NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

ARCHAEOLOGY IN NEW ZEALAND

"LIES, DAMNED LIES AND GEOPHYSICS": USES AND ABUSES OF REMOTE SENSING TECHNIQUES IN NEW ZEALAND HERITAGE MANAGEMENT

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After all, facts are facts, and although we may quote one to another with a chuckle the words of the Wise Statesman, "Lies—damned lies—and statistics," still there are some easy figures the simplest must understand, and the astutest cannot wriggle out of (Courtney 1895: 25)

Introduction

Remote sensing techniques derived from geophysics have a venerable history in archaeological practice internationally and although they have been used intermittently in New Zealand, improvements in technology and the growth of consulting archaeology have meant such studies are increasingly frequent. Commercial geophysicists specialising mainly in engineering applications are now relatively common throughout the country but the number of practitioners working on archaeological situations remains limited. The geophysicists, either from academic institutions or consultancies, have been hired on an ad-hoc basis to deal with specific situations, often in the search for burials (e.g., Bateman 2003; Nobes 1999; Geometria 2002; Sheppard 2003). Archaeologists themselves in New Zealand have dabbled with remote sensing techniques for some years on both prehistoric and historic sites with varying degrees of success. These studies have derived for the most part from academic research objectives but increasingly there has been a desire to use geophysical techniques in heritage management. In this paper, we explore some of the issues that have arisen from using these techniques as heritage management tools.

Archaeo-geophysical prospection utilises passive (e.g., magnetic) or active techniques (e.g. resistivity, conductivity, ground penetrating radar or seismic reflection) to measure variation in the physical properties of subsurface soils (Scollar 1990 and Weymouth 1986). It is the recorded variation or contrast in these properties that alert the archaeologist to the potential that anomalies may be anthropogenic in origin.

We do not here offer an extensive review of the available techniques (for recent reviews, see Clark 2000; Gaffney and Gater 2003; Clay 2006; Somers 2006; Conyers 2006; Dalan 2006; Kvamme 2006a; Linford 2006) nor do we provide a comprehensive bibliography regarding the use of geophysics in New Zealand archaeology. We are however confident that the conclusions presented here will provide a useful starting point for developing a greater synergy between geophysics and heritage management throughout the country.

Luddites and geeks

***Data**: I feel obliged to point out that the environmental anomalies may have stimulated certain rebellious instincts common to youth, which could affect everyone's judgment... Except mine of course.*
***Cmdr. Beverly Crusher**: Okay Data. What do **you** think we should do?*
***Data**: Saddle up, lock and load!*
(Movie: *Star Trek Insurrection 1995)*

Among the archaeological community in New Zealand there have been a small but vocal number of proponents of the use of remote sensing techniques for archaeological research with the remaining majority varying from actively interested, to mostly indifferent to actively opposed. For the most part, we suggest that "interested scepticism" probably best characterises the majority of archaeologists. However, there is an underlying feeling that those proponents of remote sensing represent a new frontier in archaeological endeavour and those who resist are "luddites" because they fail to recognise or comprehend this new frontier. For the latter, the remote sensing "geeks" produce results that are little more than flashy and expensive gimmicks which do little to enhance our understanding of archaeological sites. With this tension in mind, we offer a brief description of why and how geophysical surveying is implemented in archaeological situations.

There is little doubt that much of the appeal of using geophysical analysis comes from three main factors. The first is the "grail-like" attraction that it is possible to identify archaeological features in a non-destructive fashion (Scollar 1990; Lockhart and Green 2006) The second is that using remote sensing may be potentially cheaper than full excavation especially as it allows targeting of resources to specific archaeological features (Johnson and Haley

2006). Thirdly, the adoption of "high-tech" approaches adds scientific credibility to archaeological practice.

The wow factor

Put not yourself into amazement how these things should be: all difficulties are but easy when they are known. Shakespeare, *Measure for Measure*, IV, ii

There are a number of factors that have heightened the interest in non-destructive exploratory tools but from a heritage management perspective the most crucial ones probably relate to:

- identifying the presence of sub-surface archaeological features without damaging a heritage resource that is perceived as ever-diminishing;
- a greater awareness and interest in preserving not only specific features but the landscape context in which they lie; and
- resisting the pressures of development encroaching on archaeological sites.

