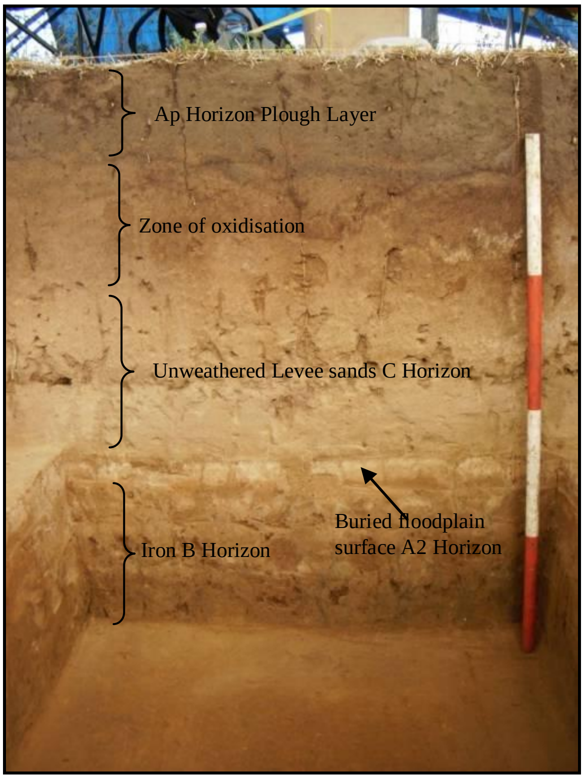
Draft

Final Archaeology Report
on the
Test Excavations
of the
Jordan River Levee Site
Southern Tasmania



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August 2010

Someone will remember us... even in another time. Sappho (600BC)

Foreword

I recall as an undergraduate student being handed an Acheulean axe from a European archaeological site dated to more than a hundred thousand years ago. Holding something so old from my own ancestors had a powerful impact on me. I mention this, because when I visited the Tasmanian Aboriginal Centre in Launceston to talk about the preliminary results from the Jordan River Levee excavation I took along with me some of the stone artefacts, which had, just a few days before, been dated to about 40,000 years - the oldest site yet known for Tasmania. I watched people holding those tools and I could see that same powerful connection take place that I had felt years before.

It is hard for anyone to conceive intellectually of something that is 40,000 years old. After all, most of us only live in terms of decades and years. Hardly anyone even remembers the names of their great grandparents, and generations before that time are almost entirely forgotten. When we do occasionally make a connection with our deeper past it nearly always sparks a profound emotional reaction, rather than an intellectual one. It did with me when I held that Acheulean axe, and I could see the same thing in Launceston as people passed around the stone tools from the Jordan River. I can only guess that our reactions are a way of reaching across all that time to people whose culture and genes we are a part of, and who may have wondered if in the future someone would remember them.

The archaeological excavations at the Jordan River, that are the subject of this report, give readers a scientists' view of the site. While this is important, it should not diminish the status or strength of the cultural connection that Aborigines can have with their places. That deep and powerful connection, that I have alluded to above, is really how most of us connect with the past and how we also define ourselves in the present. The barrage of scientific techniques, data management, statistical tests and jargon contained in this report, while impressive and sometimes daunting, are in the end just methods and a means of allowing cultural and emotional connections to be made across great spans of time. There will be a separate Social, Cultural and Historic Report produced through the Aboriginal community that will make more poignant this deep engagement of people to their past and their places, by examining the threads of that connection. But, in the end, establishing that connection is also at the core of all of the archaeological work we have undertaken.

This report is essentially about a relatively small archaeological test pitting programme undertaken on a levee on the Jordan River near Brighton in southeast Tasmania. The project has an interesting history that is discussed passim throughout the report. But for many readers the prime interest will be the factual results, briefly summarise here:

- The site is located on the western side of the Jordan River, near Brighton in southeast Tasmania (Figure 1.1).
- The site was found by Aboriginal Heritage Officer, Aaron Everett, and later recorded in 2008 by Aaron and archaeologist Dr Tim Stone during a Department of Infrastructure, Energy and Resources (DIER) initiated archaeological survey for the Brighton Northern Bypass.
- Only part of the levee is implicated in the bypass proposal and the investigation was confined close to this area. The levee itself is about 600 m long and 60 m wide. Much of the levee is located on private land.
- Initially the site was recorded as a small surface scatter of 17 or so stone artefacts (a campsite). However, the field team archaeologist Dr Stone recognised the landform on which the artefacts were located as a levee deposit. Such deposits are typically formed on floodplains as rivers break their banks and deposit numerous thin layers of silty sand. This process can occur over many thousands of years and, if occupied by Aborigines, artefacts can be buried in layers within the levee. Such sites are very rare and can provide snapshots of the past encased within the sandy sediments. Nearly every other open hunter gatherer site in Australia has been highly disturbed, making them difficult to either date or analyse.
- To test the potential importance of the site, archaeologist Rob Paton was engaged as Principal Archaeological Director to work alongside Site Director Cornelia de Rochefort, Aboriginal Heritage Officers Aaron Everett, Bob Hughes and Leigh Maynard and Dr Tim Stone (geomorphologist).
- In consultation with the Aboriginal community a method of investigating the levee was devised. This involved excavation of eight trenches across the site, both within the area proposed to be impacted by road construction and outside it (Figure 1.2).

- Careful excavation of the sediments over a 6 week period revealed that stone artefacts existed to a depth of about 70 centimetres below the surface. These artefacts are the remains of the day to day lives of the people who once lived along the banks of the Jordan River. On average we found about 70 artefacts per square metre of excavated deposit - a total of 1403 stone artefacts. We estimate that over the length of the entire levee there could be about 2.5 million artefacts. Artefact specialist Dr Sophie Collins has analysed these finds for this report.

- To determine the age of the levee, and the length of Aboriginal occupation at the site we used a dating method known as Optically Stimulated Luminescence (OSL). While this is quite a complex form of dating, it essentially tells us the last time when sunlight fell on the sandy deposits before they were covered, encasing the stone artefacts. The dating was undertaken by Dr Matt Cupper from the University of Melbourne. We have received final OSL dates for the levee. These are:
  JR03 (0.45 m depth) 26,600 ± 2.6 ka
  JR04 (0.55 m depth) 34,000 ± 2.8 ka
  JR05 (0.65 m depth) 37,500 ± 3.8 ka

- Employing an age/depth curve to the data (Figure 8.2) gives a date for the bottom of the levee and the artefacts in these sediments of about 41,000 years. This is the oldest site in Tasmania, and amongst the oldest in Australia. As such it has the potential to give us a glimpse into an unknown part of world history and the spread of *Homo sapiens* across the earth.

- Our readings of the sediments also seem to be telling us that the part of the levee that contains the archaeological material is mostly undisturbed (apart from the upper plough zone). This means that the site has the potential to allow us to pick out individual living floors and events from the distant past. This is almost unheard of from an open air site, anywhere in the world. Most sites with this potential are cave deposits that often reflect only a very small and specialised part of the lives of people.

- Our work so far certainly indicates this is a scientifically very significant and exciting site. It has the potential be an important place for interpreting the deep history of Tasmania, but also of archaeology on a world scale.

- We have worked closely and collaboratively alongside the Aboriginal community on this project and have been supported in our investigations by DIER. Recognising the potential importance of the site, DIER has lent all the support needed to conduct a high standard investigation.

The reader of the report needs to be aware that we began the excavations with nothing beyond a landscape assessment to substantiate our intuitive views that this was an old and scientifically important site. No proper levee deposits had been excavated by archaeologists in Australia before, and all indications were that most open sites were going to be unstratified and highly disturbed. In this sense, it made our work very much a first stage test pitting exploratory dig. The report, results and conclusions need to be read with this clearly in mind. Had we known the antiquity of the site and the nature of the deposits, we would have excavated differently, with different research questions directing the methodology. We would, for example, have proposed excavating a larger single area to help detect living floors and to obtain a larger artefact sample to statistically model cultural changes more effectively. Similarly, we would have had in place a more detailed OSL programme to refine and test models of site stratigraphy. Any archaeologist with a mature grasp of the discipline, fieldwork and the research process will immediately recognise the slight impatience one feels when a first stage test excavation uncovers a site of such immense promise, but the data do not always allow one to realise its potential immediately. All research is like this, with as many questions being raised as are answered at each stage.

Our investigation was foremost a simple information gathering exercise aimed at providing fuel for discussion about the Brighton Bypass proposal. We were not engaged to mitigate impact for the bridge crossing of the Jordan River. This was made quite clear in our Permit and in discussions with the Aborigines. In fact, there was no firm bridge design put forward until after we had completed our fieldwork and results began to filter through. Our job was quite a straightforward part of a process aimed at providing technical information to all parties to allow them to work through what had become a very public debate about cultural resource management in Tasmania. In this sense, our job has been completed. Enough is known about the site to assess it as being of great national and international importance, and we have a good grasp of the nature of the deposits and the site. This has been acknowledged, without argument, by all sides in the discussion. The conversation between parties continues to resolve matters with this information in mind. Certainly, there are a few more minor tasks to do to complete this test pitting phase of the project (see Recommendations), but for the most part, our work is done. My own feeling is that from an archaeological point of view, we should leave the levee intact and develop a long term strategy for its preservation. Further excavation should not occur until timely, specific and well thought out research questions, approved by the Aboriginal community, are developed.

Readers will note that we have focussed a good deal of our research in this report on the geomorphology of the site. The reason for this focus is to establish the credentials of the site in terms of its stratigraphic integrity. No matter what the age of the site, this was always going to be a major issue. If we were unable to provide some evidence that the site, or parts of it, were stratigraphically intact, the scientific significance of the site would have been markedly diminished. It would also have suggested that our hypothesis about stratified sites being located in proper levee deposits (not just sand bodies of any kind) may have been wrong. We have made the point strongly in the report that unless archaeologists can demonstrate the integrity of deposits using a variety of techniques, open site interpretation will always be brought into question.

The OSL tests provided valuable data to age the site, but of perhaps more significance was the insight they gave us about site integrity. Single grain OSL readings were chosen instead of bulk samples because they give us a notion of mixing of sediments as well as an age. Bulk samples cannot achieve these dual aims: they simply provide an age. The results from our samples showed little if any mixing of the lower levee deposits, a very pleasing outcome. Had these samples shown disparate arrays of the single grain readings, we would have had a disturbed site with limited ability to answer research questions about cultural change over time.

At the time of excavation we made a decision to take only five OSL samples initially. Doing more, without knowing anything about the nature, integrity or age of the site could have been fruitless and wasteful. Results from the five samples have now raised a series of other questions about the integrity of the upper disturbed layers. Also, we now need to date levels from several of the open trenches via OSL to give us, or others, the ability to achieve more fine grained alignment of artefact layers between pits. For these reasons we have recommended that further OSL samples be taken before our test pits are backfilled.

The artefact analysis was restricted somewhat because of the difficulties of fine grained temporal alignment between trenches. This was dealt with admirably by Sophie Collins, our artefact expert, in collaboration with Glen McPherson the project statistician. They also had to deal with the problems that have arisen because of small sample sizes from some layers. As said before, it is in the nature of initial test pitting that one does not know what is going to be found. Future researchers will, at least, have the benefit of our results to design methodologies accordingly. I would counsel, however, against excavating the site further simply to get a larger sample to satisfy statistical confidence tests. Archaeological data is, in a sense, a product of our methods, but it also has a character of its own that we are obligated not to damage simply to get a statistically significant sample size.

Completing this test pitting phase of the project has involved collaboration with many people. We have been shown great patience and kindness throughout this collaboration by all concerned.

The Tasmanian Aboriginal community have been very supportive of our work. In particular we would like to thank the three Aboriginal Heritage Officers who worked with us on site: Aaron Everett, Bob Hughes and Leigh Maynard. We look forward to working with them again in the future. There was a long period before the fieldwork where the Aboriginal community questioned the heritage processes and our role in that process. I would like to thank members of the Tasmanian Aboriginal Centre and the Tasmanian Aboriginal Land and Sea Council for taking the time to listen to us and provide advice and feedback. My personal thanks go to Michael Mansell, Jim Everett, Heather Sculthorpe and Fiona Newson.

The archaeological project was a DIER funded initiative. I know that for any developer dealing with extremely complex, publically debated heritage issues, it can be stressful. They are placed in the difficult position of dealing with the unknown - the as yet undiscovered archaeological record. I must say, however, that DIER officers maintained their full and enthusiastic support for the archaeological project throughout the process. Public Servants rarely get individual praise, but in this instance I would like to thank Selena Dixon, Andrew Fowler, Phil Cantillon, Norm McIlfatrick and Suzie Jacobson.

Personnel from Aboriginal Heritage Tasmania (AHT) likewise have shown unflagging support for this project and have been available at the shortest notice to lend whatever assistance we needed. I acknowledge and understand the pressure they have worked under. My thanks go to all the staff at AHT including Steve Gall, Michael Jones, Don Ranson, Zoe Rimmer, Liz Tew, Adam Black and Colin Hughes.

Our own archaeological team worked double shifts seven days a week to complete the fieldwork. I would like to thank them all: Jane Kwan, Marta Piech, Tom Brown, Justin Wickham, Rose O'Sullivan, Kate Rogers, Trent Graham, Tiani Borg, Alex Brewin, Alice Flynn, Dave Wines, Jenni Streafield, Parry Kostaglou, Daisy Chaston, Fiona McKeague, Laura Puddicombe and Brenden Etches.

Our senior archaeological team need also to be acknowledged. Cornelia de Rochefort was responsible for Directing the site excavation and writing many sections of the report, particularly the difficult and complex geomorphological interpretation. Tim Stone originally recognised the levee deposit and its archaeological potential. Tim's insight has carried through to the on-site analysis and reporting. Sophie Collins, working with Glen McPherson, undertook the highly complex artefact analysis. Sophie wrote the elegant report sections dealing with the artefacts. Matt Cupper undertook the crucial OSL dating and analysis. Matt managed to fit our samples into his very busy schedule. We acknowledge Matt's seminal role in this project. Dave Wines examined the modern animal bones from the site and reported on his findings. Wilfred Shawcross provided an overview of the site and its place in the archaeological record. Marta Piech and Rose O'Sullivan proof read and helped edit the documents. Professor Isabel McBryde discussed the project with me many times and I thank her for her insights and support.

Rob Paton
Principal Archaeologist
August 2010

Table of Contents

List of Figures

List of Plates

List of Tables

Executive Summary

Project Background

The Department of Infrastructure, Energy and Resources (DIER) is proposing to construct the Brighton Bypass to take road traffic on the Midland Highway around the townships of Brighton and Pontville in southern Tasmania (Figure 1.1). The Brighton Bypass Project extends north from the Derwent River to Pontville, mostly alongside the valley of the Jordan River. The project has a 'Northern Section' and a 'Southern Section' to be built concurrently with the proposed nearby Brighton Transport Hub.

In order to investigate the potential impact on Aboriginal heritage values resulting from the proposed road development, Tim Stone and Aaron Everett (2008) were engaged by GHD Pty. Ltd. to conduct an Aboriginal site survey of the Northern Section. A result of this investigation was the identification and registration of TASI 10757. This site comprises a surface scatter of stone artefacts on a floodplain landscape on the west bank of the Jordan River, near Brighton 30km north of Hobart. The floodplain landscape consists of several geomorphic features, one of which is a levee bank deposit. The surface artefact scatter identified by Stone and Everett (2008) as TASI 10757, is primarily, but not entirely, associated with the levee deposit (Figure 1.2).

The levee bank deposit was assessed as having the potential to contain a deeply stratified cultural sequence. That is, it had the potential to contain ancient intact living floors. As a result of this assessment it was recommended that a controlled excavation of a targeted sample of the levee deposit, the Jordan River Levee (JRL) site, be undertaken to test the character of the site. This testing programme was to be undertaken in collaboration with the Tasmanian Aboriginal community represented by an Aboriginal Heritage Officer (AHO).

Initial excavation of the JRL site was carried out under the directorship of Rob Paton, and the supervision of Tim Stone and Cornelia de Rochefort, over a period of three weeks from the 3rd August to 24th August 2009. The proposed scope of work and methodology for the archaeological excavation was developed by Rob Paton with reference to Stone and Everett (2008). This method statement was endorsed by Aboriginal Heritage Tasmania (AHT) and a Permit issued (Permit 911). However, issues were raised regarding appropriate collaboration with the Tasmanian Aboriginal community after Permit 911 had been issued. The Tasmanian Aboriginal Centre (TAC) requested that works be postponed until the matter could be resolved. As a result, excavation at the site ceased on 24th August 2009.

