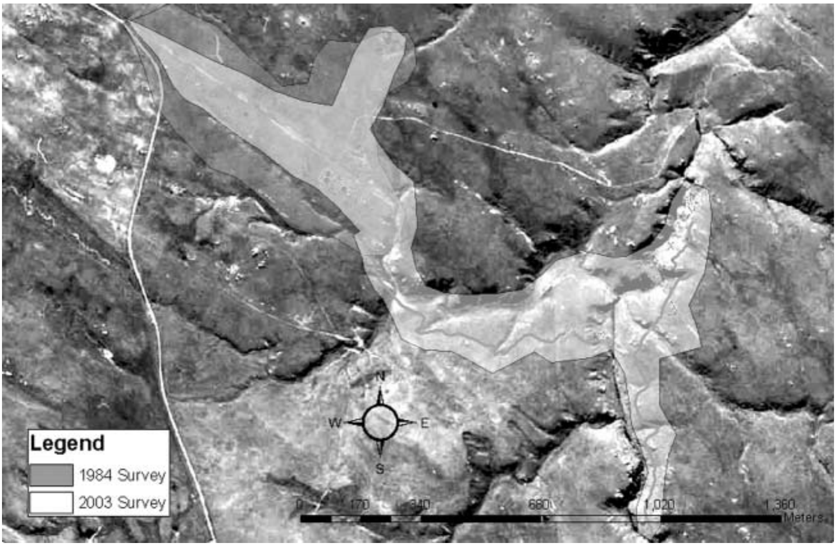

Figure 8. 1984 and 2003 survey areas.

Heritage management and GIS

Many archaeologists have walked the thin line between attracting the public to experience heritage areas while, at the same time, discouraging private citizens from wanting to go out and dig the sites themselves (Lerner & Hoffman 2000: 231). The tension between involving the public and protecting sites is increasing, especially in places where tourism has become a major industry. One of the main methods for successfully navigating this type of situation is simply to control the amount and type of archaeological data released to the public. The use of GIS for storing archaeological data makes control of that data much more efficient (Wheatley & Gillings 2002: 217). For instance, if a site contains sensitive unexcavated material (e.g., dwelling sites on the goldfields that contains items of interest to fossickers such as ceramics and bottles) an interpretive map will certainly not relate this information to the general public until after archaeological investigations have occurred. This tight control and quick manipulation of spatial data inside a GIS is well suited for heritage management purposes. It allows the archaeologist a quick and simple solution to data control.

Conclusion and further thoughts

The use of GPS and GIS to map intra-site features is growing. This is especially true as the prices of these units continue to drop, their accuracy improves dramatically, and the related software becomes increasingly intuitive. The use of these technologies is becoming widely available, and increasing numbers of researchers are exploring their uses. This is demonstrated by the spread of GIS courses for archaeology students at the undergraduate and graduate levels around the world.

However, there are concerns that need to be addressed by those wishing to use GPS. For instance, mapping out the best times of day to conduct the survey is of vital importance to ensure that the highest level of accuracy is maintained at all times. Also, like any technology, one develops a certain artistic ability to utilize GPS units to the best of their ability. This skill is best developed through education and dedicated use. Excellent resources are available from Trimble and on the internet (the author’s own GPS manual is available at http://little-yeti.com/gps/).

The use of 3D site re-constructions and the internet as a reputable vehicle for publication are also recent developments. Their acceptance is growing, evidence of the desire many archaeologists have to share their work with each other and the general public in a more timely manner. I believe this represents a genuine aspiration by members of our field to continue improving public dialogue, and the use of GPS and GIS are some of our most powerful tools.

The web version of Edward W. Tennant's thesis about the growing use of GPS and GIS in archaeology is located at http://www.little-yeti.com/nzarch.

Acknowledgements

The fieldwork was funded by an Elizabeth W. and J. William Fulbright Scholarship for Study Abroad from the University of Arkansas (Fulbright College of Arts and Sciences, USA), with equipment and lab facilities provided by the Anthropology and Surveying Departments at the University of Otago.

References

Bawaya, M., 2003. The virtues of virtual archaeology. *American Archaeology* 7: 38–43.

Branting, S. and G. Summer, 2002. Modelling Terrain: The Global Positioning System (GPS) survey at Kerkenes Dað, Turkey. *Antiquity*, 76: 639–640

Gamble, C., 2001. *Archaeology: The Basics*. Routledge, New York.

Hearn, T., 1988. *Nenthorn: Gold and the Gullible*. Otago Heritage Books, Dunedin.

Helm, O., 2001. Three-dimensional modelling of a cityscape: Vancouver, Canada. In P.A. Wigham (ed) *SIRC 2001: Sircumnavigation, where have we been?, where are we going?: Proceedings of the 13th Annual Colloquium of the Spatial Information Research Centre, 2nd-5th December 2001*, 115–116. University of Otago, Dunedin.

Jacomb, C. and S. Easdale, 1984. Nenthorn interim report. Unpublished report to Department of Lands and Survey, Dunedin.

Lerner, S. and T. Hoffman, 2000. Bringing archaeology to the public: Programmes in the Southwestern United States. In F.P. McManamon & A. Hatton (eds) *Cultural Resource Management in Contemporary Society: Perspectives on Managing and Presenting the Past*, 231–246. Routledge, New York.

Renfrew, C. and P. Bahn, 2000. *Archaeology: Theories, Methods and Practice*. Thames & Hudson, New York.

Salmon, J.H.M., 1963. *A History of Gold-Mining in New Zealand*. Government Printer, Wellington.

Wheatley, D. and M. Gillings, 2002. *Spatial Technology and Archaeology: The Archaeological Applications of GIS*. Routledge, New York.