The cost of projects is always a factor in archaeological endeavours regardless of whether they derive from academic or heritage management interests. As we discuss later, this factor can play out differently depending on the objectives of the studies and this is particularly influenced by the origin of the research objectives. Getting funding for any such research may depend on impressing those who will determine funding and the dazzling colour plots showing blobs of intact archaeological booty are a dramatic draw card.

At the heart of successful use of remote sensing techniques for archaeologists is the research design. This generally consists of statements about: objectives, location and environmental conditions, remote sensing technique, data collection, processing of results, interpretation and testing. To make things more complex this can be an iterative process with additional techniques used, alternative sampling strategies as well as a multitude of data processing algorithms. All of this leads to some form of testable interpretation.

The techniques that are considered appropriate for any particular project are determined by a number of factors. No one technique can identify all types of features in all environments (Kvamme et al. 2006) and it is important that the appropriate technique is used to find the type of features expected in the area. The English Heritage Guidelines (1995: Table 2) offers a matrix of likelihood of identifying different features using different remote sensing techniques. It is probable that much of that data will apply to New Zealand but some customisation and testing is required. This has to be based on a programme examining a wide range of geophysical studies carried out to establish what works here.

The use of multiple techniques is strongly recommended for two reasons; potential differential anomaly identification between instruments, and corroboration of anomalies identified (Kvamme et al. 2006). Although this seems a logical approach, it has proven to be problematic on occasion (e.g., Geometria 2004a) because of a confusing morass of signals. We cannot assume that a technique will work in a particular situation without testing it.

The geology of the area to be surveyed is crucial. For archaeologists, it is the modification of the background geology that is usually the focus of investigation and so it is crucial to develop a model about the land being studied:

> Decisions on survey method and the interpretation of results must depend on as thorough knowledge as possible of former land-use. Trial trenching, augering and/or testpitting may well be a preferable approach in a majority of cases (English Heritage 1995: 11).

To build a suitable model, the full gamut of traditional archaeological data (previous reports from the same area or in similar conditions), archival data as well as geotechnical information may be used to establish the likelihood of success for remote sensing. Environmental conditions can also play a major part in success as indeed can the weather.

A number of projects have been carried out in New Zealand urban environments with a mixture of results (e.g., Geometria 2004a, 2004b, 2001). Generally though, results from urban environments are rarely that successful:

> The depth and complexity of most urban stratigraphy, closely constrained by modern intrusions, metallic contamination, services and adjacent structures, provides a near-insuperable deterrent to geophysical survey. Tightly constrained sites in city centres do not offer suitable conditions for geophysical techniques, with the possible exception of GPR (English Heritage 1995:7)

Conditions within urban centres do vary and there is hope. GPR can be successful over tarmac (English Heritage 1995: 11) and more open areas (such as in parks and reserves) may provide better opportunities. Wetlands offer another possible area of study although we have not yet had the opportunity to examine the results. Internationally, remote sensing has been used in such environments, e.g., Shennan (1988), although there are obvious limitations (especially because of the "wet" part).

Geophysical surveys have yet to be proven consistently effective in New Zealand in identifying middens or other features in dune environments. Resistivity and GPR surveys carried out in Papamoa (Geometria 2004c) were used to examine whether burials had been located in an area of a subdivision.

The survey suggested that no burials were present. Subsequent excavation by Felgate and Associates (2006) confirmed that conclusion but noted:

> resistivity survey did not pick up the patch of midden exposed in Trenches 1 and 2… The ground penetrating radar study noted two sub-surface anomalies "consistent with the cut-out inner edge of two terraces, which have been filled in by erosion." (Geometria, 2004:11). No terracing was found during our investigation in the locations given by Geometria (Felgate and Associates 2006: 42).

The difficulties may arise because although often shell middens are visually distinct from a surround matrix, the physical characteristics actually being measured by the technology may not be so great. Midden, burnt areas and other such features may be identifiable where the underlying surface is dramatically different to the deposit or the burning has altered the physical characteristics of the subsurface layers (e.g., Phillips and Bader 2007). Distinguishing between natural and cultural events may be possible only via physical testing.