After considerable discussion between various parties a new methodology was submitted by Rob Paton, again with reference to Stone and Everett (2008). Works resumed at the site, with the endorsement of the TAC, the Tasmanian Aboriginal Land and Sea Council (TALSC), and AHT. This second stage of excavation was undertaken under the directorship of Rob Paton and Cornelia de Rochefort from the 8th to 26th February 2010. Specialist geomorphological services were provided by Dr Tim Stone and Dr Matthew Cupper, while Dr Sophie Collins provided on site supervision and management of artefactual material.

Subsequent to this testing programme, the results of the geomorphological assessment indicated that the JRL site had the potential to be of great antiquity, with Optically Stimulated Luminescence (OSL) results showing the deposit was up to 41,000 years old. The OSL results also suggested that the dated sandy deposits had undergone minimal post depositional mixing, indicating good stratigraphic integrity for the associated archaeological material. In light of this potential DIER amended the development proposal so as not to impact the JRL site, defined as the levee bank deposit. Instead they proposed that a bridge would span the JRL site with development impacts confined to the floodplain to the west and east of the levee bank deposit.

Aboriginal Consultation

Throughout archaeological investigations along the northern section of the proposed bypass route, there was considerable discussion of appropriate collaboration with the Tasmanian Aboriginal community. Detail of this consultation process and resolution has been reported on by Paton (2010) in the revised excavation methodology for the JRL site, attached as Appendix 1 to this report.

Aboriginal consultation was undertaken according to best practice principles in the absence of detailed Aboriginal heritage consultation protocols in Tasmania. Prior to excavation works recommencing on the levee site it was made clear that all archaeological work would be undertaken with the participation and approval of the TAC and the TALSC (refer to Appendix 1: Revised Methodology).

Aboriginal Heritage Officers Aaron Everett and Robert Hughes were present on site during the first stage of excavations from the 3rd to 24th August 2009 and during the second stage of excavations from 8th to 26th February 2010. Leigh Maynard was also present for the second stage of excavations. Further to this, Aaron Everett facilitated a community meeting on site, where various members of the Aboriginal community toured the site and were given the opportunity to contribute to the consultation process.

Excavation Strategy

The test excavation of the JRL site had two key objectives. The first was to determine if the site contained a stratified cultural sequence. The second was to demonstrate the degree of site integrity. The strategy involved the controlled excavation of four 2m x 2m excavation trenches and four 1m x 1m trenches. Trenches were aligned both perpendicular to the strike of the levee ridge, and parallel to the strike of the levee ridge (Figure 1.2). By aligning the excavation trenches across the levee ridge in this way, two cross sections of the landform may be exposed. The number size and distribution of these test pits was discussed in detail with the Aboriginal community, AHT and DIER. Apart from the archaeological research goals, we excavated under an understanding that we would damage as little of the site as possible. Considerable thought went into balancing damage to the site against retrieving enough information to allow people to understand something of the general character of the JRL site.

The deposits were excavated in 5cm spits or layers, by hand with trowel and brush in order to record and photograph artefacts *in situ*, and make detailed observations of the soil profile. Each 2m x 2m test trench was divided in to four squares (labelled 1-4), with each square further divided in to four quadrants (labelled A-D). This enabled a degree of spatial control for the artefacts that were retrieved from the sieves. All excavated sediment was placed in labelled buckets according to square and quadrant. Each bucket was recorded in a sieve log before being wet sieved by hand, through a 3mm sieve plate.

All artefactual material was bagged and labelled according to provenance and retained for further analysis. The fine sand that forms the levee deposit is ideal material for Optically Stimulated Luminescence (OSL) dating methods. Five samples were collected in total, with three being collected from Trench 2 and two from a quarry cutting located in close proximity to the JRL site. The quarry cutting provided the opportunity to date the basal sands of the floodplain deposit on which the levee was formed, allowing for a more complete geomorphological reconstruction of the site. Furthermore, a geophysical investigation using Ground Penetrating Radar (GPR) was employed at the site because of the potential for the loose sandy deposits to contain Aboriginal burials. The results of the GPR investigation showed no evidence of human burials.

Results

The TASI 10757 site represents the broader landscape setting of the JRL site. The TASI 10757 landscape is known to comprise four landform units: a buried and ancient floodplain unit; the levee deposit situated on top of this ancient floodplain unit; a modern floodplain unit; and back swamp deposits to the east and west of the levee respectively.

The two OSL ages from the buried floodplain unit show a major and rapid episode of riverine deposition in the Jordan River valley commencing before 60,000 years ago. This deposition ceased ~50,000 years ago and the river began to cut back into the sediments deposited in the valley. This cut off sediment supply to the older floodplain surface. Consequently, a weakly calcareous red brown alluvial soil developed on the abandoned floodplain. This soil surface would have been an ideal site for early Aboriginal occupation, although no such evidence was identified.

Construction of the levee on the older floodplain surface commenced ~41,000 years ago. The levee unit is comprised of three stratigraphic units. The unweathered basal sand unit (dating from 41,000 to 26,000 years old), an oxidised unit identified as a zone of maximum biological activity and a surface plough zone unit. The upper two units have not been dated at present. The three OSL ages thus far obtained from the unweathered basal sand unit show gradual overbank deposition over a period of ~12,000 years. However an age depth trend line fitted to the three OSL ages suggests that the levee formed from ~41,000 to 12,000 years ago, a period of ~30,000 years.

With climatic amelioration during the Holocene (from 10,000 years ago), the hydrological regime of the Jordan River changed and conditions for levee formation ceased. The modern floodplain unit east of the levee formed during this period of time.

The nature and extent of the back swamp deposits on the distal floodplain are unknown as these were not the subject of this investigation. The only information regarding this unit comes from one excavation trench, which contained up to 50cm of ploughed silty and clayey sediment. The older floodplain unit is 50cm below the surface in this trench and is likely to extend further to the west.

The alluvial architecture of the Jordan River, including the JRL site, was formed during a period of extreme landscape instability. Fluctuating climatic conditions during the Last Ice Age undoubtedly influenced the behaviour of the Jordan River. However the alluvial sequence cannot confidently be tied to broader palaeoclimates without further investigation and dating. In any case, the complex response of fluvial systems to climate change makes correlation of the alluvial sequence to climatic episodes inherently problematic. For this reason, the back swamp deposits to the west of the levee unit may prove a more useful environment to retrieve palaeoclimatic information. The back swamp deposits have the potential to contain deep clayey and silty sediments. If conditions over time have permitted, these deposits may contain a detailed vegetation record of the environmental conditions during the period of human occupation.

However, the real value of the JRL sequence is that it provides a rare insight into a period of human history during the Last Ice Age, of which little is known, either in Tasmania or on the Australian mainland. This is particularly the case at open sites with nearly all older Tasmanian sites being rockshelters.

The archaeological material retrieved as a result of the excavation process was primarily associated with the levee bank unit.

An important archaeological consideration in any excavation is the ability to prove that artefacts found within buried sediment actually correspond to the radiometric dates retrieved. Put simply, the OSL method dates the last time a single sand grain was exposed to sunlight, it does not date the artefacts. One of the most important tasks faced by an archaeologist is to prove the association of the buried artefactual material with the dated sediment. This association cannot be assumed.

For this reason, a detailed analysis of site formation process and post depositional disturbances to the JRL site has been undertaken. The primary question is whether the artefacts were buried when the levee was forming, or did another process bury the artefacts after the levee formed? One of our tasks was to prove that the artefacts were buried during the formation of the levee in order to associate those artefacts with the OSL results. This is how we are able to make statements about the great antiquity of Aboriginal occupation at the site.

The essential goal of stone artefact analysis is to provide a detailed understanding of the prehistoric technology at a site and its relationship to the hunter-gatherer populations responsible for its manufacture and use. The purpose is to increase our understanding of prehistoric behaviour by examining changes and adaptations over time.

The JRL site was utilised by highly mobile prehistoric hunter-gatherer groups. The lack of locally available raw material forced groups to bring their own raw materials to the site, to conserve these raw materials and to continue to transport those items that were not exhausted for future use elsewhere. The primary activities undertaken at the site were tool maintenance and rejuvenation, with very low levels of manufacture also present. Artefact densities at this stage indicate that groups occupied the site for short term visits only; the lack of locally available raw material and inability to manufacture new tools at the site is a likely cause.

The presence of Aboriginal flaked pieces of glass at the JRL site provides evidence of a connection between Aboriginal and European occupation at the site during the historic period. This site with its sound stratigraphic profile and dates extending from ~41,000 years through to the European contact period is remarkable. The JRL site records the long and vital history of Aboriginal occupation in the area.

Management Recommendations

General Recommendations

1. Copies of this Draft Final Report should be supplied to the TAC offices, the TALSC, DIER and AHT. Comments on the report should be sought from these organisations. These comments need to be considered when making any decisions about site management.

2. The archaeologist should be available to present the report verbally to key individuals and organisations.

3. This report should be read in conjunction with the separate Social, Cultural and Historical Report being prepared by an Aboriginal Heritage Officer and historian. If made available, cognisance needs to be taken of the contents and recommendations of that report when considering management options for the Jordan River crossing.

4. Discussions should commence with the Aboriginal community regarding the curation of the stone artefacts from the excavation. The range of options - from reburial to Museum storage etc. - should be canvassed with the community. The project archaeologist should be available to meet with the Aboriginal community to discuss the various options.

5. A Cultural Heritage Management Plan (CHMP) should be developed for the JRL site, in consultation with the Aboriginal community. The CHMP should consider the levee as a whole unit and take into account the findings of this report as well as the Social, Cultural and Historic report being when prepared by the Aboriginal community representative and historian. Obviously, the key component of the CHMP will be the ongoing management of the site, ideally by the Aboriginal community. This may be a complex process as much of the levee is private land. Some large sections to the north of the proposed bridge are government owned.

Archaeological Recommendations

6. The JRL site is a scientifically important site. We strongly recommend that the levee, as an archaeological site, be preserved and protected. In the long term this can be achieved by the development of a detailed CHMP as recommended above. In the short term measures need to be taken to preclude any development activities that would impact directly on the levee, as it is defined in this report.

7. The test pitting programme reported in this document could, with the permission of the Aboriginal community, be supplemented with further excavations to provide additional samples, or to answer in more detail the research questions about the JRL site. However, for a number of reasons I would strongly recommend that no additional archaeological excavations of the levee take place at this time. Firstly, there are still a number of tests (pollen, OSL dating, conjoining) that should be undertaken as part of this initial test pitting programme. The details of these tests are discussed below. Secondly, it would be, in our opinion, destructive to dig more of the levee simply to get a statistically larger sample of artefacts to satisfy mathematical confidence tests. Thirdly, this an important site, and before any additional archaeological excavations take place, refined, timely and detailed research questions need to be formulated taking into account the findings of this report as well as the Social, Cultural and Historic report. Finally, the value of any additional digging needs to be discussed with, and endorsed by, the Aboriginal community.

8. It is recommended that the following archaeological works be undertaken as part of the current test pitting programme:

> **8a.** Pollen cores should be taken from the backswamp deposits on the western side of the levee, if suitable sediments exist (see Figure 8.1). Analysis of these cores could potentially provide a useful environmental record to help interpret the cultural sequence from the levee. The pollen core report should form a later addendum to this report.
>
> **8b.** If permission is obtained from the Aboriginal community, a conjoin analysis should be undertaken on the artefacts from Trenches 1-8. This analysis will provide highly useful information on artefact reduction sequences as well as the integrity of the site. Again this report should form a later addendum to this report.
>
> **8c.** Further OSL dating of the site is essential to: (1) enable an alignment of the artefact levels between the trenches; (2) further assess the geomorphic modelling for the site in this report; (3) further refine the age of the site. Approximately 10 additional samples will be needed. This number may have to be refined in consultation with the dating laboratory. Samples should be taken before the trenches are backfilled. Sections of this report will need to be revised when the new OSL data are available.

9. The eight test trenches should lined with a permeable membrane and backfilled with clean sand. A stainless steel metal peg engraved with the trench number should be placed immediately below the ground surface at the northwest corner of each pit to allow their accurate relocation in the future.

Mitigation

From the outset it was made clear that this current study was a research investigation designed to inform discussion about the Jordan River crossing and its potential impact on Aboriginal cultural material. When we began the investigation nothing was known about the character of the JRL site. The current bridge proposal had not been designed at this stage. Our analysis of the landscape and stratigraphy derived from our investigations and DIER bore holes (detailed in this report) indicates the boundaries of the levee are approximately from its face at the east to Trench 8 in the west. Archaeological material is likely to occur further west than Trench 8, although this will be in a disturbed context and not on the levee. To the east is a modern floodplain that has been test pitted and is unlikely to contain Aboriginal cultural material.

To mitigate impact on the JRL site, and the wider site TASI 10757, the following is recommended:

10. Consider the comments from organisations and individuals to this report and the Social, Cultural and Historic Report if it is made available.

11. Have an on-site meeting as soon as possible with the Aboriginal community including representatives from the TAC and the TALSC. A detailed on-ground description can then be given by DIER engineers about the exact impact of the proposed Jordan River Crossing. The archaeologist should also attend this meeting to provide advice. Without this on-ground meeting, there is likely to be considerable confusion about ongoing plans.

12. Based on the above meeting, devise a plan to mitigate impact. This could, but should not necessarily include things like fencing a buffer zone and further test investigations. This mitigation plan could form part of the CHMP.

1 Introduction

1.1 Preamble

The Department of Infrastructure, Energy and Resources (DIER) proposes constructing the Brighton Bypass to take road traffic on the Midland Highway around the townships of Brighton and Pontville in southern Tasmania. The Brighton Bypass Project extends north from the Derwent River to Pontville, mostly alongside the valley of the Jordan River. The project has a 'Northern Section' and a 'Southern Section' to be built concurrently with the nearby Brighton Transport Hub.

In order to investigate the potential impact on Aboriginal heritage values resulting from the proposed development, Tim Stone and Aaron Everett (2008) were engaged by GHD Pty. Ltd. to conduct an Aboriginal site survey of the Northern Section. This investigation identified site TASI 10757. This site comprises a surface scatter of stone artefacts on a floodplain landscape on the west bank of the Jordan River, near Brighton 30km north of Hobart (Figure 1.1). The site is bounded to the east by the Jordan River and to the west by the rail line. The floodplain landscape comprises several features, one of which is a levee bank deposit. The surface artefact scatter identified by Stone and Everett (2008) as TASI 10757 is primarily, but not entirely, associated with the levee deposit (Figure 1.2).

Figure 1.1: Location of the JRL site and study area

The levee bank deposit was assessed as having the potential to contain a deeply stratified cultural sequence. That is, it had the potential to contain ancient intact living floors. As a result of this assessment it was recommended that a controlled excavation of a targeted sample of the levee deposit, the Jordan River Levee (JRL) site, be undertaken to test the character of the site. This testing programme was to be undertaken in collaboration with the Tasmanian Aboriginal community represented by an Aboriginal Heritage Officer (AHO).

1.2 The JRL Site

The Jordan River Levee site comprises the levee bank deposit situated on the alluvial floodplain unit identified as TASI 10757. The floodplain is approximately 1000 metres long and 300 metres wide. The levee bank deposit is approximately 0.6 to 0.8 metres deep, 600 metres long and 60 metres wide. In this instance, site size has been inferred from an on-site evaluation by Stone and Everett (2008), and through archaeological test excavation. The western boundary of the site has been inferred from the excavation of Trench 8 located at the distal end of the levee bank. The western boundary of the levee bank is unlikely to extend in a straight line north and south from Trench 8 and is more likely to be sinuous in nature. The eastern boundary of the site is identified as a break in topography as the levee is situated above the modern floodplain. A discussion dealing with the identified and inferred boundaries of the site is presented in Section 13. The boundaries of the site should be treated as indicative only.

1.3 Project History

Initial excavation of the JRL site was carried out under the directorship of Rob Paton, and the supervision of Tim Stone and Cornelia de Rochefort, over a period of three weeks from the 3rd August to 24th August 2009. The proposed scope of work and methodology for the archaeological excavation was developed by Rob Paton with reference to Stone and Everett (2008). This method statement was endorsed by to Aboriginal Heritage Tasmania (AHT) and a Permit issued (Permit 911). The overall aim of the excavation was to test the potential of the site and recover evidence of changes in site use and lithic technology over time.

