So-called historic sites in New Zealand, i.e., those created through occupation after the arrival of European settlers, frequently contain tens of thousands of artefacts distributed across hundreds or thousands of square metres of deposit. The challenge for archaeologists, particularly those involved in mitigation archaeology, is to excavate quickly across large areas without losing critical information through which site formation processes and the nature of artefact discard can be reconstructed.

We report here on a recent archaeological excavation of a mid-19th century fortified Māori village, Oropuriri, in the Taranaki region of New Zealand, where more than 50,000 artefacts were recovered in an area excavation covering around 3000 square metres. Excavation of the village was prompted by the need to re-align a highway and was supported financially by the road construction authority (Transit New Zealand) and, by the traditional owners of the site, members of the Puke Tapu hapū of Te Atiāwa. The challenge for the archaeologists was how to excavate an artefactually rich site where literally tens of thousands of pieces of bottle glass, ceramics and metal objects (as well as faunal remains and many other artefact types) were associated with around 2500 features (postholes, pits and trenches)—all within a ten-week period that the construction requirements and funding would allow. The approach we adopted, and on which we report here, was to employ a variety of electronic systems that permitted the very rapid recovery of provenience information for individual artefacts as well as the three-dimensional position and shape of features. We achieved this without the constraints imposed by conventional archaeological survey control via excavation units of bounded squares.

Our key items of survey equipment were a Cyrax laser scanner, used for creating three-dimensional models of features; a robotic total station, for recording the shape of features; and three reflectorless total stations, for recording the position of individual artefacts. We also describe the systems we used for the analysis of the materials
recovered, particularly the use of Geographic Information System (GIS) software and a relational database. Finally, we discuss the use of virtual reality models as media with which to illustrate the process of archaeological data formulation and interpretation to interested parties.

OROPURIRI VILLAGE SITE

The site of Oropuriri, designated N19/262 in the New Zealand Archaeological Association site recording scheme, was initially identified by one of us (MT) during a mitigation survey. Surface evidence was limited to a low rectangular depression about 20m long and 7-8m wide set into the side of a low hill and facing out to sea. In New Zealand such depressions frequently represent the remains of house sites, although with these dimensions, the house would be a particularly large one by archaeological standards (Prickett 1982). The surface evidence prompted an application for permission to excavate and the first investigations were undertaken during a two week period in 2002.

Excavation revealed that the depression was indeed the remains of a large house, likely to represent a wharenui ‘meeting house’. On the basis of the material found within it, it was dated to the mid-19th Century. The excavation strategy emphasised the precise recording of artefactual material found within the house, because previous archaeological work has shown that the symbolic use of space in Maori houses seen today has a deep antiquity and is manifest archaeologically in the distribution of artefacts (Prickett 1992, Sutton 1990, 1991). However, ground surface irregularities, geophysical survey (particularly soil resistivity) and limited excavation outside the house quickly indicated that there were a large number of archaeological features in addition to the large house structure. This necessitated a re-evaluation of the excavation strategy and requests for additional funds to conduct a further eight weeks of excavation.

At this point, we faced a critical decision concerning the precision level at which singular artefacts were recorded. As mentioned above, historic sites can produce very large numbers of artefacts in New Zealand, particularly fragments of bottle glass and ceramics (Smith 1990, 2004). Because of the volume of material, it can be tempting to evaluate the diagnostic potential of artefacts during excavation and consequently record those with a lesser potential differently to those with a higher value. The problem, of course, is posed by the question: diagnostic of what? A complete or almost complete object, whose date of manufacture or intended function can be easily interpreted, is not necessarily more valuable to the analysis than a fragmented or undecorated object. As those of us who teach method and theory repeatedly tell our students, it all depends on the nature of the research question. At Oropuriri we had a large house surrounded by what appeared to be the remains of associated residential structures. It was certainly of interest to understand the range and form of artefacts because they might allow us to determine the date of occupation at the site. Complete or near complete objects would also help us to interpret the nature of activities undertaken at Oropuriri, but the many thousands of fragmented artefacts had the potential to help us piece together the sequence of activities that were involved during different phases.
of occupation at the site—periods of use followed by abandonment and then perhaps re-occupation. To answer such questions, broken bottle glass, even when fragmented into many thousands of pieces, might be as important as a complete decorated cup or even a dated coin. For example, piles of discarded glass fragments piled against a wall might be an indication of the behaviour that occurred after the large house was abandoned; rubbish piled into pits would provide an indication of refuse-generating behaviour. In a site so clearly associated with Māori (as indicated by the structural remains), the nature of what is considered refuse—which European-derived artefacts were discarded and in what form—can provide insights into 19th century values as important as the presence of complete structural remains. The decision was therefore taken to continue the strategy of individually recording each used artefact when excavating the large house.