This highlights the difficulty in interpreting the "success" or "failure" of a geophysical study. Not finding the burials constituted a "true negative", the possible terrace a "false positive" and not identifying the midden a "false negative".

The prospect of identifying common features relating to Maori sites such as storage pits is perhaps more hopeful. Bassett *et al.* (2004) brings together an extensive amount of information regarding kumara gardening practices with interpreting the results of geophysical survey of two visible kumara storage pits:

> The disturbances seen in the GPR profiles combined with the general design and linear arrangement… of the pits and their location at the top of a hill… strongly suggests they are raised-rim kumara storage pits used for over wintering. Some of the deeper features noted in the GPR response are also consistent with modification of the pits over time (Bassett et al. 2004:213)

The results from the Bassett *et al.* (2004) study also illustrate the benefits of a strong research design based on a multi-disciplinary approach to an archaeological landscape in which the remote sensing results make a useful contribution. A second point to bring out here, is that the survey was not used to identify the pits which were clearly visible but examine whether it was possible to characterise any internal structure to them – which it probably succeeded in achieving (although this was never tested). It is not known whether this was a cost effective approach compared with excavating the pits, but it was non-destructive and shows much promise.

Data collection is carried out after establishing a grid across the area to be surveyed. The nature of this grid is critical as it ultimately affects the resolution of results obtained (Scollar 1990, Weymouth 1986). Surveys conducted internationally and in New Zealand (e.g., Terrell 1998, Geometria 2002, De Vore 2005) routinely acquire data at 50cm intervals, which is generally sufficient, however small features may not be detected and may require a greater number of readings per square metre to define.

The results of the data collection usually require a degree of processing to properly identify “anomalies”. Various filtering processes such as despiking, low pass filtering etc can be used to reduce “noise” in the data due to modern cultural disturbances (such as paths, electrical cables, cars etc), instrument and handling errors. We do not provide details here but refer those brave readers who would like to know more to some of sources previously cited. It is sufficient to note that the mathematical techniques are used to provide “better” results, however care must be taken due to the potential of losing important data or introducing spurious features (Kvamme 2006b). An example of the usefulness can be seen in Terrell (1998) where data was subjected to several processes to pinpoint the position of suspected graves.

Reading the entrails

You’ve got to accentuate the positive, Eliminate the negative, Latch on to the affirmative, Don’t mess with Mister In-Between. (From the song, *Accentuate The Positive* by Johnny Mercer / Harold Arlen)

Having processed the data to identify “anomalies” the most crucial stage is interpreting what they might mean. Here a number of factors are likely to come into play. The research objectives and background information outlined in the research design shape the likelihood that any anomaly might be an archaeological feature and what type it might be. We can only refer once more to the English Heritage (1995:33) guidelines and point out that “it is crucial that the distinction between fact and surmise is clear”. This means that testing of any interpretation must be an integral part of any research design.

De Vore (2005:15) states “refinements in the geophysical interpretation are dependent on the feedback from subsequent archaeological investigations”. In almost all circumstances, any interpretation of remote sensing data requires some degree of testing (Hargrave 2006). This process, commonly referred to as “ground truthing”, is fundamental to the validity of the exercise. Testing the results is likely to involve at least some excavation to determine whether the interpretations can be supported. Various sampling strategies may be employed in this exercise and the results may be supported by additional, more refined remote sensing to establish the presence and character of archaeological features.

Testing allows the results to be interpreted as:

1. True positive: an anomaly that is clearly the result of an archaeological feature or event
2. False positive: an anomaly that is not the result of an archaeological feature or event
3. True negative: the lack of a anomaly which reflects the fact than no archaeological feature or event can be found
4. False negative: no anomaly is identified but an archaeological feature exists.

Examples can be found in many cases but it is important to realise that in any one area, any and sometimes all four situations may be at play.

The complexity of this may have important implications from a statutory perspective. For instance "false negatives" may mean that some features will not be identified as archaeological sites and protected and untested "false positives" afforded protection that is not warranted.

Not surprisingly there is a tendency for reports to emphasise the positive results of any investigation but in this arena, negative results – even areas which are not "anomalous" - must be well understood (and tested) as their interpretation may have serious impact on any future decisions regarding an archaeological site.