However, due to issues relating to appropriate collaboration with the Tasmanian Aboriginal community, the Tasmanian Aboriginal Centre (TAC) requested that works be postponed until the matter could be resolved. As a result, excavation at the site ceased on 24th August 2009. After considerable discussion between various parties a new methodology was submitted by Rob Paton with reference to Stone and Everett (2008). Works resumed at the site, with the endorsement of the TAC, the Tasmanian Aboriginal Land and Sea Council (TALSC), and AHT. This second stage of excavation was undertaken under the directorship of Rob Paton and Cornelia de Rochefort from the 8th to 26th February 2010. Specialist geomorphological services were provided by Dr Tim Stone and Dr Matthew Cupper, while Dr Sophie Collins provided on site supervision and management of artefactual material.

Subsequent to this testing programme, the results of the geomorphological assessment indicated that the JRL site had the potential to be of great antiquity, with Optically Stimulated Luminescence (OSL) results indicating the deposit was up to 41,000 years old. The OSL results also indicated that the sandy deposits which were dated had undergone minimal post depositional mixing, indicating good stratigraphic integrity for the associated archaeological material. In light of this potential DIER amended the development proposal so as not to impact the JRL site, defined as the levee bank deposit. Instead they proposed that a bridge would span the JRL site with development impacts confined to the floodplain to the west and east of the levee bank deposit.

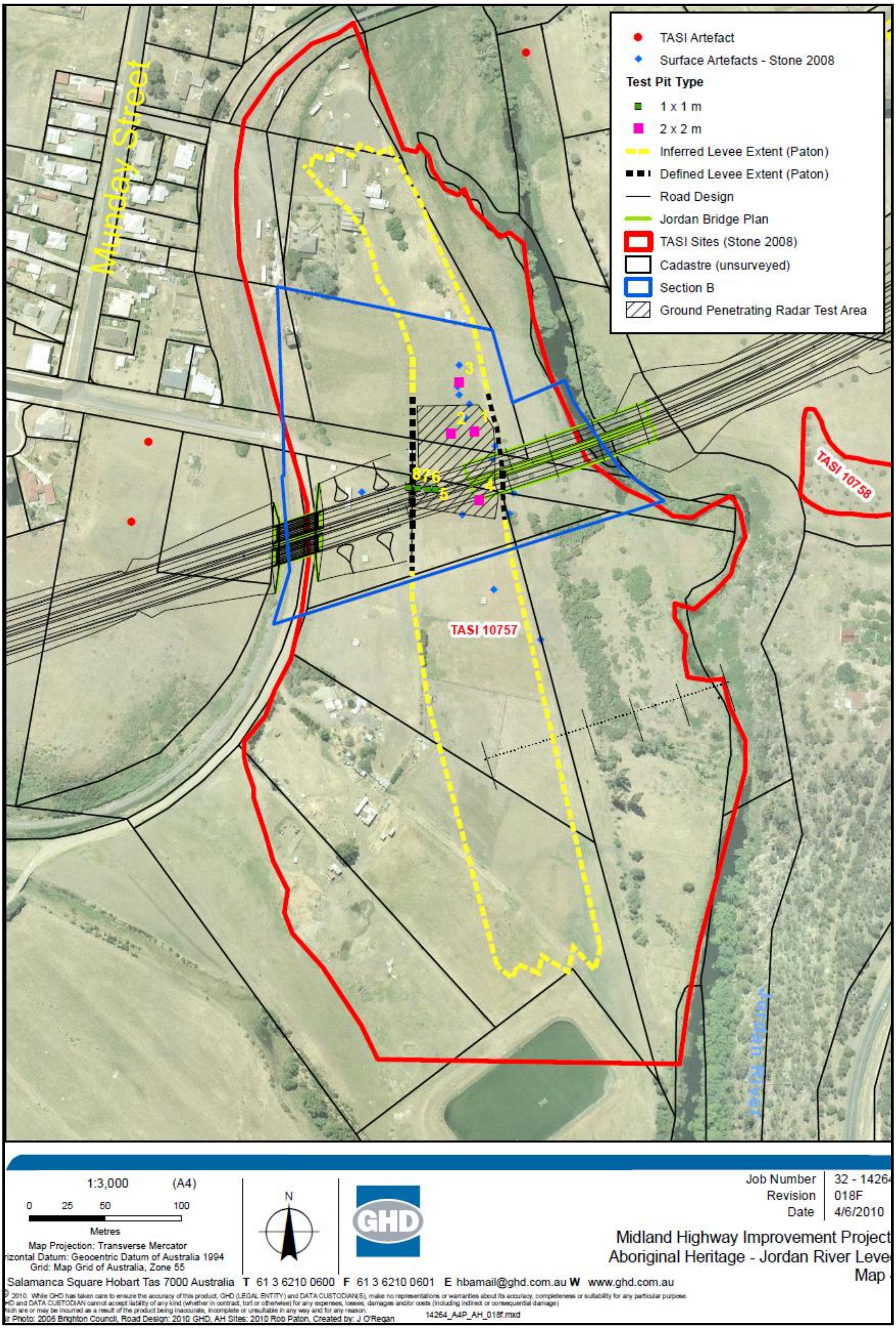


Figure 1.2: Map of the study area detailing TASI 10757 and the known and predicted extent of the Jordan River Levee site

1.4 Development Proposal

The Brighton Bypass Project is a key component in the Southern Tasmania National Transport Network Investment Programme 2007-2015. The proposed Brighton Bypass will become part of the Midland Highway (and Auslink network), connecting the city of Hobart with population centres in the north of the State. Under the project, the towns of Brighton and Pontville will be bypassed, forming a new highway offering a higher level of service. The Northern Section study corridor stretches from the southern outskirts of Brighton to the Midland Highway ~1.1 km north of Pontville. This proposed route will take highway traffic up to 2km east of Brighton across three major roads (Briggs Road, Tea Tree Road, Rifle Range Road), and the South Line Railway. The width of the corridor varies over the ~6km long route depending on the type of infrastructure required. The widest section is at the northern end to accommodate future ancillary infrastructure. Here it is up to 800m across. However, most of the corridor is only ~100m wide.

The concept design provides for a 110km/h speed dual carriageway along the majority of the bypass route, incorporating a 4m wide central median strip with a central Wire Rope Safety Fence. Initially the development footprint in the vicinity of the levee site was to consist of a carriageway supported by fill over a distance of ~110m as it approached the proposed Jordan River Bridge. However, once DIER was aware of the potential significance of the JRL site the design was reviewed. The first generation design would have resulted in significant impacts on the levee deposit that would have been unacceptable to DIER as well as the Aboriginal and archaeological communities. A bridge design involving a 70m span was developed to avoid permanent impact on the levee deposit. Once the preliminary results of the investigation were announced, another design concession was made to the bridge construction methodology, with the long bridge spans to be launched from above rather than lifted from below to avoid impacting the JRL site.

This report provides an assessment of the levee bank deposit identified as the JRL site. The JRL site is one component of the larger site identified by Stone and Everett (2008) and registered with AHT as TASI 10757. TASI 10757 comprises the entire floodplain feature bound to the east by the Jordan River and to the west by the rail line. The Permit issued to undertake test excavations was to assess the potential of the levee bank deposit only. An assessment of the floodplain to the east and west of the JRL site was not included in the archaeological testing programme as the Permit conditions specified a programme to ‘test’ the identified archaeological potential of the levee bank deposit (Appendix 1). However, an assessment of the risk of impacting any potential archaeology of the wider TASI 10757 site in relation to the proposed bridge development is included in Section 12.

1.5 Aboriginal Collaboration

Throughout archaeological investigations along the northern section of the proposed bypass route, there was considerable discussion of appropriate collaboration with the Tasmanian Aboriginal community. Detail of this consultation process and has been reported on by Paton (2010) in the revised excavation methodology for the JRL site, attached as Appendix 1 to this report.

Aboriginal consultation was undertaken according to best practice principles in the absence of detailed Aboriginal heritage consultation protocols in Tasmania. Prior to excavation works recommencing on the levee site it was made clear that all archaeological work was to be undertaken with the participation and approval of the Tasmanian Aboriginal Centre and TALSC (refer to Appendix 1: Revised Methodology).

Aboriginal Heritage Officers Aaron Everett and Robert Hughes were present on site during the first stage of excavations from the 3rd to 24th August 2009 and during the second stage of excavations from 8th to 26th February 2010. Leigh Maynard was also present for the second stage of excavations. Aaron Everett also facilitated a community meeting on site, where various members of the Aboriginal community toured the site and were given the opportunity to contribute to the consultation process.

It should be stressed that this particular project has been one of the first large scale investigations using new protocols in Tasmania. As such it has attracted more than its fair share of public and media attention. Under such critical scrutiny there is a tendency to only see the things that are wanting in the process and ignore all of the hard work and dedication of many people who have strived to see the heritage studies completed to the highest standard. To go some way to rectifying this matter, the Principal Archaeologist Rob Paton had the following letter printed in the Hobart *Mercury* (December 2009):

> Dear Editor,
>
> As Principal Archaeologist on this project I have read with interest the articles, letters and comments on the Brighton Bypass archaeology and impasse. Until we archaeologists are able to fully investigate the sites along the Jordan River with Aboriginal consent and participation enough has probably been said about the character and importance of the archaeology.

Without the benefit of more information, it is not possible for anyone to make any clear statements about the scientific importance of these sites, other than to say they have "considerable potential" to tell us some things about the deep history of Tasmania.

What has not been mentioned throughout the reporting of this impasse is the considerable personal and professional effort that has been put into this project by Aborigines and Public Servants. This has impressed me. While I acknowledge disputes remain between these parties, all sides have worked in good faith with the archaeologists for the best outcome. Knowing the pressure of these large development projects, particularly where there is constant media, I have been encouraged by the high moral and professional standards displayed by all. Tremendous efforts have been made without individual acknowledgement by people in the TAC, the Tasmanian Aboriginal Land Sea Council, Aboriginal Heritage Tasmania and DIER to resolve problems where common ground has been often hard to find. I have been deeply moved by the sacrifices people have been willing to make to accommodate disparate views. It gives me confidence that a resolution is close at hand.

Rob Paton
Archaeologist

1.6 Limitations of the Investigation

Several limitations and constraints affect this study;

- First, the aim of this programme was simply to date the JRL site and make a preliminary assessment of its 'archaeological value'. We were very much going into unknown archaeological territory when we began the excavations, with no comparable investigations having occurred in Tasmania. This meant that the methodology was a best guess for the type of site we anticipated. As it turned out, our methods were sufficient to provide information to assess the broad character of the JRL site. However, given the age and intact nature of the site, our few test pits cannot realise the full research potential of this important site, nor was this our aim. What we have done is provide information to allow the archaeological value of the site to be assessed and initiate an informal debate about its management;

- Like all research, our results can be tested, further assessed and refined. We acknowledge this mutable quality of our work and encourage reassessment as more data are obtained;

- Three OSL samples have been taken from Trench 2, and two other samples from a nearby quarry. The results of this analysis are presented in this report. However, further radiometric studies are recommended, specifically the dating of Trench 1 and collection of further samples from the other trenches. This is necessary in order to refine the temporal framework established for the site and to further establish the integrity of the deposits;

- Artefact conjoin analysis is not possible at this point in time. The Aboriginal community would prefer that the artefacts not be labelled with ink, as it transforms cultural material into "scientific specimens." Carrying out this research, if it is allowed at a later date, will provide further data to assess the integrity of the archaeological material and consequently also provide a better understanding of the scientific significance and research potential of the JRL site.

1.7 Report Structure

The report is structured as follows;

- Section 2 comprises the environmental background and provides a geomorphological and environmental context in which to interpret the results of the archaeological investigation. The significant part played by post-depositional processes such as soil formation and bioturbation are also addressed;

- Section 3 presents a review of the archaeological background which is pertinent to understanding the significance of the JRL site. This review provides a context within which to compare the JRL site to other archaeological sites on both a national scale. Reference is also made to its potential international importance in terms of some research themes;

- Section 4 outlines the methodological approach and technical design of the excavation process and data management. This section defines the research questions applied to the data.

- The results of the excavation are presented in Section 5 and deal primarily with the soil stratigraphy. The ground penetrating radar analysis is presented in Section 6 and the radiometric results are presented in Section 7. Site formation and post depositional disturbance are presented in Section 8 and the artefact analysis is presented in Section 9;

- Research questions presented in the method statement are discussed in light of the results of this study in Section 10. A statement of significance defined for the JRL site is presented in Section 11. Management recommendations are presented in Section 12.

2 Environmental Background

The purpose of this section is to provide a geomorphological and environmental context in which to interpret the results of the archaeological investigation. The geomorphology focuses on the evolution of the floodplain including formation of the levee. Environmental change over the past ~120,000 (the Last Glacial Cycle) in Tasmania and the contribution of rivers to understanding past climates is also reviewed. Finally, the significant part played by post-depositional processes such as soil formation and bioturbation at the JRL site is discussed to complete the picture.

2.1 Palaeoclimate

The Last Glacial Cycle is a period characterised by frequent and rapid changes in global climate and the dispersal of modern humans around the globe. During this period, massive ice sheets and glaciers advanced and retreated. In Australia glacial episodes were confined to the Snowy Mountains and Tasmanian highlands. Glaciers were most extensive in Tasmania where ice caps formed on the Central Plateau and West Coast Ranges, with valley and cirque glaciers on the adjoining mountains (Barrows *et al* 2002). With so much water locked in the ice sheets during a glacial episode, sea levels fell by as much as 150m. During interglacial periods when the ice melted, sea levels rose again. Relative sea level data are available from a variety of records, most notably the marine terraces of the Huon Peninsula in Papua New Guinea (Figure 2.1) and Barbados (Murray-Wallace 2007:3024; Lambeck and Chappell 2001:679).

Fluctuating sea levels over the Last Glacial Cycle resulted in the periodic exposure of Australia's continental shelf. At their lowest levels, mainland Australia, Tasmania and New Guinea formed a single landmass termed Sahul, or Greater Australia. Tasmania became separated from mainland Australia during the last full interglacial period ~135,000 years ago, but maintained intermittent connections to the mainland up until ~43,000 years ago (Lambeck and Chappell 2001). Figure 2.2 shows the sea level history of Bass Strait. The lowest land contours (sills) relative to sea level are shown for both sides of the now submerged Bassian Plain. From this reconstruction, Lambeck and Chappell (2001:684-685) show the presence of tenuous connections between the mainland and Tasmania at ~76,000 years ago, 68-62,000 years ago and 46,000 years ago. The first sustained connection occurred ~43,000 years ago and lasted until ~12,000 years ago, when Tasmania was once again apparently isolated from the mainland. These data are supported with the archaeological record, which thus far has shown the earliest evidence of human occupation of Tasmania from ~41,000 years ago (See section 7), however it does not preclude the possibility for earlier crossings when a more tenuous connection was available 46,000 years ago. It is doubtful that the crossing took place any earlier as firm archaeological evidence places occupation of the mainland of Australia to around 50,000 years ago (See Section 3.1).

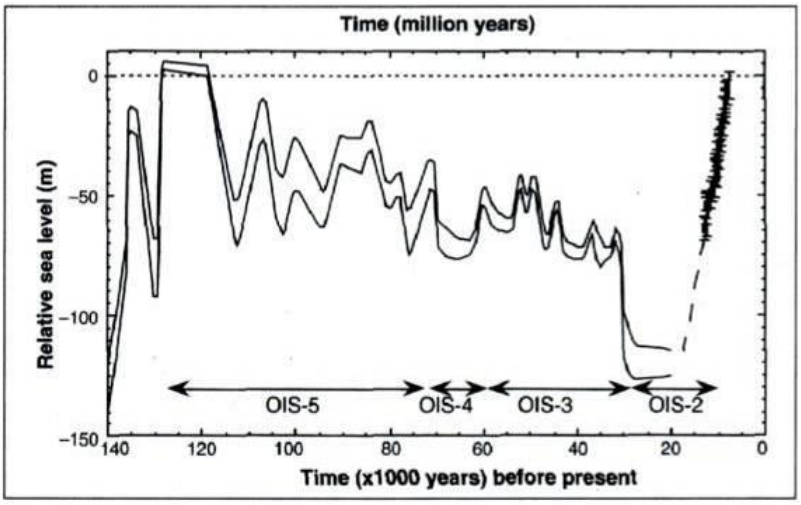


Figure 2.1: Quaternary relative sea level curve from the Huon Peninsula PNG (from Lambeck and Chappell 2001:680)

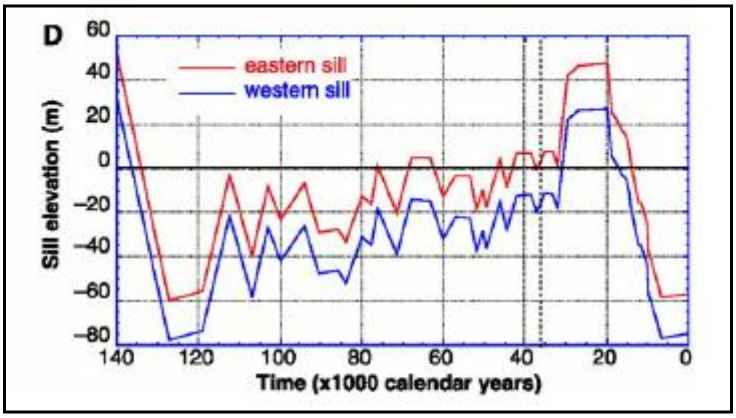


Figure 2.2: Change in elevation for the land bridges to the east and west of the Bass basin with respect to coeval sea level (from Lambeck and Chappell 2001: 684)

Fluctuations in global sea level correlate with changes in global temperature. This is shown by the oxygen isotope record derived from deep sea cores. The Last Glacial Cycle is divided into five Oxygen Isotope Stages (OIS). The earliest, OIS 5, contains a warm period very similar to present day conditions. OIS 4 was a shorter, cold-dry period, with glacial conditions. OIS 3 is one of further climatic deterioration and increasing cold. It is also a period of average Quaternary conditions. OIS 2 is the last glacial period that has a peak of extreme cold and aridity at the Last Glacial Maximum (LGM). OIS 1 is the much warmer Holocene period, and includes the present day.