We also sought technological solutions to the problems posed by the large number of features our investigations indicated were located outside the meetinghouse. As excavation continued, it became apparent that these features pre-dated the meetinghouse, and that we were in fact excavating the front portion of an 1850s Māori village, one fortified in response to a period of political unrest known as the Puketapu feud.

**RECORDING STRATEGIES**

The recording strategy we developed used a primary division between artefacts and features, and we used different types of equipment to record the different types of information depending on this division. Artefacts were defined as objects that could be held, and our excavation protocol required that all such items be assigned a unique identification number and be individually located in three-dimensional space.

Features could not be held in the hand, hence were not artefacts. Their presence was generally indicated by a discolouration in soil, visible in a two-dimensional plan across a cleaned soil surface, but their definition involved the excavation of a cavity in the ground. The excavation protocol required that their shape be recorded in both two and three dimensions. The two-dimensional view involved tracing their shape by using a series of connected points. The three-dimensional view required that the shape of the excavated feature surface be recorded, in effect recording the shape of the impression left once the contents of the feature had been removed.

To ensure that we could excavate rapidly and with a similar precision level across the entire site, it was essential that one excavation standard be applied at all times. We also sought the flexibility to excavate following the distribution of features as they were uncovered, rather than be constrained by arbitrary excavation units. Therefore, we employed an increasingly sophisticated array of electronic survey instruments over the course of the three excavation seasons: the first in 2002 and then during two four-week periods in 2004.

We established a series of datum points around the periphery of the site, tied to the New Zealand map grid coordinates. Survey instruments were locked into the grid by using the “resection” method, in which the position of an instrument is located using any combination of three or more datum points, allowing great day-to-day
flexibility in the positioning of the recording devices. This allowed a high degree of
tactical latitude by permitting the concentration of instruments at particular points
where we were working.

Using the results of the soil resistivity survey as a guide, the site was broken into
a series of arbitrary units designated with a letter code. These areas were simply work
zones of some tens of square metres in area. They were labelled for convenience with
a two-letter naming system and were assigned to groups of three to seven excavators.
Each team was equipped with a total station for recording. Depending on the pace of the
excavation, new work areas were defined on a daily basis. In contrast to conventional
excavation recording strategies, these areas were not used in the recording system.

Excavation was undertaken following the natural stratigraphy by hand, except that
a mechanical excavator was used to remove the turf. The stratigraphy was not complex
and consisted of three layers: the vegetated brown topsoil, a charcoal rich mottled
soil, containing the bulk of the cultural items, and the basal weathered volcanic ash
into which a large number of features were dug. Within these features, more complex
stratigraphic divisions were possible, reflecting the complexity of the fill events at
some point in their history.

New Zealand archaeological sites commonly have multiple features, cutting into
one another and representing the repeated infilling and construction of pits, terraces
and postholes. This proved not to be the case at Oropuriri, except in the fill of some
features. In these instances we used our system to record the complex stratigraphic
sections in their three-dimensional position.

Recording Artefacts

Once the mechanical excavator had removed the turf, sediments were progressively
removed by hand. As items were identified, they were flagged with a coloured wooden
skewer (of which we had several hundred) and the total station operator recorded the
location of the artefacts. Numbered bags (tagged with pre-printed labels) were used
to collect the artefacts. The system we adopted was based on one in use for a number
of years to excavate Palaeolithic sites (e.g., McPherron and Dibble 2002) and builds
on systems in use in New Zealand (e.g., Holdaway and Irwin 1993). We made use of
reflectorless total stations, increasing the speed at which samples could be logged.
The identification number printed on the bag tag matched the identification number
generated in the total station, forming the basis for the relational link between the item
and its location. Layer information was written onto the bag and transcribed in a field
laboratory to a relational database, as described below. This was an acknowledged
weakness in the system and one that could have been easily overcome by logging to
handheld computers in the field.