Simply the best?

Geophysical survey will not be justified in many circumstances, although magnetic, resistivity and GPR methods can be invoked when encouraged by specific expectations (English Heritage 1995:11).

The success of using remote sensing techniques in heritage management lies in understanding the context of interpreting the data rather than the data itself. For example, Ladefoged *et al.* (1995) and Bassett *et al.* (2004) both involve geophysical studies of areas of known archaeological value, a pa in one case and kumara storage pits in the other. Both studies provided excellent results for their research objectives but from a heritage management perspective, the usefulness of the data might be interpreted differently. Finding a buried ditch at the outer boundary of a pa might assist in determining the extent of a site that would need to be protected but identifying possible postholes and drainage within clearly visible pits that are already protected has less impact (if no less interesting).

One of the key attractions to using remote sensing is the argument that it would be cheaper than excavation. This derives very much from research based strategies where archaeologists have the ability to pick and choose the "best" sites and then use appropriate sampling strategies to maximise their funds to achieve stated research objectives. In heritage consultancy the situation may be quite different. Statutory processes, influenced in part by archaeologists, are designed to accommodate competing demands on land and they ultimately determine which archaeological features are preserved, damaged or destroyed. This places very different stresses on research design and methodology.

This is most obviously apparent in using geophysics to explore areas that are destined to be completely modified by a proposed development. Using remote sensing may be useful to identify target areas but if the area is going to be excavated what is the point? It adds significant cost and if it is used to dramatically change the research strategy, it is just as likely to mean that features not picked up by the techniques are less likely to be investigated (or investigated less thoroughly) than those that are identified despite their potential archaeological values. We are not arguing that remote sensing should never be done on an area that is to be destroyed but it probably should not happen a great deal and any available funds would be better directed to the excavation and analysis stages of the project.

While it may seem obvious that remote sensing is most useful in identifying features to preserve, there are caveats even to that. Foremost, preserving areas of anomalies which have not been sufficiently tested is not justified under the statutory framework that now exists and therefore may not be "reasonable." The result of preserving some areas may involve sacrificing others and just because an area is deemed less important due to a lack of geophysical visibility does not mean it is less important archaeologically.

In essence, we might argue that it is unfair to expect developers to pay for remote sensing work to identify archaeological features unless there are demonstrable benefits to them doing so in terms of meeting their statutory obligations. If this can be shown and be justified on reasonable grounds, then the opportunity to carry out geophysical research should be encouraged. This does not mean developers have to like it but it is important to recognise their stake in the process.

There may also be the opportunity to make the use of geo-prospecting for archaeological features more palatable to developers if it is part of geo-technical work carried out on a project area. We assume most consulting geophysicists make a living doing something that somebody wants, so if we can find common ground, then this might improve the situation for archaeologists.

The one major question is how effective geophysical survey is when compared with other methods of archaeological investigation. No systematic study has been carried out in New Zealand but one study from the UK compared the results of desk-based assessment, fieldwalking, geophysical survey and machine trenching (Hey and Lacey 2001). Their major conclusion was that while the non-intrusive methods of evaluations all had their merits in different situations, they all had serious problems across the range of archaeological remains examined:

> Machine trenching was the only effective means of predicting the character of the sites in this study and, even though it was more expensive than other methods, the improved quality of information and greater certainty from which to devise a mitigation strategy, made it cost effective. In practice, all the projects adopted more than one technique of evaluation and the combination of judiciously selected methods proved to be a powerful predictive tool (Hey and Lacey 2001: vii).

Interestingly, the study suggested that the single most important factor in evaluating the success of interpreting archaeological sites was the period (and feature type) from which the sites were dated (Hey and Lacey 2001: viii). Geophysical techniques were effective on Roman and medieval sites but less so on Neolithic and Bronze Age sites (Hey and Lacey 2001: viii). The crucial point to take from this study is an understanding that remote sensing techniques do not offer a panacea for archaeologists working on cultural landscapes in New Zealand and particularly those landscapes that pre-date European interaction with Maori.