Climatic deterioration from ~45,000 years ago culminated with a dramatic plunge in global temperature and sea levels commencing ~30,000 years ago. In Tasmania, summer temperatures in montane areas decreased by 6-10 degrees (Hiscock 2008). Conditions became increasingly dry, with less rainfall and increased evaporation. Decreasing effective precipitation led to shrubs and trees being replaced by grasslands (Hiscock 2008). Pollen cores indicate the presence of grassy alpine to sub-alpine communities throughout the western half of Tasmania. The much drier, eastern half is classified as glacial-arid during this period, although the south east was probably not quite as dry. A pollen core taken from Pipe Clay Lagoon in the south east of Tasmania demonstrates a shift from dry Eucalypt forest to very open Eucalypt savannah in the period 25-20,000 years ago and a corresponding increase in Cyperaceae, Poaceae and herbs (Jackson 1999:78-79).

Exceptionally cold and dry conditions prevailed worldwide between ~21,000 and 18,000 years ago, which is the Last Glacial Maximum (LGM). Cosmogenic dating of moraines in the Snowy Mountains and in Tasmania confirms that this was the period of maximum glacial advance in these regions (Barrows *et al* 2002). Maximum periglacial activity is placed at between ~16,000 and 23,000 years ago based on cosmogenic dating of block fields in NSW, Victoria and Tasmania, with peak periglacial activity centred ~21,000 years ago (Barrows *et al* 2004).

Barrows *et al* (2002, 2004) and Kiernan *et al* (2004) also report evidence for glacial advances that pre-date the LGM. Cosmogenic exposure ages for the Timk moraine at Schnells Ridge, Tasmania, show glaciation at ~38-40,000 years ago, ~67-74,000 years ago and ~133,000 years ago (Kiernan *et al* 2004). Barrows *et al* (2001, 2002) obtained a similar series of cosmogenic exposure ages from the Snowy Mountains for glaciation at ~39-46,000 years ago and ~59,000 years ago. Similarly, Barrows *et al* (2004) obtained an exposure age of ~58,000 years ago from Mt. Little Higgingbotham, Victoria and ~56,000 years ago from the Ben Lommond plateau, Tasmania.

2.2 Floodplain Evolution

The alluvial architecture of the Jordan River valley, including the JRL site, is the result of a complex set of fluvial processes operating under average Quaternary conditions. The floor of the valley at the proposed bypass crossing contains the Jordan River floodplain. This is a Late Quaternary to Holocene depositional unit of fine sand, silt and clay that forms an alluvial flat up to 300m wide. The present day Jordan River is inset below the flat in clayey channel deposits.

Floodplains are extremely complex landforms that record the depositional history of a river (Brown 1997:17). Morphological units within a floodplain are generally defined by their position, geometry and composition. Stream type and behaviour control the distribution of floodplain sediments. Basic channel forms range from the braided, multiple channel form, characteristic of streams supplied with large quantities of sand and coarser debris, to the meandering form typical of lowland floodplains. Other environmental factors such as the underlying geology, topography and inherited floodplain morphology may also control the development of a floodplain. Development of the Jordan River floodplain is constrained by the underlying bedrock and existing alluvial architecture.

Long term river history is driven by Quaternary climate change (Brown 1997:33-36; Williams *et al* 1999:144-148). During glacial periods, rivers lengthened across large areas of exposed continental shelf, with their base levels[1] dropping up to 150m in response to sea level falls. The drop in base levels invigorated these rivers, which accelerated erosion and the rivers incised in search of the new base levels. Rapid river migration and incision resulted in terracing of the abandoned floodplains. Conversely, the capacity of rivers to erode and transport sediment is reduced when base levels rise in accordance with rising sea levels. This can trigger sedimentation along rivers and valleys fill. This cycle of incision and aggradation would have occurred many times during the history of the JRL site.

Other contributing factors to changes in river morphology include changes in temperature, precipitation, vegetation cover and erosional processes. Variable rainfall and lower temperatures during glacial periods would decrease vegetation cover, exposing soils to erosion. Sediment yields increased, with coarser debris being washed into the river system. Consequently, river morphology changed. For example, meandering rivers that carry a sediment load of fine clay and silt during an interglacial period would probably form braided river channels during a glacial period because of the increased sediment load. Changes of this type occurred frequently during the Quaternary period and resulted in a complex and fragmented suite of deposits of varying age and character (Williams *et al* 1999:150).

The complex response of any given river system to climate change precludes palaeoclimatic inferences being made from alluvial deposits. Williams *et al* (1999:152) explain that during a glacial period the catchment of a river may lose its vegetation cover resulting in accelerated erosion. The increased sediment load may exceed the capacity of the river to transport the sediment, which is deposited further downstream. However, once the sediment supply from the hill slopes is exhausted, the sediment-free water would then incise the lower valley floor deposits that had previously been aggrading. Terrace formation would happen sometime after the change to cold glacial conditions. Changes of this sort (termed complex response in riverine environments) do not correlate with any external trigger owing to unknown time lag responses (Schumm and Parker 1972, in Williams *et al* 1999:152). This complex response makes interpretation of Quaternary riverine landforms, such as the JRL site, a problematic area of environmental reconstruction as changes in base level were happening at the same time as changes in river hydrology, vegetation and climate (Williams *et al* 1999:152).

2.3 Levee Formation

Levees are sedimentary deposits formed by repeated overbank flooding of river banks (Figure 2.3). During a flood event, the velocity and depth of water flowing outside the river channel is less than in the channel, which acts to hydraulically segregate and deposit material suspended by the flood waters. The coarsest sediments (usually fine sand and silt) are deposited rapidly adjacent to the channel while the finest sediment (clay) is deposited away from the channel. Multiple flood events construct a levee adjacent to the active river channel (Mount 1995; Hudson n.d).

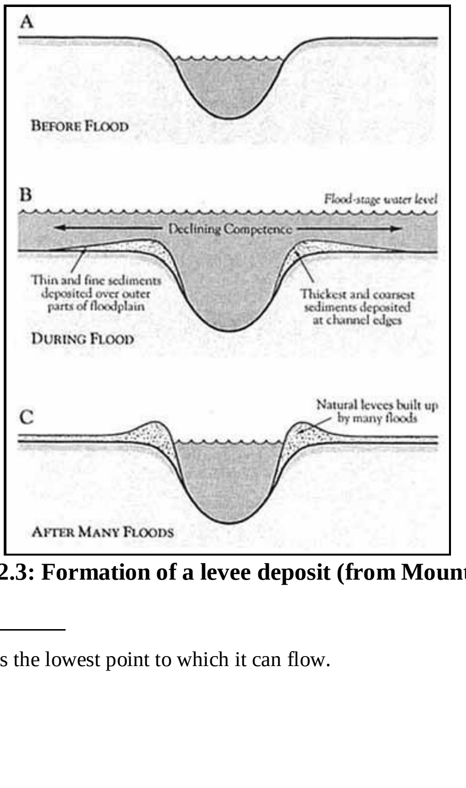


Figure 2.3: Formation of a levee deposit (from Mount 1995)

[1] The base level of a river or stream is the lowest point to which it can flow.

Levees that result from large-scale, frequent flooding contain individual strata-sets[2] ranging from centimetres to decimetres thick. The strata-sets decrease in thickness away from the river channel owing to the rapid lateral loss of hydraulic power and attendant decrease in sedimentation rates. Consequently, the strata-sets appear wedge-shaped in profile. The length of time that strata-sets will be preserved is dependent on the type of sediment, particle size (sand, silt or clay), nature of the bedforms and pedogenic regime (Hudson n.d.). Generally speaking, the coarser sedimentary structures are more resilient than finer clay laminae over time.

2.4 Soil Formation

Soil formation or pedogenesis is the process whereby a variety of factors (climate, topography, fauna, flora and time) interact to alter the original composition and structure of a parent material. For this investigation, the parent material is the alluvial sand, silt and clay deposited during formation of the Jordan River floodplain. Once soil formation commences, primary sedimentary structures (strata-sets) are usually obliterated over the passage of time.

Soils are generally described with reference to their degree of soil profile differentiation or *horizonation*, which develops over a long period of time. A typical soil profile contains an A_1 horizon over a B_2 horizon, over a C horizon. The A_1 horizon is a surface mineral horizon mixed with dark organic matter. If the A horizon has been leached, that part is referred to as the A_2 horizon. The B_2 horizon is an illuvial, residual or other concentration of silicate clay, iron, aluminium, humus or carbonate precipitated from above. It will generally display the strongest structure[3] and the brightest colour. The C horizon is the parent material, which may be unweathered sediment or bedrock (Isbell 1996; McDonald *et al* 1990).

Levee soils display predictable changes in soil type (catenas) from the channel bank to the back of the floodplain. The degree of pedological organisation increases with distance from the channel because sedimentation rates decrease in that direction. Soils formed on the levee close to the river channel may only have an A horizon on top of the unweathered parent material. The reason is that uninterrupted deposition will slow or prevent soil profile differentiation. Moreover, soils closer to the river channel will be coarser grained, sandier and well-drained as a consequence. These well drained soils will show higher rates of oxidization compared to soils developing at the distal end of the floodplain. Oxidization is easily recognized as a brighter red or orange soil colour. Bedforms do not survive because of bioturbation (see below).

Soil structure is more pronounced away from the river where sedimentation rates are lower. Here, soils often display distinct A and B horizons, with more bioturbation and more frequent mineral nodule formation. Levees also have the potential to contain or conceal palaeosols, which represent former land surfaces. These buried or fossil soils may represent long breaks in deposition between flood events or the relict surface of an older landform (Hudson n.d).

The dynamics of soil formation are fundamental to interpreting the archaeology and depositional history of the JRL site. The following presents a framework for understanding post-depositional disturbance at the site within a soil context. The concept of biogenic burial as a mechanism for site formation is also introduced.

2.5 Bioturbation: A Mechanism for Site Formation

Bioturbation is a pedogenic process that slowly mixes material in the soil profile. It is particularly relevant to archaeologists excavating open sites because it explains the shallow burial of artefacts left on the soil surface when there is no other demonstrable mechanism for artefact burial. Bioturbation (or pedogenesis more generally) will mix together artefacts unrelated in time and as a consequence any possibility of a stratified cultural sequence is lost. Artefact mixing as a result of biomechanical processes has been the topic of a number of research papers in the past twenty years (e.g. Johnson *et al* 1987; Johnson 1989, 1990, 1992; Vermeersch and Babel 1997; Peacock and Fante 2002).

Johnson (2002:7-8) lamented that few in the fields of archaeology, pedology and earth sciences recognize the importance of biomechanical processes and that the subject has no generic language or supporting theory. This is certainly the case in Australia where the effects of bioturbation on artefacts are rarely considered in the literature. Bioturbation generally falls under the banner of post depositional disturbance in the Australian context, with case

[2] Stratum: a single bed of sedimentary material, generally consisting of one kind of matter representing continuous deposition. In this instance a stratum may be the deposition of a fine sand layer as a result of a flood event. Strata- sets may comprise one of a number of parallel layers one upon another, i.e. fine sand layers overlain by clay layers. These layers generally appear as laminations in section (layers upon layers of deposition)

[3] Soil structure refers to the shape and development of the peds formed within the soil. A ped is the natural aggregation of soil particles (sand, silt and clay) and may be described according to a variety of forms, i.e. crumb, blocky, polygonal. A soil with well developed structure is a soil with strong pedological development, as over time the primary sediments will naturally form into soil aggregates (peds) and the longer the period of time the more pedological or structural development.

studies dealing with the effects of various animals and soil biota on archaeological sites. For instance, post depositional disturbance and artefact redistribution patterns have been identified through the activity of owls (Cosgrove 1995), birds (Cane 1982) and termites (Williams 1968). The effects of soil fauna such as worms, beetles and ants have generally been overlooked. Consequently, most Australian archaeological studies regard bioturbation as simply a disturbance process. It is rarely recognised that bioturbation is in fact a mechanism by which artefacts may become buried within a soil.

As early as 1837, Charles Darwin (1881 in Johnson 2002) drew attention to the role of earthworms and demonstrated how objects placed on the soil surface became buried. Put simply, earthworms ingest soil at depth and then deposit it on the surface as fecal castings - a slow process of upward translocation of fine soil material. Large inclusions such as gravel and artefacts that earthworms cannot ingest will eventually sink to the lower zone of earthworm bioturbation.

Many other species of soil biota are involved in translocating soil and texturally reorganising it. Soil fauna that both burrow and translocate small particles to the surface cause large clasts to settle downward relative to the soil fine fraction. The depth at which clasts settle ultimately corresponds to the base of major biological activity. Consequently, 'stone lines' often form at the extent of biomechanical influence (Johnson 1990; Baleck 2002). This zone of biomechanical influence is also known as the 'biomantle' and generally constitutes the A horizon of a soil profile.

Stone artefacts are no different to any large clast in the biomantle. Initially, a scatter of stone artefacts (a 'living floor') may be buried by a depositional event such as a flood or a sandstorm. If the deposit is not deep and the event does not recur, post-depositional bioturbation may mix the artefacts in the developing (and buried) soil profile. Alternatively, the artefacts may be distributed vertically in the soil profile as the result of bioturbation alone.

Various studies have modelled the rate of biogenic burial, which varies widely depending on the type of soil fauna present. Australian examples are sparse. Some species of termites are known to burrow up to 50cm below the surface and deposit up to one tonne of soil per hectare per year on the surface (e.g. Holt and Lepage 2000). Paton (1989) illustrates the effect of the common worm, of which there were once several hundred native species. According to CSIRO studies (in Paton 1989), Australian worms are estimated to turn over about 1.8cm of sediment per 100 years. Over a 1000 year period this would result in artefacts moving down the soil profile about 18cm.

Inferences about past human behaviour based on the positions of artefacts should only be made within such a geomorphological and pedological framework (Peacock and Fante 2002:91-92). Establishing the original position of the artefacts and any movement is critical to understanding and dating the archaeological record.

It is for this reason that we have devoted considerable research into this topic in our assessment of the JRL site.

2.5.1 Modelling soil development

Soil genesis proceeds along two pathways, specifically progressive and regressive pathways (Johnson *et al*, 1987). Progressive pathways work to promote horizonation and/or chemical stability while regressive pathways work to provide homogenisation and/or chemical instability. Both pathways are in operation to some degree at the same time. The result of these opposing processes constitutes the overall soil developmental pathway (see also Peacock and Fante 2002). For any given soil profile, the structural characteristics of the soil reveal the dominant pathway. Biomechanical processes can contribute to either progressive or regressive soil development.

Peacock and Fante (2002:98-100) present specific criteria that can be used to model soil development in relatively homogenous silty-sandy soils and the effect progressive and regressive pathways have on artefact positioning within the soil. Progressive dominant soils will have well developed horizons and particle size and will follow a predictable sequence; typically a silty or loamy A horizon with translocation of clay further down the profile.