Linking the handheld computers and the total stations into a wireless Bluetooth
system is the next logical stage in the evolution of this system, allowing a relational
database for all items and features to be built in real time (i.e., at the point where
the feature or item is excavated). Based on our experience at Oropuriri, this is likely
to be an economical way to reduce laboratory time as artefacts could be checked as
they are recorded. Such a system would also allow us to identify any errors at the
point of data acquisition. Despite what at times seemed an overwhelming volume of technology, we could not stretch to the purchase of sufficient handheld computers or Bluetooth connections to fully implement such a system (but see below).

Our recording protocol allocated only a single total station shot to each item, this despite recent studies that have demonstrated the value of analysing not only the three dimensional location of objects but also their orientation in three-dimensional space (e.g., McPherron 2005, McPherron et al. 2005). Our reasoning here was that the majority of the items recorded were fragmentary and were not of a form where points could be consistently defined to determine dip and strike (as is the case for the stone artefacts recorded by McPherron and colleagues). This is another acknowledged weakness in the system that we will strive to overcome in future.

Despite the inability to analyse the orientation of artefacts, the point locations together with descriptive attributes entered into a relational database and GIS (see below) permitted the analysis of the distribution of different sized artefacts dispersed across various parts of the site. It was possible to show, for instance, that glass bottles smashed around the bank of the large meeting house were dispersed differently to bottles that formed a large concentration of fragmented glass in front of the house porch area. The way artefacts are dispersed around the features has much to say about how, and potentially when in the sequence of occupation, the artefacts were deposited.

As noted above, the intention was to apply the artefact recording protocol equally to all objects, no matter what their apparent “diagnostic” value. This we did, but it must be acknowledged that at times the application of this rule caused a degree of consternation among the excavators. The temptation was always to bag multiple artefacts together if they were of a similar “un-diagnostic” form. Recording the three dimensional position of literally thousands of pieces of fragmented bottle glass puts a strain on excavators and total station operators alike, and requires large numbers of bags and labels. The answer to the scepticism about anything useful being obtained from such detailed recording is, of course, that as a means to understanding past behaviour we are interested in how the archaeological deposit formed, that even the most fragmentary item tells us about disposal behaviour. But in New Zealand such questions are novel in historical archaeological contexts.

Any recording system, no matter how detailed, involves the loss of some information. Despite our interest in preserving the absolute position of items, we lost some information noted as items were excavated. Of particular concern was the relationship between items that could be fitted back together. Some of these items were fragmented after deposition, others during the course of their use and disposal. Whatever the cause of the fragmentation, refitting data is of considerable value, and we were forced to reconstruct refits back in the laboratory at a considerable cost of time. Ceramic objects, for instance, proved to contain a particularly large number of refits. A solution to this problem is to add additional data fields to a database constructed on handheld computers at the point of excavation, a system that we will implement in future fieldwork.
Recording Features

Features, i.e., those things that cannot be held, were treated in a different way to artefacts. As their presence was defined by excavation, a two-part number was assigned to the feature. The first part of this number acted as a unique identifier for the feature. Thus F1001.1 represented a change in soil colouration identified as a posthole. Within this feature was a second darker stain identified as a post cast, the remains of a partially rotted post situated within the posthole. Following our recording system, this sub-feature within F1001.1 was labelled F1001.2. Further sub-features were identified as needed.

Feature recording involved a multistage process. As excavators revealed features, they were given a number that was written onto a reusable plastic tag. Attributes of the feature including a description of its form, sediment colour, size and probable function were made into a single palmtop computer running a simplified relational database. Size measurements (length and breadth) were taken with a hand tape and simply formed a means of cross-checking if an error occurred in the recording process. The key recording device, used to precisely record the shape of features, was a robotic total station. This device was set to take points at 2cm intervals. The operator delineated the outline of the feature with a 360° prism, indicating the start and end points of the feature, and associated the set of three-dimensional coordinates recorded in the total station with the feature number. We found that the 2cm interval provided an outline of small postholes sufficiently precise to differentiate between those that were cut with spades and those dug with some other implement. The recording interval was also sufficiently precise to record the shape of post casts within the postholes, where these were present. Of course, recording in this way produced a huge volume of data, but this data was always recorded electronically, never by hand, and was directly entered into CAD (Computer Aided Design) and GIS (Geographic Information System) packages. A high data volume did not therefore add significantly to analysis time nor, given the speed with which features could be traced, did it slow down the excavation.