On reasonable grounds

'These people,' Cicero complained to me one morning, 'are a warning of what happens to any state which has a permanent staff of officials. They begin as our servants and end up imagining themselves our masters!' (Robert Harris, *Imperium* 2006: 289–290)

In researching this paper, we were unable to identify any specific guidelines in planning documentation relating to the use of geophysics on New Zealand sites. In the UK, English Heritage published guidelines in 1995, previously referenced, providing a detailed framework about how this geophysical survey can be used in heritage management.

The lack in New Zealand reflects the differences in the uptake in geophysics here, the legislative framework and the differences in both the socio-political and archaeological landscapes in which stakeholders in New Zealand heritage management engage.

As in research-oriented approaches, the main objectives of using geophysical survey are to determine the location, extent and character of archaeological features in a particular area. In 1999 Walton, in providing a detailed guide to assessing values of archaeological sites in New Zealand, concluded:

> Geophysical survey… is little used for practical and interpretative reasons. Even when archaeological remains are detected, it is often difficult to determine the nature, quality, and age of the remains…There is, nonetheless, potential for further development of these methods in terms of better resolution of data and use of computer graphics to improve representation of data and interpretation (Walton 1999:17).

Recent changes in technology have certainly improved the quality of outputs from geophysical studies but the evidence that this has improved outcomes for heritage management remains more elusive.

Despite the problems, both Territorial Local Authorities (TLAs) such as the Auckland City Council and Auckland Regional Council, along with the New Zealand Historic Places Trust (HPT) have been using, or advising the use of, remote sensing techniques in heritage management. For the TLAs, the attraction of remote sensing lies in being able to use a non-destructive technique to assist in managing heritage resources that fall under their purview via the Resource Management Act (RMA). This allows some scope in avoiding the statutory requirements of the Historic Places Act (HPA) as they can avoid damage to a site while also allowing them to provide useful management data from those heritage items not directly covered by the HPA (such as post-1900 sites).

For the HPT, remote sensing offers the possibility of an additional tool for countering, or at least deflecting, the very aggressive pressures of recent growth in the local economy. Better identification of archaeological sites without the need for excavation allows greater opportunity for preservation of sites prior to any development.

In the case of burial sites, of whatever age, the use of remote sensing can be particularly appealing to both TLAs and the HPT given the significant sensitivities of these sites to local communities. In these cases, the more information, the better directed any work can be.

The dangers lurk both in the methodological and political realms. In some sense remote sensing will always produce a "result" whether anomalies are identified or not, and prove to be positively associated with archaeological features or not. If planning decisions may be influenced by these results then it is crucial that these possibilities are properly identified, sufficient testing carried out to validate any interpretation and that this is all properly communicated to the non-specialist audience. There is a real danger that if legal processes are used to protect a geophysical anomaly that is not sufficiently proven to be archaeological in nature then not only does it bring archaeological practice into disrepute but there may be a legal consequence. Equally, the failure of a remote sensing exercise to find archaeological features may mean that sites and features will be unnecessarily destroyed without proper evaluation.

One example of the HPT's promotion of remote sensing during a statutory process highlights these difficulties. A condition of a recently issued Authority 2006/159 for one area in central Auckland stated:

> [Condition] '4. That prior to any initial earthworks in the area of the western portion of the proposed construction site, including the area of the existing grandstand at the Domain end of the proposal, the ground surface shall be assessed and investigated with a fluxgate magnetometer in 0.5 x 0.2m grid sections to determine the potential for further subsurface features associated with historic occupation of the site.'

We note three aspects relating to this project:

1. The area described for the research is in an urban setting, near standing structures and where there have been significant activities over the last 150 years. Geologically also the soils in this part of Auckland contain high iron content.
2. The area covered by this Authority will be completely modified by the proposed development
3. A specific remote sensing technique is identified.

It should be apparent based on the analysis presented earlier, that several difficulties arise from such a heavy-handed approach. Firstly, the English Heritage guidelines point out that geophysical survey in urban environments is highly problematic and given the specific conditions in central Auckland this is probably made worse.

Secondly, we question the reasonableness of expecting a developer to pay for geophysical testing in an area that will require full excavation under archaeological supervision.