Artefacts present within the sequence will typically form a stone line at the base of the zone of bioturbation. This is typically at the interface of the A horizon (zone of maximum biological activity) and the B horizon (zone of clay and mineral deposition). Archaeological models of progressive soil pathways and the affect of bioturbation indicate that artefacts will retain a fair semblance of their original, generally horizontal, placement on the surface.

The model assumes that artefacts are deposited on the surface at some point in the past. Downward artefact movement begins immediately, with some artefacts transported down through the soil via root holes and faunal burrows and some settling down through the profile as voids beneath them collapse. As root diameter decreases with depth, there is a corresponding decrease in the size of the artefacts that are transported downward. Larger artefacts are relatively resistant to downward movement unless they tilt. A stone line begins to form at the base of the A horizon, with the accumulation of finer sediment at the top of the profile. A few smaller artefacts may be translocated upward by the movement of worms and other soil biota, but artefact density in the upper stratum will be low.

A very distinct pattern will begin to emerge with artefact frequency and size according to depth. The highest frequency of artefacts will comprise the stone line and will correspond to the boundary that represents the maximum extent of biological activity. Size sorting will be evident with smaller, lighter artefacts translocated both up and down the soil profile. The translocated artefacts will correspond with root size and the actions of soil biota.

Regressive dominant soils will be homogenous and display simple soil profiles with a distinct lack of horizonation. Regressive agents include tree upheaval, ploughing and other agricultural activities that mix the soil. Artefacts within the regressive dominant soil will be oriented at random angles rather than lying in a generally horizontal plane.

In this model, artefacts are left on the soil surface and begin to sink downwards as described in the first model. A major disturbance such as tree upheaval will return the soil and artefacts to the surface. This produces a mixed particle size and clast distribution, with artefacts oriented at random angles rather than lying in a generally horizontal plane. The effect of tree upheaval homogenises the biomantle but enriches the surface with stone after rain washes fine particles from the upturned tree roots, a process that exposes and concentrates stone at or near the surface.

Different forms of bioturbation produce biomantles of different kinds. The type of biomantle formed will depend on soil particle size, the burrowing characteristics of the biota and the rates at which sedimentary processes operate. The intensity of bioturbation will vary spatially and temporally because environmental factors are not uniform or static. Faunal and floral turbation may affect a soil concurrently. The combination of these factors together with the multitude of textural characteristics and other soil processes can create a complex picture (Johnson 2002).

Despite the complexity and variability across different environmental regions, the above model is based on universal pedogenic principles applicable to any open archaeological site, including the JRL site. Site formation at the JRL site will be examined through the lens of these principles to help model the pattern of artefact distribution at the site.

In combination with single sand grain OSL analysis, this interpretation of our archaeological data will produce conservative, but reliable conclusions. We have also presented all relevant data sets to allow either independent testing of conclusions or avenues for ongoing investigations at the JRL site.

3 Archaeological Background

3.1 Dating the Arrival of Humans in Greater Australia

The Jordan River Levee site was occupied by Aboriginal people from ~41,000 years ago. This places the site amongst the oldest in Australia. During this time period Tasmania was connected to the mainland of Australia, which in turn was a much larger continent, connected to Papua New Guinea. This large land mass has been commonly termed Sahul or Greater Australia. Research to date has identified a wealth of archaeological sites scattered across the country that attest to the presence of humans close to or before 40,000 years ago. Hiscock (2008: 34-35) cites examples of sites such as Allen's Cave, Carpenter's Gap, Cuddie Springs, Devil's Lair, GRE8, Lake Mungo, Malakunanja, Nauwalabila, Ngarrabullgan, Parmerpar Meethaner, Puritjarra and Riwi, all of which attest to occupation by 40,000 years ago.

For this early period occupation is found in a variety of environmental zones and is characterised by rockshelters, caves and open sites. By 35-25,000 years ago occupation of Greater Australia covered most environmental zones from lacustrine and riverine through to more arid environments and highlands as well as the large islands off the northeastern coast of Papua New Guinea (Figure 3.1) (Habgood and Franklin 2008:189).

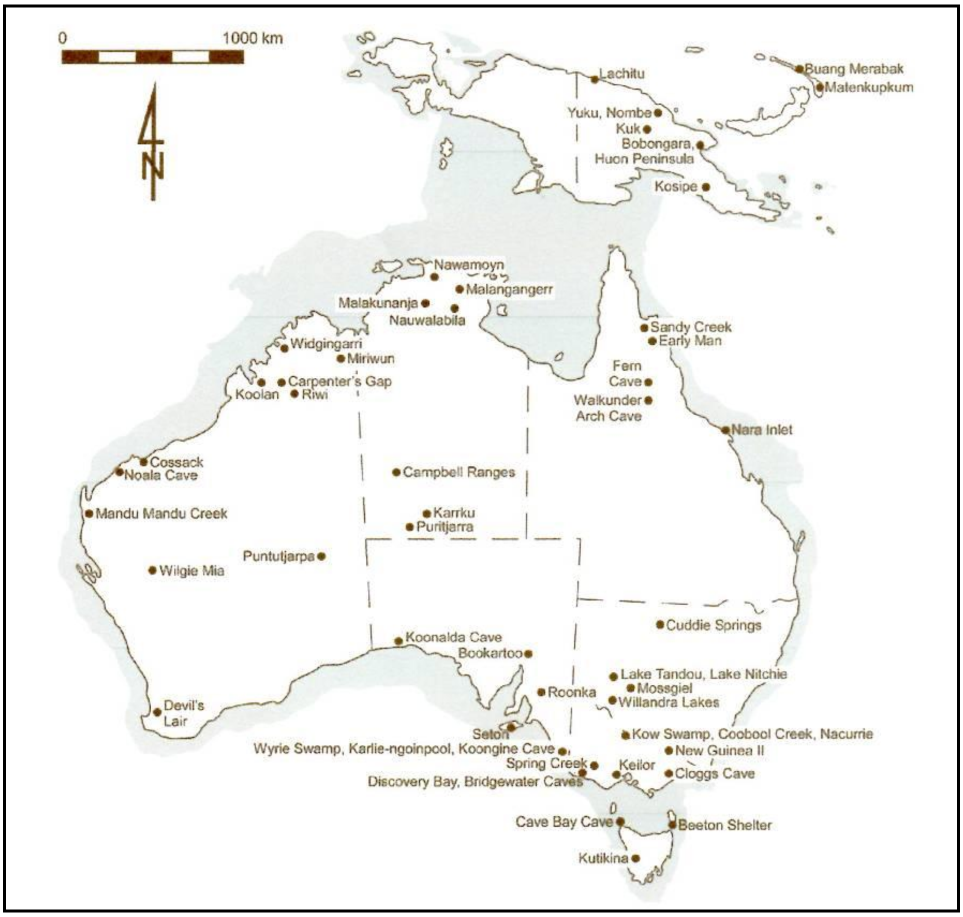


Figure 3.1: Major Archaeological Excavations in Australia

Throughout the greater continent of Australia there are a handful of sites which archaeologists have argued attest to human occupation from before 60,000 years ago, with some claims stretching as far as 100,000 years ago. Such claims have far reaching ramifications relating to theories about the spread of human beings across the planet. For this reason these sites have been heavily scrutinised by researchers.

The argument for an Aboriginal presence up to 100,000 years ago is based principally on evidence of anthropogenic induced vegetation change. Researchers who hold to this theory suggest that the presence of increased charcoal fragments in the pollen cores is evidence of Aboriginal firing practices. They argue that these changes in the charcoal regime cannot be correlated with any natural climatic events. In Tasmania, Johnson (1999) has forwarded just such a hypothesis for an Aboriginal presence in Tasmania from the time of the last interglacial. Singh and Geissler (1985) also argued for human induced vegetation change from 130,000 years ago as recorded in pollen cores from Lake George basin in south eastern Australia.

Most researchers dismiss claims of this sort because the association of the charcoal with human activity is tenuous. In order to substantiate claims of great antiquity, it would be necessary to prove that the charcoal was produced by humans. But there are many other variables affecting charcoal deposition in lake sediments, such as the type of the vegetation, the amount of standing fuel, the nature of the fire regime, and the amount and timing of erosion that washed the charcoal into lakes. As a result, charcoal concentrations in pollen cores, which date back hundreds of thousands of years may be interpreted as evidence of naturally intensified burning regimes (Hiscock 2008:27-28). Proof of human activity needs the presence of cultural material and a firm association of that cultural material with radiometric dates.

The argument for human occupation of Greater Australia extending to 60,000 years ago is based on five key sites. These are: Huon Peninsula PNG (44-61,000 years BP), Nauwalabila (53- 60,000 years BP), Malakunanja II (45-61,000 years BP), Devils Lair (46-64,000 years BP) and Lake Mungo (46-62,000 years BP). The majority of these early sites have been critiqued and assessed as unreliable with conservative estimates based on secure dating evidence placing occupation around the 45,000 years ago (O'Connell and Allen 2004; Allen and O'Connell 2003).

The doubt cast on evidence for occupation at or before 60,000 years ago is centred around issues of artefact context and site taphonomy. Sceptics have quite rightly called for more detailed post depositional studies at these older sites. At present evidence for earlier occupation is weak, but it should not be dismissed entirely. For instance, Hiscock (2008:24-44), points out that there is in fact no doubt that sites like Lake Mungo and Malakunanja were occupied 45,000 years ago. Therefore, while the debate as to the integrity of these sites is valid and that the reliability of the radiometric results does bring the question of earlier occupation under scrutiny, this does not necessarily preclude the possibility of such occupation.

The established evidence of occupation at 45,000 years ago does not in fact date initial colonisation of Greater Australia. Rather, it gives us a minimum date for colonisation. Evidence for initial colonisation is likely to not have survived, being located on the now submerged continental shelf. It is therefore conceivable that people became archaeologically visible (45,000 years ago) at sites in the south, such as at Lake Mungo, long after initial colonisation. Hiscock (2008: 44) concludes that while the speed at which humans spread across the continent is not known it is possible that initial colonisation occurred 45,000-50,000 years ago. Initial colonisation of the Greater Australian landmass is far more likely to have occurred 50,000-60,000 thousand years ago.

Where people originated from before their arrival in Greater Australia is a matter of considerable debate, well beyond the scope of the present study and the data we have generated. The main contribution of the present investigation to international research is simply to highlight the potential importance of the JRL site to some major research themes. It would be too much of a tangent to review how the JRL site fits in with other international sites of comparable age, as so many of these sites are either poorly dated or reported. Such a report would be a major study in itself. Suffice it to say that the JRL site is important to two related broad themes of study.

Firstly, the JRL site can clearly contribute not only to ideas of human colonisation of Greater Australia, but also the investigation of *Homo sapiens* expansion across the planet. In terms of just its age alone, the site is well beyond the first southern expansion of *Homo sapiens* elsewhere in the world. In the Americas, for example, the oldest reliably dated sites in the south are from around 15,000 years in Chile (Mont Verde). Some suggest occupation prior to this, c33,000 years, but considerable debate surrounds this claim. The disparity between the Greater Australian ages, including the JRL site certainly raises some interesting questions about the path *Homo sapiens* took, if indeed they did come "out of Africa". It has even been suggested, I suspect somewhat impishly by Michael Mansell, on ABC radio that humans could have originated in Tasmania and then moved north.

A second related theme of international research is the stratigraphic integrity of the JRL site. For such an old, open site, to have the potential to contain intact cultural deposits makes it very important. Similar old sites in Europe, such as for instance Dolni Vestonice in the Czech Republic, have been the centre of major international research for decades. These types of sites are acknowledged to be rare and provide an unparalleled insight into the deep past. Some of the most important sites in Africa, to illustrate, are not those that are the oldest, but are the ones that are well dated and contain very rare stratigraphic integrity. We only have to look at the contribution to human knowledge from sites like Olorgesailie in the African Rift Valley to realise the potential that open intact sites have (Isaac and Isaac 1977).

3.2 The Pleistocene Archaeological Record (45,000-10,000 years)

The Pleistocene archaeological record in Australia includes a wide corpus of sites across the country. It is not the intent of this report to document in detail the contents of all of these sites, but rather to broadly summarise their character. A more detailed review of Tasmanian Pleistocene sites and models of human socio-economic settlement patterns developed for Pleistocene Tasmania are presented below, while more detailed comparisons of those sites as compared to the JRL site are presented in Section 9.

Pleistocene Aboriginal people have been portrayed by scientists in the past as culturally and technologically simple, altering little over time (see White and O'Connell 1982). This interpretation was in part based on the limited archaeological record of the time. These ideas are for the most part a product of nineteenth century cultural stereotypes, founded in concepts of social evolution which saw societies progressing from simple to complex (Cosgrove *et al* 1990:59; 1999:359; Hiscock 2008:106;). These ideas were reinforced by arguments for a Holocene cultural intensification taken up by archaeologists (see Lourandos 1985). This saw entrenched and conservative views about the simplicity of Pleistocene cultures contrasted with a seemingly more diverse and richer recent archaeological record (Cosgrove *et al* 1990; Hiscock 2008), thus perhaps over emphasising the simplicity of older sites.

However, with new discoveries and changed perceptions, a very different picture of Pleistocene life has emerged. The Pleistocene archaeological record provides evidence of long distance and wide ranging exchange of exotic materials, specialised economic strategies, and sites that contain a wealth of material made from stone, bone and shell. This suggests a well established and varied pattern of adaptation to a multitude of differing environments. Occupation across Greater Australia was not necessarily continuous during this time, with some sites being abandoned during the Last Glacial Maximum (LGM) (see Veth 1989) and others such as southwest Tasmania flourishing during the same period (Franklin and Habgood 2007; Habgood and Franklin 2008).

Complexity and variability is certainly apparent at many of the older Australian archaeological sites. Franklin and Habgood (2007) and Habgood and Franklin (2008) provide an excellent summary of Pleistocene innovation and change at these sites. For the purposes of this report, it will suffice to provide a summary of their findings. The author's detailed survey of the Late Pleistocene record of Greater Australia identified four broad phases of change and innovation. These phases characterise the nature of the Pleistocene archaeological record.

Phase 1: From ~40,000 years ago

This period shows evidence of long distance trade, complex lithic assemblages and diverse economies. The long distance exchange of *Dentalium* shell beads and baler shell recovered from Riwi Cave and Carpenters Gap Rock Shelter 1 has been identified as early as 42,000 to 29,000 years ago. Transport of ochre from over 300km is evident in deposits dating to 20,000-25,000 years ago from Mandu Mandu Rockshelter on the Cape Range Peninsula. At Cuddie Springs, western New South Wales, artefacts argued to be 28,000 to 35,000 thousand years old have been linked to quarries located 60km and 120km away. Exchange or transport of Darwin Glass from a meteorite impact crater over a distance of up to 100km has been found in rockshelter sites in southwest Tasmania dating to the Late Pleistocene (see Section 3.3 below). Stone tool assemblages from this period are dominated by retouched and unretouched flakes. However, stone hatchet heads are also found in Papua New Guinea assemblages from this period.

Terrestrial fauna appear to be the main resource exploited during the late Pleistocene, though the exploitation of fresh water shellfish certainly occurred around palaeo river and lake systems in south eastern Australia (Franklin and Habgood 2007:2-8,10). Marine resource exploitation is better known from the Holocene period. There is a general lack of coastal Pleistocene archaeology in Australia. But this is probably related to fluctuating coastlines under average Quaternary conditions, with most evidence now destroyed. Bowdler (1977, 1990) developed an elegant coastal colonisation model, dependant on marine exploitation. This model was challenged by Beaton (1985) who argued that coastal resources would have been exploited only intermittently. Franklin and Habgood (2007:7) conclude that while evidence from Sahul is equivocal, there is clear evidence for marine resource exploitation from islands off the northern Greater Australian coast from 20,000 to 40,000 years ago.

Phase 2: From 32,000 years ago

In this phase Franklin and Habgood (2007:10) describe the appearance of personal ornaments in the form of shell beads. *Dentalium* shell beads were recovered at Riwi Cave and Carpenters Gap Rockshelter 1, while small cone shells and fragments were recovered from deposits dated to 32,000 years ago at Mandu Mandu Rockshelter. There is evidence of possible grindstone technology at Cuddie Springs dating to 28,000 to 35,000 thousand years ago, and in Tasmania there is evidence of intensive exploitation of macropods (see Section 3.3). Stone tool technologies continue in the same tradition, however thumb nail scrapers appear in Tasmania and ground stone hatchets are introduced in northern Australia.