Excavation of feature fills proceeded as with sediment outside features, except that items found within features had the feature number added to their database form in addition to the unique identification number.

Once features were emptied of fill, a CyraX laser scanner was used to record the shape of the feature. The laser scanner uses a time-of-flight principle to create a point cloud of three-dimensional coordinates that provide a precise indication of the shape and location of objects (Mulrooney et al.:n.d.). The technology is in some sense similar to that used in a total station. However, rather than a single laser point or a single stream of such points (such as that created with the robotic total station), the laser scanner pulses a stream of points systematically across a surface. The laser scanner (Fig. 1) can be set up at virtually any angle as long as the laser stream can “see” the target. Unlike a total station, datum targets are placed within the scan and subsequently located with a reflectorless total station. Software permits the point cloud coordinates to be registered in the same projection as the points used to locate the datum targets. The scanner can be moved to record from a different angle, removing blind spots, and the different scans combined easily, if the same sets of targets are used during separate scans.
Figure 1. *a.* Cyrax laser scanner and a point cloud of one of the rectangular pits excavated at Oropuriri. *b.* The point cloud provides a precise indication of shape and is used to calculate the pit fill volume.
Much thought was given to how to employ the scanner at Oropuriri, since the possibility existed to take scans at nearly every stage of the excavation process. It could, for instance, be useful to record the shape of features in a series of stages, as they were progressively excavated. However, because of the need to prepare the surface to be scanned by cleaning and removing any superfluous gear (not to mention excavators), repeated scans were costly in time and resource. For this reason we limited the scanner images to single views, once the fill from the features was removed.

Our rationale for this was twofold: first, we wished to use the scanner derived data as a means to produce a three-dimensional primary record of the shape of features. In the past, features in New Zealand sites have been recorded via two-dimensional plans or sometimes via profiles associated with dimensions (e.g., length, width and depth). Photography has also been used (but not photogrammetry). Such records provide a precise record of the two-dimensional shape of features but only a general idea of their three-dimensional form. Three-dimensional measurements are likely to include a high level of variance—much of it derived from the way measurements are taken. The scanner is able to solve some of these issues by providing a uniform precision level for recording shape (although it is still dependent on the excavator accurately identifying the boundaries of features).

Second, we wished to provide a dataset with which the process of excavation could be visualised. An issue faced by New Zealand archaeologists is how to convey to interested stakeholders what it is that archaeologists are about. Typically, archaeological reports in New Zealand are written for a professional archaeological audience, however this group forms only one of a growing number of groups interested in the outcome of archaeological work. At Oropuriri we were fortunate to have the support of tangata whenua ‘people of the land’, and a large number of Māori visited the site. For many, this visit formed their first exposure to archaeology. Towards the end of the ten weeks of excavation, a very large area was open, permitting visitors to carefully walk within the village (Fig. 3, see below). What struck us about the comments from visitors was that the large area exposed provided a visual clarity that enhanced the ease with which the mechanism of archaeological excavation could be understood. We wished, through the use of the scanner, to produce the data from which we could create a virtual reality image of the process of archaeological investigation to recreate the visual experience that visitors had acquired during the excavation (see below).

Digital photography provided the final type of data acquired during the excavation of Oropuriri. Digital images were acquired for both tactical and strategic reasons. Tactical images provided detail of such things as the relationship between a small number of features or a particular group of items. Strategic images were taken to provide a colour source for the three-dimensional reconstructions of the feature surfaces. These images were taken by a photographer who was raised above the site in a cherry-picker so that top-down pictures could be taken. While visually impressive (Fig. 3), these images suffer the problems imposed by parallax, so cannot be used as a data source with which to measure the spatial position of features. They can, however, be draped across the three-dimensional reconstructions of the excavated surfaces recorded with the laser scanner or used as a backdrop for GIS views of the site (Figs 2 and 5, see below).
Integration of the Datasets