Thirdly, in specifying a specific technique, the HPT makes the use of this technique an issue of legal compliance rather than that of archaeological method. This means regardless of appropriateness of the technique suggested there is little option but to use even if, during the course of a project, it proves not to be the most appropriate. We argue that such specificity is best left in the research strategies submitted to the HPT and which can be modified in consultation with all parties throughout the project. A further consequence is that as a compliance issue, the use of the technique is simply a matter of whether there is an attempt to carry out such an exercise rather than whether it provided any useful information for the archaeological or statutory processes.

One other possible complication in the New Zealand situation that may also occur is that with a relatively limited pool of geophysical practitioners, the specification of a particular technique, or even operator, might place an unnecessary burden on the developer to comply by placing the suppliers of that service in a strong competitive advantage with legal implications for all parties. This would not only undermine the credibility of the statutory process but also limit the acceptance of the wider range of possibilities offered by consulting geophysicists now available.

Finally we highlight the need to provide a process for the storage and management of the data collected from surveys. Currently there is not central resource for the effective archiving of the data collected from surveys, such as the Archaeology Data Service (e.g., Schmidt n.d.) in the UK. This data may be useful both for projects in the area where it was collected, at some future time, and to inform on other similar projects within New Zealand. Only textual information is currently required by the statutory bodies.

Ground truths

"The Truth is Out There". The X Files (TV 1993)

The analysis of the role of geophysics in heritage management in New Zealand presented here suggests a number of points. These include:

1. Remote sensing in heritage management still remains in the arena of scientific endeavour rather than as an "out-of-the-box" commercial application.
2. The use of remote sensing techniques should be carried out within well-constructed and explicitly outlined research strategies that detail the objectives, methodologies and interpretation of the results.
3. The classification of "anomalies" as archaeological must be made carefully. This involves using corroborative data from independent sources (e.g., archival information), explicit sampling strategies and most importantly, test excavations to "ground truth" the results.
4. Areas that are not classified as "anomalies" by a remote sensing technique may be of archaeological value and must also be tested.
5. Whether geophysical surveys can be considered more cost effective than excavation must be considered on a case-by-case basis and particularly if excavations are going to be carried out as part of an authority.
6. Significant research is required to examine how remote sensing techniques can be effectively used for identifying archaeological features found in New Zealand and in New Zealand conditions.

7. The need to provide a centralised storage of geophysical information relating to archaeological sites in an accessible format so that the information from projects can be re-analysed as research continues and used to inform future projects.

Overall, we argue that the use of geophysical data in statutory planning and protection processes must be done within a defined, scientifically-backed framework to provide an explicit and reputable basis for decision making. Most probably any benefits of geophysical survey are likely to be maximised if the survey work is carried out earlier in the statutory process.

We have purposefully constructed "straw-men" to tilt at, but hope that the comments here provoke a response that leads to improved strategic integration of remote sensing techniques for heritage management. This can only be done if the various stakeholders in heritage management embrace the deal for continuing dialogue and recognise the benefits and limitations of remote sensing techniques as they evolve. In some situations remote sensing may be unnecessary while in others in could be crucial. Each case has to be evaluated within a well constructed framework. We do consider that, to date, the results in New Zealand suggest that the onus of proving the effectiveness, both scientific and statutory, of remote sensing techniques for heritage management remains with its proponents. The "luddites" have good reasons to remain sceptical but will have to be responsive to appropriate situations for remote sensing.

We conclude by arguing that there are at least three "truths" for carrying out geophysical studies for archaeological purposes in New Zealand. Firstly, *Ground truth No 1*, Geophysical studies on archaeological projects must be grounded within an explicit archaeological research strategy requiring both archaeologists and geophysicists to work together. Secondly, *Ground truth No 2* is that the detection of geophysical anomalies (or lack of them) does not fulfil either professional or statutory criteria for the identification of archaeological features without suitable corroboration. Finally, *Ground truth No 3* is that while the potential of remote sensing in archaeological practice in New Zealand remains high, the onus is on practitioners and statutory bodies to prove its effectiveness by ensuring high standards of practice. For New Zealand archaeologists using geophysics, the truth remains out there: in the ground. We will probably have to use a spade, trowel or digger to find it.

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