Phase 3: From 20,000 years ago

This phase documents a variety of personal ornamental items and imagery, including bone beads, pendants and notational pieces. The use of personal ornaments and imagery during the Pleistocene has been identified at Riwi Cave, Carpenters Gap Rockshelter 1, Mandu Mandu Rockshelter and at Devils Lair. Devils Lair also contained engraved limestone plaques and bone implements. The dating of rock art has proven difficult, yet it is well documented during this period. Cemeteries appear along the Murray River system after the LGM and bone points, wooden tools and grind stones become more common in archaeological assemblages.

3.3 Tasmania: Occupation from the Late Pleistocene

Archaeological excavation of limestone cave deposits in the Maxwell Valley of southwest Tasmania has demonstrated Aboriginal occupation dating back 35,000 years (Cosgrove 1995). This period of occupation includes the Last Glacial Maximum or "Ice Age" of 20,000 years ago. It was during this period that cooler temperatures reduced the forest cover of the region (Kiernan *et al* 1983). Late Pleistocene cave sites are known in the valley of the Weld River, the Cracroft Valley and the Ida River karst (Jones *et al* 1988; Cosgrove 1989; McGowan, 1990). Some of these caves have paintings preserved on the walls.

One of the first cave sites in which a Pleistocene human presence was documented in southwest Tasmania was Beginners Luck Cave in the Florentine River Valley. Archaeological excavations uncovered stone artefacts and the remains of butchered animals dating back 20,000 years (Murray *et al* 1980). A number of other sites located within the Franklin River Valley (Figure 3.2) also appear to have been occupied at this time, such as Deena-Reena Cave and the open air Flying Fox site (Jones 1990; Freslov 1993; Porch and Allen 1995). Kutikina Cave, dates from 20,000 to 15,000 years ago and archaeological excavations at this site have uncovered a wealth of material, comprising 37,000 stone artefacts, bone points, and over 35kg of bone fragments, predominantly of Bennett's wallaby. Stone artefacts were largely derived from glacial outwash river pebbles and included notched and denticulated flakes, core fragments with abruptly retouched edges and thumb nail scrappers made from a glassy impactite (Darwin glass) from a meteorite crater located 26km northwest of the site (Mulvaney and Kamminga 1999:183).

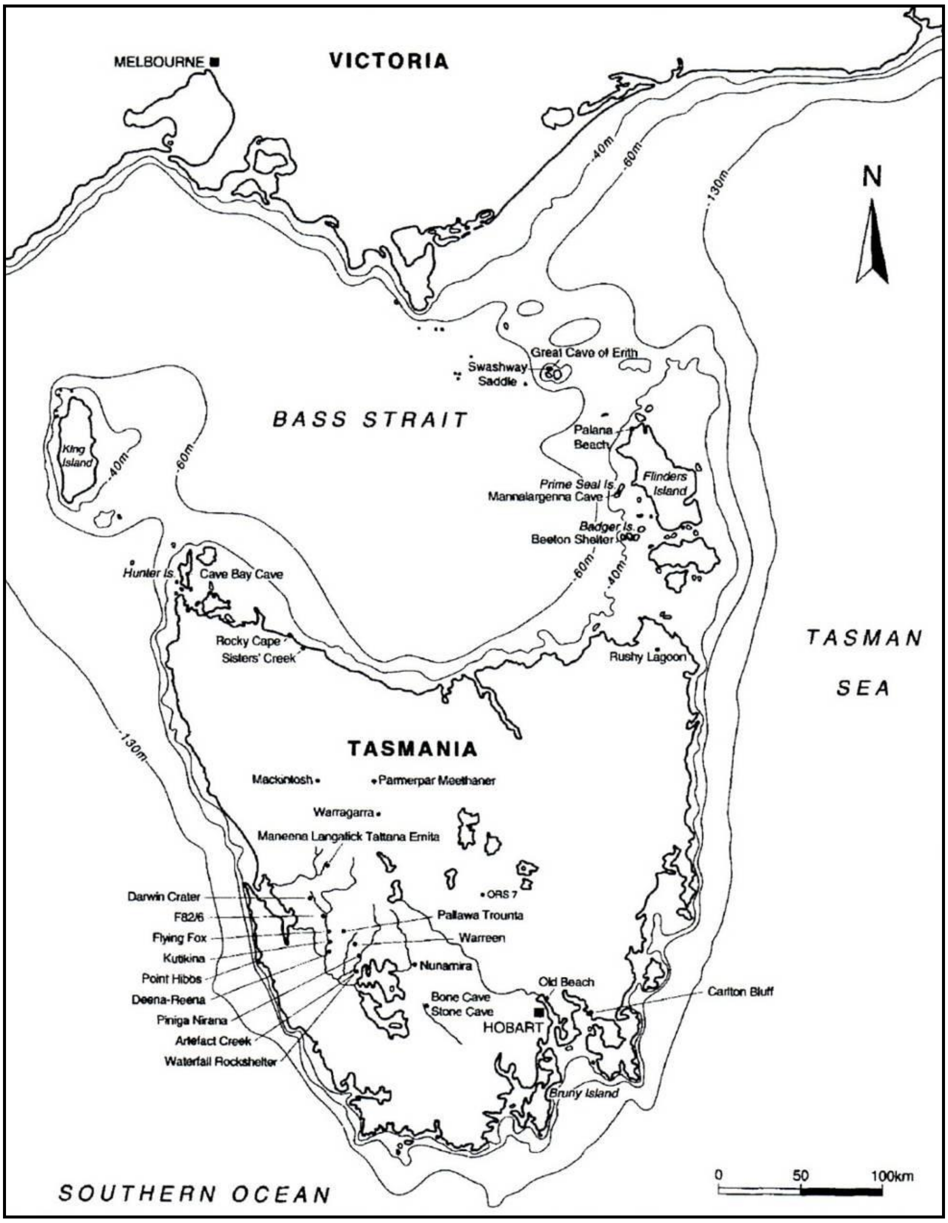


Figure 3.2: Map detailing location of sites mentioned in the text (image from Porch and Allen 1995:715)

Several kilometres east of Kutikina Cave is Warreen Cave in the Maxwell River Valley. Prior to the discovery of the JRL site, this site and Parmerpar Meethaner, in the Forth Valley northwest Tasmania, were the two oldest known sites in Tasmania. The sites are 35,000 years old and 34,000 years old respectively (Cosgrove 1999). Warreen Cave contained more than 20,000 stone artefacts and 140,000 bone fragments. Artefacts were dominated by small quartz flakes and the bone assemblage dominated by Bennett's wallaby as at Kutikina (Mulvaney and Kamminga 1999:186-187).

The richness of Kutikina and Warreen cave sites appears to be a characteristic of many south western Pleistocene cave sites. Excavations at Nunamira Cave and Bone Cave, occupied from 30,000 to 13,000 years ago, recovered thousands of stone artefacts and bone fragments per cubic metre of deposit (Cosgrove 1999:367; Cosgrove *et al* 1990:66), however sites found along the Nelson River such as Mackintosh, Piniga Nairana and Maneena Caves show relatively lower levels of cultural material. These sites date to ~20,000 to ~11,000 years ago (Cosgrove 1999:367-368).

Paleaoecological models developed for southwest of Tasmania describe how cooler temperatures during the LGM reduced forest cover, creating ecological niches of open grass land which supported wallaby populations. The richness in cave site deposits is thought to be associated with humans targeting the wallaby aggregation sites, to hunt the ecologically tethered animal populations. This explains the predominance of wallaby bones in the archaeological assemblages (Cosgrove *et al* 1990). Recent research by Pike-Tay *et al* (2008) has documented seasonal human land use patterns and occupation for four of the south western caves sites, namely, Bone Cave, Kutikina cave, Nunamira Cave and Warreen cave. Their analysis demonstrates evidence of seasonal hunting (autumn, late winter/early spring) indicative of a systematic approach to land use and resource exploitation. This highly developed and targeted subsistence pattern is unique to southwest Tasmania. Exactly how this model articulated with eastern Tasmania where resources were more scattered with unpredictable rainfall (Figure 3.3), or how the coasts were integrated into this system is not known.

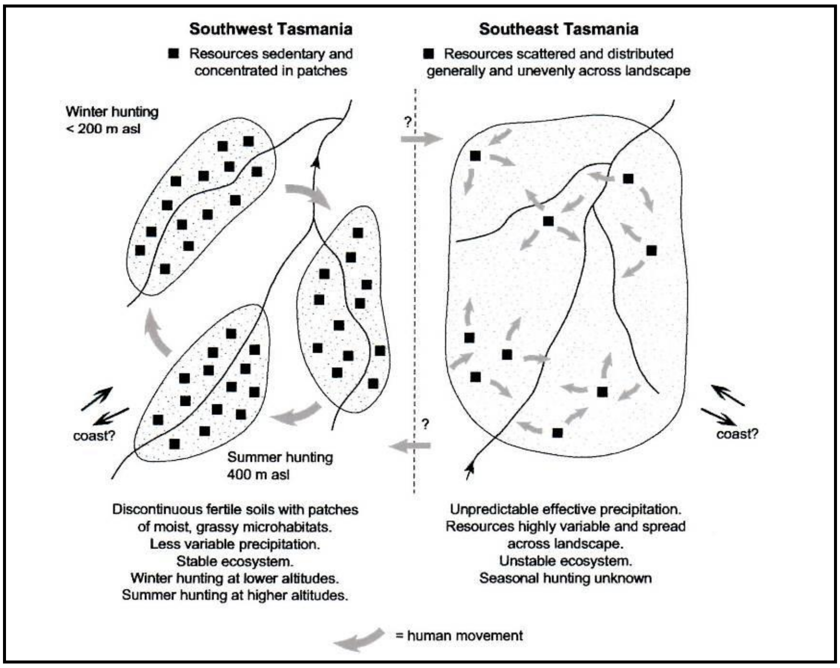


Figure 3.3: Proposed model of Pleistocene human land use (image from Pike- Tay *et al* 2008:p542)

Artefacts made from Darwin glass have been found at a number of cave sites including Warreen Cave, Pallawa Trounta, Nunamira Cave and Mackintosh Cave. The latter site marks the northerly distribution of this material, while Nunamira Cave marks its most easterly distribution (Cosgrove 1995). This material was transported from its source (the meteorite crater) over a distance of 100km and suggests long distance transport and/or exchange networks. The distribution of Darwin glass is geographically skewed. For instance, the material does not occur in the south eastern site, ORS 7. This site has a distinct faunal butchery pattern and evidence may mark a human behavioural boundary within south western Tasmania (Cosgrove 1995).

In northern Tasmania, the lower LGM sea levels allowed the occupation of the Bassian Plain. Occupation of cave sites such as Cave Bay cave on Hunter Island, Mannalargenna Cave on Prime Seal Island, and Beaton Shelter on Badger Island indicate occupation of the Bassian plain after ~22,000 years ago (Bowdler 1977; Sim 1994) reflecting low levels of occupation on the Bassian Plain at this time (Cosgrove 1999).

Another early Aboriginal site in northern Tasmania is the Warragarra rockshelter in the Upper Mersey Valley below the Great Western Tiers (Lourandos 1983). This shelter contains evidence of Aboriginal hunting from before 9,000 years ago. Most coastal sites in Tasmania (and the Australian mainland) date from 6-7,000 years ago when global sea levels stabilized following the melting of the glaciers and ice-caps. Shell middens in the Furneaux Group of islands are the oldest dating to 9,000 years ago (Sim 1994). One of the longest, continuous cultural sequences in Tasmania has been excavated at Rocky Cape, some 20km east of Smithton (Jones 1971). Rockshelters containing stratified midden material show Aboriginal occupation dating back 8,000 years. About 3,500 years ago, fish remains may have ceased to be deposited in the excavated sequence. Stone tool technology also changed during this period. Bone points and undifferentiated quartzite flakes characterize the early assemblages. Around 5,500 years ago bone points disappear from the tool kit to be replaced by stone artefacts made from a wider range of raw materials.

Aboriginal occupation of southeast Tasmania during the Pleistocene period is poorly represented in the archaeological record. ORS 7 in the upper Shannon River valley, which drains the southern edge of the Central Plateau, was occupied intermittently from 30,000 years ago (Cosgrove 1995a). However, the density of artefacts at this site is very low compared to cave sites in the southwest (Cosgrove 1995a).

Early Aboriginal occupation of the Derwent Estuary region is indicated by a Pleistocene aeolian sand sheet that mantles a hilltop at Old Beach. The sand sheet contains stone artefacts at its base that are older than surface occupation (hearths and shell middens) dated to ~5,500 years ago (Sigleo and Colhoun 1975). It is possible that stone artefacts were buried when the dune sand was blown from the bed of the Derwent River during a period of low sea levels. However, pedogenic processes are known to move objects down soil profiles and they may be younger (see Section 2.5).

Sigleo and Colhoun (1982) reported similar Pleistocene landform and stone artefact associations from the Glenfield dune near the Jordan River Estuary and Crown Lagoon lunette near Oatlands. Stone artefacts and hearths comprised these sites. The basal Pleistocene sand units of at these two landforms did not contain archaeological material.

The Old Beach site is the only open site in Tasmania argued to be of Pleistocene age. However, there has been no direct dating of it and the argument is tenuous relying on two charcoal ages from aeolian landforms elsewhere. One is an age of ~15,000 years ago from the base of a dune near Richmond and the other an age of 25,000 years ago from the base of a dune at Pipe Clay Lagoon. The artefacts at the base of the Old Beach sand sheet are claimed to fall within this range of Pleistocene ages because this is the period when sand was deposited.

Most Aboriginal sites around the Derwent Estuary have been located along the shoreline. The Carlton Bluff midden began forming 8,000 years ago (Brown 1986, 1991). The majority of sites in this area date from ~6,000 years ago when rising seas stabilized near to their present level. The sites are mostly shell middens dominated by *Mytilus planulatus* and *Ostrea angasi*. Stone artefact assemblages are often associated (Searle 1992). Basal radiocarbon dates from six middens show that they began forming between 5,800 and 5,200 years ago (Brown 1986). Stone artefacts excavated at Risdon Brook are associated with charcoal dated to 4,900 years ago (McGowan 1985).

Officer (1980) located most of the known shell middens around the Derwent Estuary demonstrating the largest concentration at the mouth of the Jordan River. One of these sites, JRM 1 now registered as TASI 1355, was excavated (Gaffney 1978; Gaffney and Stockton 1980). Seven stone artefacts were recovered from the 35cm deep midden deposit but no fish or animal bones. Interestingly, *Mytilus planulatus* was replaced by another mussel, *Xenostrobus securis* in the excavated sequence. *X. securis* has a wide salinity tolerance and probably indicates decreasing salinity in the Jordan River. The sequence dates from between 900±800 and 3620±260 (Stockton 1981).

3.4 The Jordan River Valley

The Jordan River valley upstream of the proposed Brighton Bypass is rich in Aboriginal stone artefact assemblages (Stone and Stanton 2006). Ethnohistorical records suggest that the river formed a tribal boundary between the Big River Tribe, numbering 3-400 people, and the Oyster Bay Tribe, numbering 6-800 people (Brown, 1986). Stone and Stanton (2006) proposed that the Jordan River valley was probably intensively occupied by Aboriginal people, particularly as it is a natural conduit between the Central Plateau and the Derwent Estuary. Accordingly, a high density of Aboriginal sites can be expected in the river valley.

Brown (1986) included the Jordan River valley in his regional overview of the archaeology of South East Tasmania. His findings were partly based on the unpublished survey results of Cosgrove who sampled some of the archaeological record of the Jordan valley. Brown (1986) concluded that most Aboriginal sites in the mountainous hinterland of southeast Tasmania are located on the floors of major river and creek valleys. The footslopes adjoining these areas and sandstone shelters were also preferred campsites. Kee (1990) drew similar conclusions from her study of the Midlands, identifying alluvial terraces, old floodplain surfaces and gentle slopes adjacent to rivers and creeks as likely Aboriginal site locations. Stone and Stanton's (2006) Aboriginal site survey of the proposed Waddamana-Risdon Vale 220kv transmission line confirmed the predicted high density of sites in the Jordan valley. They located a total of 16 Aboriginal sites in the middle reaches of the Jordan and 19 potential Aboriginal site locations. Most of the confirmed sites are stone artefact scatters (n = 14) and the remainder are isolated artefacts (n = 2). A large number of rockshelters were noted in the sandstone escarpments that form the valley. Some of these rockshelters may have been occupied but those investigated did not contain any surface archaeological traces. Stone and Stanton (2006) identified two "narrows" in the Jordan Valley, where Aboriginal cultural material is concentrated. One is the Elderslie Sandstone Formation reach (between the Sand Hills and Heathy Hills) and the other the Broadmarsh reach (between Gards Hill and Terrys Hill). Some of the sites along these reaches are so large that they cover entire landforms. The distribution of stone artefact sites in the Jordan valley shows a preference for sandy landforms as campsites. These landforms include sandy bedrock spurs, alluvial terraces and dunes. Stone assemblages typically comprise flakes of chert, quartzite, silcrete and chalcedony, with minor elements of mudstone and petrified wood.