The key to the successful completion of any archaeological excavation is only partly determined by the efficacy of fieldwork. As related in numerous textbooks (e.g., Barker 1993) and by experienced field archaeologists, the critical work is the laboratory analysis of the material, and even more so in working the results of this analysis into a written report. In the modern world of commercial archaeology, there is little room to spend time slowly accumulating the results of analysis; contract reports are due within weeks or months, rather than years, after fieldwork completion. At Oropuriri we faced the dual problems of a large number of features, representing a variety of structures formed at different times in the past, and an even larger number of artefacts—all of which, according to our theoretical position, had the potential to convey useful information. Our approach to analysing this material, and ultimately to report creation, was to harness the power of relational databases with a GIS as our key strategic piece of software.

In the field, all excavated items were processed and initial descriptions of material entered into a relational database table together with each item’s identification number and stratigraphic layer. Back in the laboratory all material was cleaned and dried, and the material description checked. All items were also weighed. The database constructed in the field was updated and became the primary database used for item analysis. Different types of materials were then separated for more detailed identification and analysis. The results were also entered into relational database tables, each of which could be linked back to the primary database table and the GIS through the unique identification number. It is at this point that the necessity of slavishly following a rule of recording the location of every object becomes clear. If all items are recorded in the same way, the information entered at each stage of the analysis process can be combined through the use of GIS and database software permitting very rapid analysis. Inevitably, there were some errors in the field, as when more than one item was associated with a single number, which required laborious reallocation of numbers and coordinates in the laboratory.

While a detailed consideration of context is hardly new to archaeology, the ability to analyse the context of tens of thousands of items is unique to historic archaeology in New Zealand. The key to implementing the research design successfully is the use of a vector GIS. More than simply software to make site maps, the GIS permits us to statistically and visually determine spatial patterning in a subset of items falling on or in particular sets of features. Because these items are described in database tables that can be interrogated by the GIS, it is a simple task to tabulate the frequency of items of different forms that equate with features reconstructed as forming houses, pits and palisades. Details of the form and function of items can be combined with details of the degree of fragmentation and weight. This permits an analysis of the taphonomic history of the site as well as the composition of assemblages that have accumulated in the base of pits or against house walls. None of these analyses are in themselves unusual in archaeology. But the combination of a GIS and relational database significantly increases the speed and scale at which analyses can be performed.

All excavated features were added to the GIS for the site (Fig. 4, see below). Features were identified based on their form with categories for posthole, pit, trench and fireplace. At a later stage, inferences were drawn concerning which features
related together functionally, following normal archaeological practise. Thus based on posthole shape, position and alignment, groups of features were identified as belonging to a house structure. The GIS provided a rapid and flexible means for drawing such inferences, since the spatial relationship of features could be assessed (and measured) on the computer screen without the need to sift through multiple hand-drawn maps.

To illustrate the process of how different data sets were combined, one of the 13 houses identified at Oropuriri is detailed in the colour figures. Top-down photographs stitched together to form a single image illustrating the excavated surface (Fig. 2). The features identified during excavation are superimposed on this photograph from the site GIS. Items are then added as a separate layer. Finally, a virtual reality reconstruction of the whare is provided, a series of still frame pictures reproduced here to illustrate what is in fact an animated process that shows the progression from excavated archaeological surface to reconstructed structure (Fig. 5).

**VISUALISATION**

At one level, Figure 5 provides a series of striking pictures that illustrate what was found in more detail than the conventional line diagrams populating most archaeological reports. The illustrations provide a more realistic representation. because they include much more data than is provided by typical illustration methods. “Realism” is a goal of many virtual reality reconstructions in archaeology (Gillings 2000, 2005), although like other forms of visual anthropology, the representation of reality is always constructed since only particular images or view-sheds are selected. Archaeologists select what is to be shown and determine the attributes to be shown in the image. At Oropuriri, we attempted to formulate a clear research goal for “virtual reality” visualisation to meet the criticism of “virtual reality” in archaeology, which claims that much effort is expended to make pretty pictures for no particular reason. As discussed above, one of the advantages of a large area excavation was the ability for visitors to the site, particularly tangata whenua, to comprehend the relationship between archaeological method and the interpretation of results. The rectangular and circular features filled with darkened soil that to us were so obviously postholes were not so visible to those without long experience of archaeological excavation. Visitors expressed to us their initial distrust of what appeared to be almost a metaphysical leap between the creation of field evidence (e.g., the removal of a pit fill defining the hardened pit walls) and the reconstruction of a structure (e.g., a rectangular storage pit). However this scepticism evaporated to a large degree when people were able to view the way fill broke away from compacted surfaces or when the circular stains turned a right angle to form the corner of a structure. Observation of the relationship between archaeological features (e.g., stained sediment from a posthole) and the reconstructed structure seemed critical. Rather than simply reconstruct “what was” in the past, it seemed to us that visualisation offered a means to document the process of archaeological research through a media that is ultimately visual.