3.5 Lower Jordan

Planning studies undertaken previously for the proposed Brighton Bypass and Transport Hub account for most of the known Aboriginal sites along the lower reaches of the Jordan River valley and surrounds. Of relevance are those by Stokes and Summers (1993), Parham (1993), Searle (1996), Richardson (1996), Scotney (1996), Maynard (2002), Stanton (2008, 2008a, 2008b, 2008c, 2008d) and Everett (2008). These field studies have resulted in the registration of 19 Aboriginal sites, comprising stone artefact scatters, stone quarries and isolated artefacts. Cosgrove's (1984) survey also located two large scatters (TASI 1433 and 1434) in a sand sheet ~2km west of Pontville (see Brown 1986). Initially, the Department of Transport engaged Stokes and Summers (1993) to survey the Tea Tree Road corridor between Brighton and Colebrook. One stone artefact scatter and six isolated artefacts were located, with three of the isolated artefacts (TASI 6835, 6836 and 6837) located in the Jordan valley between Brighton and Tea Tree. Siltstone was the most frequently recorded raw material followed by cherty hornfels, mudstone and silcrete, typical of Jordan River assemblages.

Parham's (1993) survey for the proposed Brighton Bypass route between the Boral Quarry and Brighton Lodge (either side of Crooked Billet Creek) did not locate any Aboriginal sites because of poor ground surface visibility. Searle (1996) extended this survey the full length of the proposed bypass route but could only locate two Aboriginal sites. One is a small cluster of chert artefacts on the east bank of the Jordan River near Geard Place (TASI 7463). The second is a small quartzite quarry (now deregistered) located beside the rail line some 2km east of Brighton (TASI 7464). Richardson (1996) located another artefact (a silcrete scraper) during a survey for the proposed Midland Highway/Brighton Lodge Interchange. This find was made on the southern outskirts of Brighton some 400m west of the Jordan River, outside the Northern Section. However, the site was not registered on the TASI and retains in the literature its field designation of BLA-001.

Closer to Pontville, Scotney (1996) located a very large stone artefact scatter (TASI 8676) centred on a sandy ridge between the Jordan River and Bagdad Rivulet. The ridge runs parallel with the disused Douglas Aspley rail formation. A total of 91 artefacts were recorded over a distance of ~1km. Of these, 39% were formal tools such as scrapers. Scotney (1996) located six more artefacts on a tributary of the Bagdad Rivulet ~600m to the east of TASI 8676 (outside the Northern Section) and an isolated artefact on the south side of Rifle Range Road (inside the Northern Section). Neither site was registered (see also Scotney 1997, 1997a). Maynard (2002) surveyed a small portion of the Pontville Small Arms Range Complex (PSARC) close to the Bagdad Rivulet. The isolated artefact located by Scotney (1996) was found to be part of a scatter of stone artefacts that Maynard registered as TASI 9158. The site overlooking the rivulet contains several waste flakes but no tools (in contrast to TASI 8676), which suggested a reduction site where tools were made and taken away for use. The remainder of the PSARC, extending beyond Shene Hill, is unsurveyed. However, local knowledge reported to Maynard suggests that there are rockshelters at the extreme northeastern end of the PSARC.

Recent surveys by Stanton (2008, 2008a, 2008b, 2008c, 2008d and 2008e) for the proposed Brighton Transport Hub and southern section of the proposed Brighton Bypass have located a total of seven Aboriginal sites. Perhaps the most significant of these is TASI 10601 located on the Parkholm property not far from Boral's Bridgewater quarry (Stanton 2008). The site is a large stone artefact scatter that follows the contours of two low ridges for a distance of 650m. Surface artefact density was estimated at 1/5- 400m^2 over an area of ~120,000 m^2. Among the artefacts are steep-edge and round edge scrapers, retouched flakes and large flakes. Chert, silcrete, quartzite and mudstone are the dominant raw materials, with porcellanite (white chert) also recorded. Many of the artefacts retain 10-30% cortex suggesting a local source. Stanton (2008) also located two artefacts (TASI 10602) close to the Parkholm residence.

Subsequent investigations of an alternative transport hub site by Stanton (2008a, 2008b) located three Aboriginal sites associated with Crooked Billet Creek (TASI 10648) and Ashburton Creek (TASI 10649 and 10650) west of the Midland Highway. All are relatively small scatters (five artefacts or less) located alongside these creeks. TASI 10648 is currently the subject of an archaeological excavation. Stanton (2008c) returned to the original transport hub site to survey the proposed Boral East site east of Parkholm. An isolated round-edge siltstone scraper was recorded on a ridgeslope (TASI 10651). Further artefact finds (TASI 10667 and 10713) were made by Stanton north of Crooked Billet Creek. Only three artefacts were recorded at these two sites (Stanton, 2008d). The Northern Section of the proposed Brighton Bypass was initially surveyed for Aboriginal sites by Everett (2008) who located six new exposures of stone artefacts in the study area. Four of these exposures were located alongside Briggs Road east of Brighton and two near Pontville. Everett's finds were re-identified and registered on the TASI as part of this investigation (see Section 8). Huys (2008) recently surveyed the Southern Section of the proposed Brighton Bypass locating six Aboriginal sites (five stone artefact scatters and an isolated artefact) along the proposed road alignment. Each site comprised between one and six sparsely distributed artefacts. Two of the sites (STR4 and STR5) were claimed to have Aboriginal glass artefacts (five in total) struck from green bottle glass. Given that only twenty artefacts were recorded in total across the six sites, the ratio of stone to glass artefacts is 4:1, which is interesting and unusual.

CHMA (2008a) was engaged by Pitt and Sherry to implement a more detailed Aboriginal heritage assessment for the proposed southern section of the Brighton Bypass. In the course of the field survey assessment a total of six

Aboriginal heritage sites were identified (Sites TAS1 10801-10806). Five of these sites are classified as artefact scatters (10802-10806), with the remaining site (10801) being an isolated artefact. All of the five identified artefact scatters were small (in terms of artefact numbers), comprising between two and six artefacts. The combined artefact assemblage for the six sites equates to 20 artefacts (CHMA 2008a).

Based on the findings of the field survey, CHMA (2008a) assessed the archaeological sensitivity of the southern section of the Brighton Bypass as ranging between moderate through to very low sensitivity. The archaeological sensitivity ratings presented by CHMA (2008a) were subsequently tested through an extensive sub-surface investigation programme.

CHMA (2008; works in progress) also undertook extensive surface and sub-surface investigations at the at the new Transport Hub involving sites 10648 and 10650. Site 10648 was found to comprise a range of cultural features, including moderate to high densities of surface and sub-surface artefacts, stone procurement sites and possibly an early European occupation site. All of these heritage features are spatially linked and may be temporally linked as well. As such, they can be considered to be part of the one site complex.

The main focus of Aboriginal occupation in this area appears to have been elevated terraces on the southern and northern margins of Crooked Billet Creek, with activity radiating out from this area. The terraces are located in a very sheltered part of the small valley associated with Crooked Billet Creek, at a point where the creek flattens out to form what appears to be a small swamp area. It is likely that these elevated terraces were regularly utilised as interim camp locations by Aboriginal people in the area. Foraging activity (including the procurement of stone materials) would have occurred in the broader valley area, with people returning to these terrace areas to process their harvests. The occupation of this area appears to have extended through to the post contact period as evidenced by the presence of flaked bottle glass. There is some evidence to suggest that Aboriginal activity in this area during the post contact period may have shifted from the terraces either side of the Creek, slightly to the east to the lower northern slopes of a nearby prominent hill. Why this is the case is uncertain (CHMA 2008 works in progress).

Site 10650 comprised a low (and in some areas low-medium) density scatter of stone artefacts that are broadly distributed across the southern and south-western section of the crest of a broad hill. In the course of undertaking field investigations at site 10650, a silcrete stone procurement site was identified and recorded. This site consists of a discreet concentration of silcrete/quartzite nodules (varying in size from a soccer ball to a tennis ball). The nodules are located on the basal southern side slopes of a hill, on the northern margins of Ashburton Creek. This is just south of the southern boundary of the Hub site. These nodules have been the focus of extensive procurement activity, with several thousand artefacts (mainly primary flakes and *debitage*) noted within a 50m radius of the nodules.

Given the dominance of silcrete stone artefacts at site 10650, and the close spatial association of the site with the silcrete procurement source, it appears that this site is representative of sporadic activity associated with the procurement of stone from this source. The likely scenario is that Aboriginal people were carrying out initial procurement and reduction activities at the procurement site itself, and then secondary reduction processing at other locations (including site 10650). The results of the test pitting undertaken at site 10650 indicate that the movement of the silcrete material from the stone procurement site was generally north toward Crooked Billet Creek and site 10648. Secondary reduction processing appears to have been mainly carried out at site 10648, and along the western edge of the hill summit between sites 10648 and 10650 (CHMA 2008 works in progress).

As part of the investigations undertaken by CHMA at the Hub site, a series of test pits was excavated between sites 10648 and 10650, with the main aim being to determine the presence or absence of cultural materials in this area and to define any connection between the two identified sites. Low to moderate densities of artefacts were noted along the western edge of the hill summit separating sites 10648 and 10650.

The results of the investigations provide a very clear indication that sites 10648 and 10650 are spatially, and most likely temporally, connected. In other words sites 10648, 10650 and the artefacts identified in the area in between these sites are best interpreted as being part of the one large site complex (CHMA 2008 works in progress). Two radiocarbon dates are presently being assayed for the excavations at sites 10648 and 10650. The initial readings give a time range for occupation from ~ 3500 years to ~150 years. The latter date fits well with the use of glass at the sites.

4 Methodology

This section details the methodology and technical design of the excavation process and data management. It details the excavation strategy and the methods of information retrieval and management employed. Moreover, this section defines the research questions outlined in the method statement (Appendix 1) and refines these in light of what actually came out of the excavations.

4.1 Research Questions

The overall aim of the excavation was to test the potential of the JRL site and recover evidence of changes in site use and lithic technology over time. Therefore, several research questions have been devised as a part of this methodology in order to better identify and define these types of cultural and technological changes through time.

1. Was the site occupied throughout the period of levee construction or occupied only after the levee was constructed?

This question invites comparison between surface and subsurface cultural layers. The hypothesis that the levee deposit contains a stratified cultural sequence will be tested by controlled archaeological excavation and radiometric dating of the sediments. This will establish a chronology of occupation for the site and show changes in site use and lithic technology over time, including periods when particular raw materials were preferred (exploited) over others. The limiting factor on the depth of excavation will be the age and origin of the basal sediments and whether or not these sediments have the potential to yield cultural material.

2. How intact or disturbed is the site? This is very important since the integrity of all other results depends on it. Field observations indicate the following post-depositional processes:

- Disturbance by tree and grass roots, tree upheaval;
- Mixing by natural pedogenic processes;
- Repeated ploughing;
- Soil erosion, particularly by wind and water;
- Trampling by stock and farm vehicles; and
- Potential vertical and horizontal displacement of artefacts in the soil by the above processes.

3. Questions to ask of the lithic assemblages

The purpose of stone artefact analysis is to provide a detailed understanding of the prehistoric technology of the site and its relationship to the hunter-gatherer populations responsible for its manufacture and use.

The principal aims and methods of the stone artefact analysis were as follows:

- Examine variability across the site and over time by exploring different proportions of raw material use and techniques of artefact manufacture. Attribute analysis of artefacts will allow a determination of whether different raw materials were used differently across the site;
- Investigate the relative availability of raw materials through examination of conservations strategies such as platform preparation, core reduction and rejuvenation activities; and
- Explore the extent to which the site was used for the manufacture of stone tools or for maintenance and use at the site. Core frequencies, artefact size and the presence of modified and unmodified flakes on site were compared to assess the frequency of artefact manufacture on site.

A detailed technological analysis was undertaken by Dr Sophie Collins on the stone material from all eight trenches.

4. Wider questions to be considered

- How does TASI 10757 compare with other known sites in the region?
- Can TASI 10757 be linked with the recent ethnohistoric past and documented tribal groups in the region?

The first of these two questions is part of the archaeological brief. The second question is being addressed in a separate report (social, cultural, historical) commissioned through the Tasmanian Aboriginal Community. This report is a separate, but complimentary, piece of work to the archaeological investigation. The authors of that report are independent and their report and its contents and recommendations should be considered separately.

4.2 Test Excavation Strategy

As stated above, the test excavation of the JRL site had two key objectives. The first was to determine if the site contains a stratified cultural sequence. The second was to demonstrate the degree of site integrity. The strategy involved the controlled excavation of four 2m x 2m excavation trenches and four 1m x 1m trenches. Trenches 1 and 2 were aligned perpendicular to the strike of the levee ridge, and Trenches 3 and 4 were aligned parallel to the strike ridge. Trenches 5-8 were placed perpendicular to the strike of the levee towards the distal end of the levee in order to identify the edge of the levee landform. By aligning the excavation trenches across the levee ridge in this way, two cross sections of the landform were exposed; one encapsulated the soil stratigraphy from river front to the distal end of the levee and the other defined the lateral spread of the artefacts both within and outside of the potential impact zone (refer to Figure 4.1).

It should be noted that the number size and distribution of these test pits was discussed in detail with the Aboriginal community, AHT and DIER. Apart from the research goals outlined above and detailed in the method statement, we excavated under an understanding that we would damage as little of the site as possible. Considerable thought went into balancing damage to the site against retrieving enough information to allow people to understand something of the general character of the JRL site. We also began the excavation, knowing little beyond that there was a levee, an environment conducive to stratification, though there was no certainty of that and that there were 17 or so artefacts on the surface of the levee. Beyond that, we knew little, other than such a site had, in our combined opinions, considerable archaeological potential.

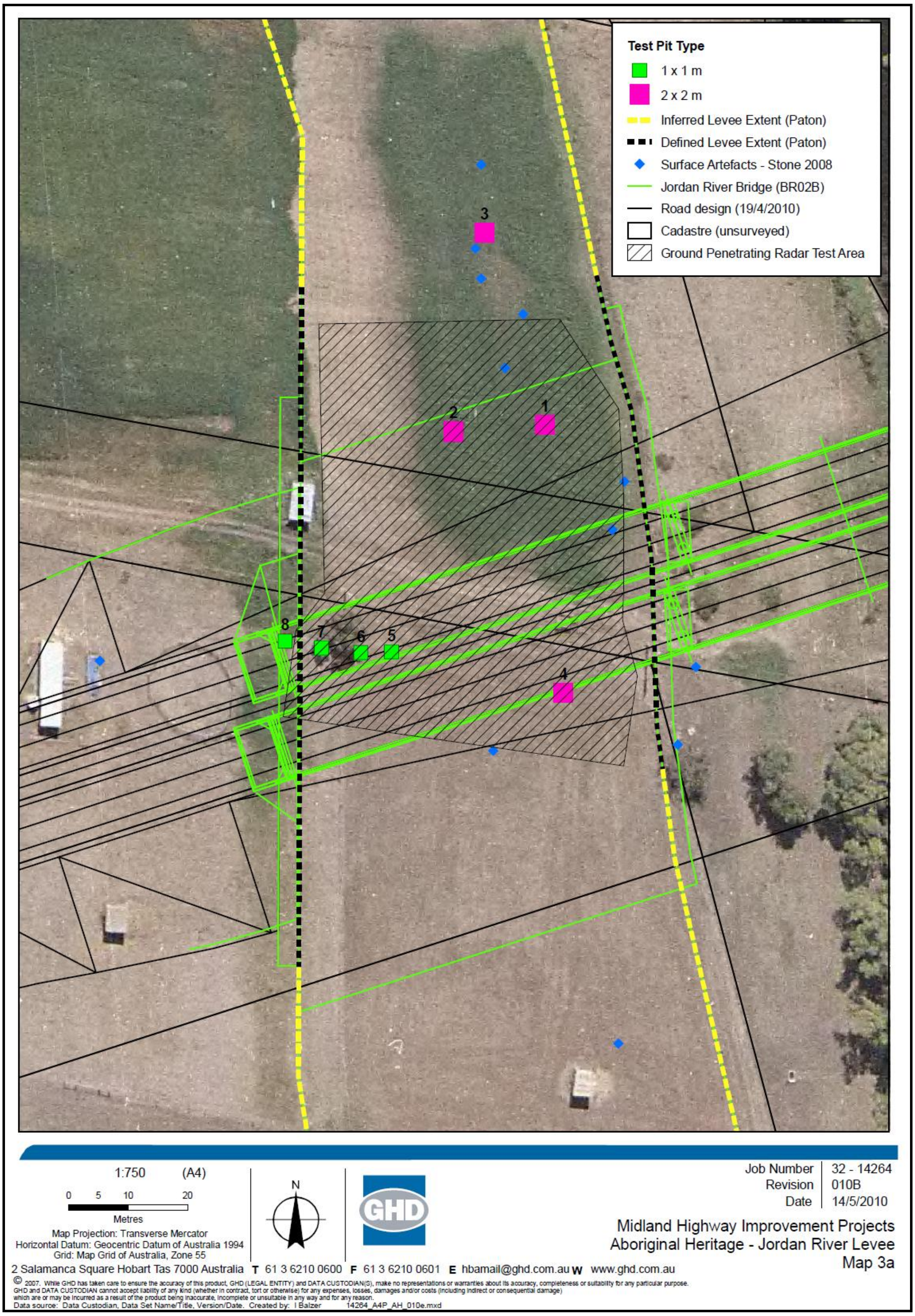


Figure 4.1: Map detailing the location of the excavation trenches in relation to the levee site

4.3 Excavation Methodology

Two different methodologies were applied to the test trenches at the JRL site. This is due to the fact that the methodology was revised in February as a result of the issues raised during the consultation process with the Aboriginal community and DIER and AHT. The initial methodology has largely been conformed to and is summarised below. This methodology applies to Trenches 1 and 2.