One of our initial attempts is displayed in Figure 5. There are several points to notice about the reconstruction. The virtual reality image, or rather the series of images that
forms the animation, is what Gillings (2000), using Gray’s (1995:343) terminology, would call a manufactured intensity. The image is an accurate representation of what was found in the sense that the first image displays a model of the excavated surface complete with depressions representing postholes captured with the Cryax laser scanner. At the precision level of the scanner (±6 mm @ 1.5m - 50m range, 1 Sigma), the surface is an accurate representation of the completed excavation. But what is represented is constructed by the trowels of the excavator seeking to highlight material remains (postholes, the hearth, a hard-packed earth floor) that have archaeological significance. The colouration of the surface seeks to emulate the colour of the sediment, as the excavator exposed it. The surface is “prepared” in that extraneous surface material has been removed for scanning and photography (Fig. 3).

We have sought to capture the moment of excavation because it best illustrates the archaeological nature of the excavated surface. In the same way the reconstructed whare in Figure 5 is a construct, deliberately emphasising the structural components of the building that can be validated by extension from the archaeological features. The whare is pristine; there is no attempt to “realistically” weather the structure or to scatter the debris of everyday life about the house. The ground surface has not changed from the texture and colour of the archaeological excavation. In sum, we are manipulating the virtual reality image to illustrate a particular relationship between archaeologically defined data and reconstruction. To the observer it is clear what was actually found (the posts placed in the postholes) and what is imagined (the roof of the structure and the texture of the walls). There is no attempt at subterfuge.

The success or otherwise of our visualisation will be judged by those who view it. It is our goal that a virtual reality model of the excavation project will be one of the things we return to the community, one that will enhance the historical significance of the site, which is destined to be partially covered by a road. It will show what it is that archaeologists were able to interpret on the basis of ten weeks of excavation. The virtual reality image is no substitute for the village as it existed in the past; instead it is another way for archaeologists to convey what it is they discover to an interested public. As we have constructed it, it places emphasis on the real process of archaeological inference rather than “picturing” what life was like in the past.

* * *

Oropuriri is an exceptional site, partly because of the state of preservation of the features and partly because of the rich artefact record. For archaeologists in New Zealand, however, such sites pose a significant challenge. Large, rich sites demand considerable resource, both at the point of excavation and subsequently during analysis and write up. In excavating Oropuriri we deliberately sought to challenge conventional approaches to excavation and analysis by applying techniques that permitted the rapid recording and spatial analysis of thousands of items and features. While the substance of the analyses we undertake at the site may not be unusual in New Zealand archaeology, the scale at which we are undertaking them is. It is likely that the results we obtain will differ from those discovered through earlier archaeological work; patterns apparent when 2000 postholes are analysed will not be apparent if
an area encompassing only 200 postholes was exposed. Similarly, we hope that the Oropuriri example will show that the analysis of whole artefact assemblages is as valuable in historic sites as it has proved to be in prehistoric sites. The presence of large numbers of items does not justify a research design that limits analysis to only the “diagnostic” items if we are interested in understanding processes of refuse disposal in the past. What was discarded, and equally where it was discarded, has much to tell about the attitudes people held in the past. Finally, through the use of electronic survey equipment and modern computer software, we are developing new ways to visualise the process of archaeology.

Field archaeology at the scale conducted at Oropuriri is an expensive business. To justify archaeology’s claim to a larger share of society’s resource, we need to develop new ways to better convey archaeology’s unique perspective on the past. Modern computerised recording and visualisation methods offer archaeologists the tools to excavate at the scale needed to tackle the large, complex sites in New Zealand.

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