1. All 8 trench sites were surveyed with the use of differential Global Positioning System (GPS). The pits were aligned to the north and placed perpendicular and parallel to the strike of the levee (i.e. along an east west and south north axis).

2. The deposits were excavated in 5cm spits or layers, with exception of instances where a clear change in the soil/sediment unit became evident. In these cases spits were generally variable in depth depending on the nature of the contact between the two units.

3. Excavation of the 5cm spits was conducted by hand with trowel and brush in order to record and photograph artefacts in situ, and make detailed observations of the soil profile.

4. Each 2m x 2m test trench was divided into four squares (labelled 1-4), with each square further divided in to four quadrants (labelled A-D). This enabled a degree of spatial control for the artefacts that were retrieved from the sieves. This division and sub-division is shown in Figure 4.2. Each 1m x 1m test trench was also divided according to four quadrants (A-D), the sub-division of which is shown in Figure 4.3.

5. Where artefacts were encountered through hand excavation, their location in the test trench was measured according to the x, y and z axis of the trench. All x and y measurements were taken from the eastern and northern walls of each square, respectively. Z measurements were taken from a datum, set up using differential GPS, along the western wall of the trench. Depth was measured from this point using a string line and line level.

6. The inclination of the long axis and dip of individual artefacts was recorded on the hand excavated artefacts. A hand held compass was used to measure the inclination, while a clinometer was used to measure the dip. These measurements were taken in order to test for post-depositional disturbances.

7. All excavated sediment was placed in labelled buckets according to the square and quadrant from which the sediment came. Each bucket was recorded in a sieve log before being wet sieved by hand, through a 3mm sieve plate. A copy of the sieve log recording form is located in Appendix 2.

8. All artefactual material was bagged and labelled according to provenance and retained for further analysis.

9. Stratigraphic sections were recorded and three dating samples were taken from Trench 2. It is the intention that further OSL samples be taken from the other trenches at a time yet to be determined.

10. A standard site recording form was used for each excavated spit. Details included site name, trench, square and quadrant number, the documentation of bioturbation markers, soil colour and texture, frequency and size of both organic and inorganic inclusions, and a sketch plan for the documentation of the artefacts that were hand excavated. An example of a site recording form is located in Appendix 2.

11. Soil colour was measured with a Munsell Soil Colour Chart, and soil texture was identified using a soil texture field sheet. Soil texture is a measure of the behaviour of a handful of soil when moistened and kneaded into a bolus and then pressed out between thumb and forefinger. Nineteen grades of texture, such as sandy loam, clay loam and silt loam, are commonly recognised (see table in Appendix 2).

The remainder of the test trenches 3-8 were also excavated and managed in accordance with the guidelines outlined above, with the exception that no *in situ* artefact recording was undertaken. Specifically, point 5 in the list above was not applied to trenches 3-8. However, spatial provenance was controlled with the grid system applied to each trench, while vertical control was maintained with the use of 5cm spits as outlined in points 2 and 4.

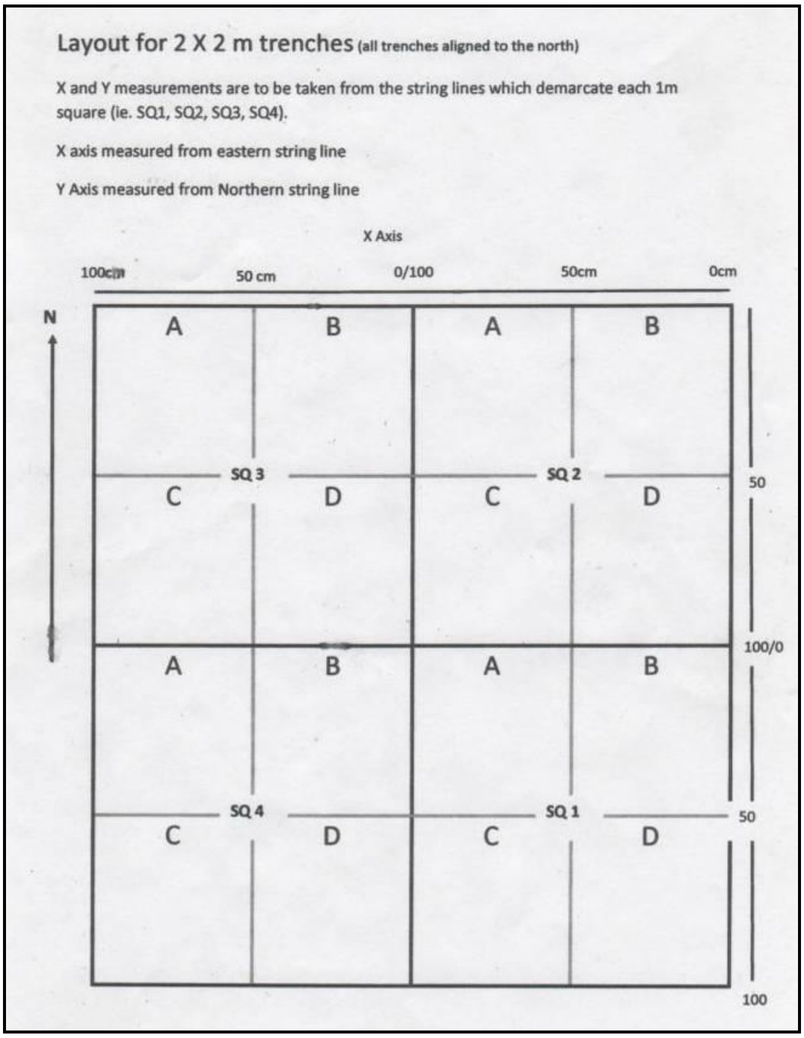


Figure 4.2: Subdivision of 2mx2m test pits, showing squares (1-4) and quadrants (A-D)

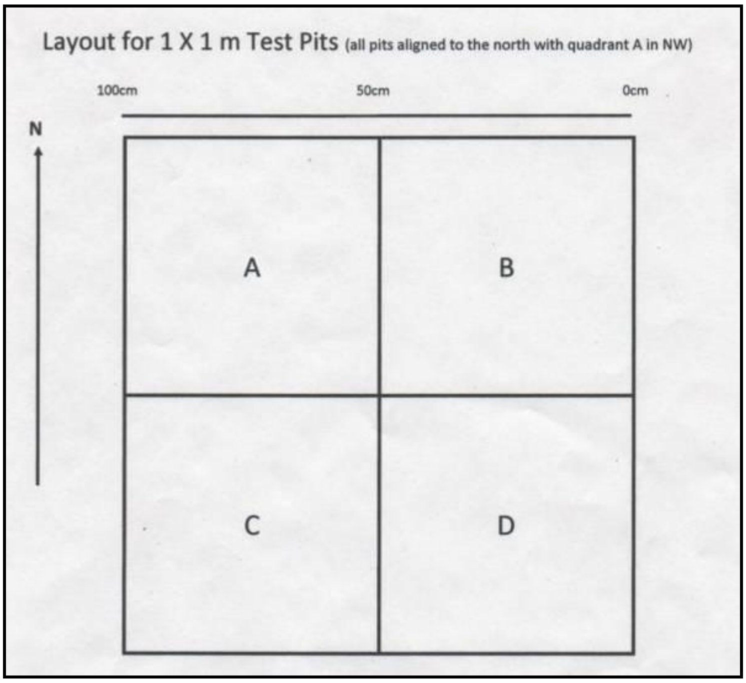


Figure 4.3: Subdivision of 1mx1m test trenches, showing quadrants (A-D)

4.4 Artefact Analysis

The essential goal of stone artefact analysis is to provide a detailed understanding of the prehistoric technology of a site and its relationship to the hunter-gatherer populations responsible for its manufacture and use. The purpose is to increase our understanding of prehistoric behaviour by examining and understanding the tools that made subsistence and survival possible. In the case of the JRL site, two specific aims were established:

- To determine whether a new cultural sequence can be made for Southern Tasmania, for the time frame of levee accumulation; and
- To explore how TASI 10757 compares with other known sites in the region.

4.5 Radiometric Dating

The fine sand that forms the levee deposit is ideal material for optically stimulated luminescence (OSL) dating methods. Five samples were collected in total, with three being collected from Trench 2 and two from a quarry cutting located in close proximity to the JRL site. The quarry cutting provided the opportunity to date the basal sands of the floodplain deposit on which the levee was formed, allowing for a complete geomorphological reconstruction of site formation history at the JRL site. Analytical methods, and sample collection procedures employed are presented in Section 6.

4.6 Ground Penetrating Radar

A geophysical investigation using Ground Penetrating Radar (GPR) was conducted from the 15th to the 19th February 2010 at the JRL site by GBG Australia. GPR was employed at the site because of the potential for the loose sandy deposits that comprise the JRL site to contain Aboriginal burials.

The methods and detailed findings of the GPR survey are presented in Appendix 3 as a separate report.

5 Results

The results presented in this section deal with the soil stratigraphy. The ground penetrating radar analysis is presented in Section 6 and the radiometric results are presented in Section 7. Site formation and post depositional disturbance are presented in section 8 and the artefact analysis is presented in Section 9.

5.1 Soil Stratigraphy

Stratigraphy at the JRL site is comprised of two soil stratigraphic units. The upper unit is comprised of the levee deposit and the lower unit is made up of a buried floodplain soil upon which the levee is situated. The levee itself comprised of three soil stratigraphic units, namely the plough layer, a zone of oxidisation and unweathered alluvial sand deposits. The floodplain soil is comprised of a truncated A2 horizon and underlying Iron B horizon and B2k horizon and a basal Ck horizon. Each of these units are described below.

The soil stratigraphy is the same for all 8 trenches. The levee deposit is from 67cm to 85cm deep with the underlying floodplain soil over 1m deep. Owing to the homogeneity of soil stratigraphy across the site it is sufficient to present schematic sectional data from a selection of excavation trenches only. In order to provide a cross section of the soil/sediment deposits from the river channel to the distal end of the levee, two cross sections are outlined in Figures 5.1 and 5.2, comprising trenches 4-8 and 1, 2 and 8 respectively.

The top soil unit across the JRL site has been identified as an A_p horizon. This is simply a top soil mineral horizon which has been transformed through ploughing. In Trenches 1 and 2, the contact between the A_p horizon and underlying sub-soil was carefully excavated (Plates 5.1 and 5.2) in order to differentiate artefacts associated with the plough layer and the underlying soil. As a result spit 4 in Trench 1 and 2 is variable in thickness. A similar method of separation of the two soil units was applied in Trenches 3-8, however, no plough marks were evident. Across the site the plough layer ranged from 20 to 30cm in depth, was Dark Brown (7.5YR 3/2) to Brown (10YR4/3) in colour, and varied from a Fine Sandy Clay Loam to a Sandy Clay Loam soil texture (refer to Appendix 2 for field texture classes).

Plate 5.1: View facing west of plough furrows in Trench 2: depth 25-30cm

Plate 5.2: View facing north of plough furrows in Trench 1: depth 25cm

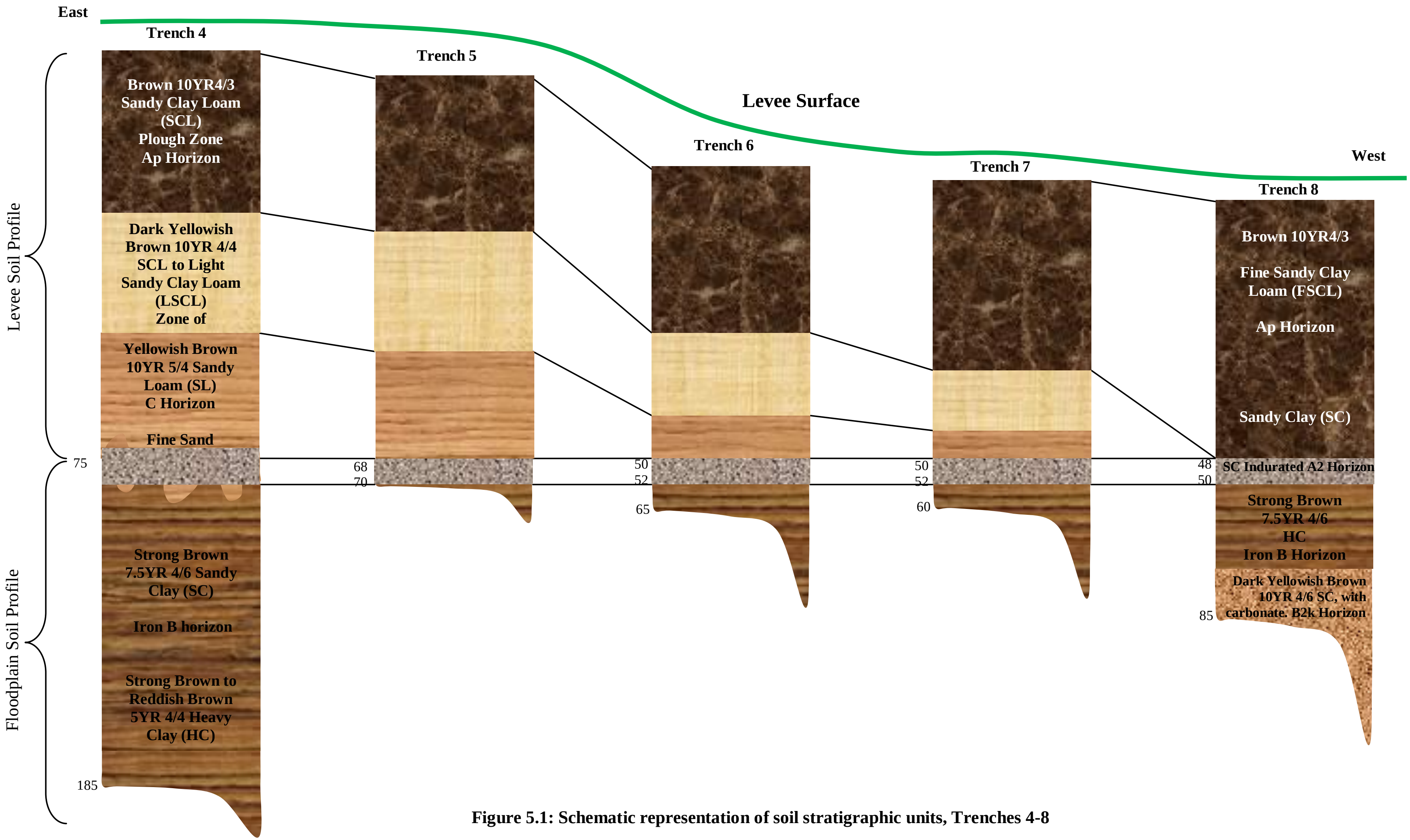


Figure 5.1: Schematic representation of soil stratigraphic units, Trenches 4-8

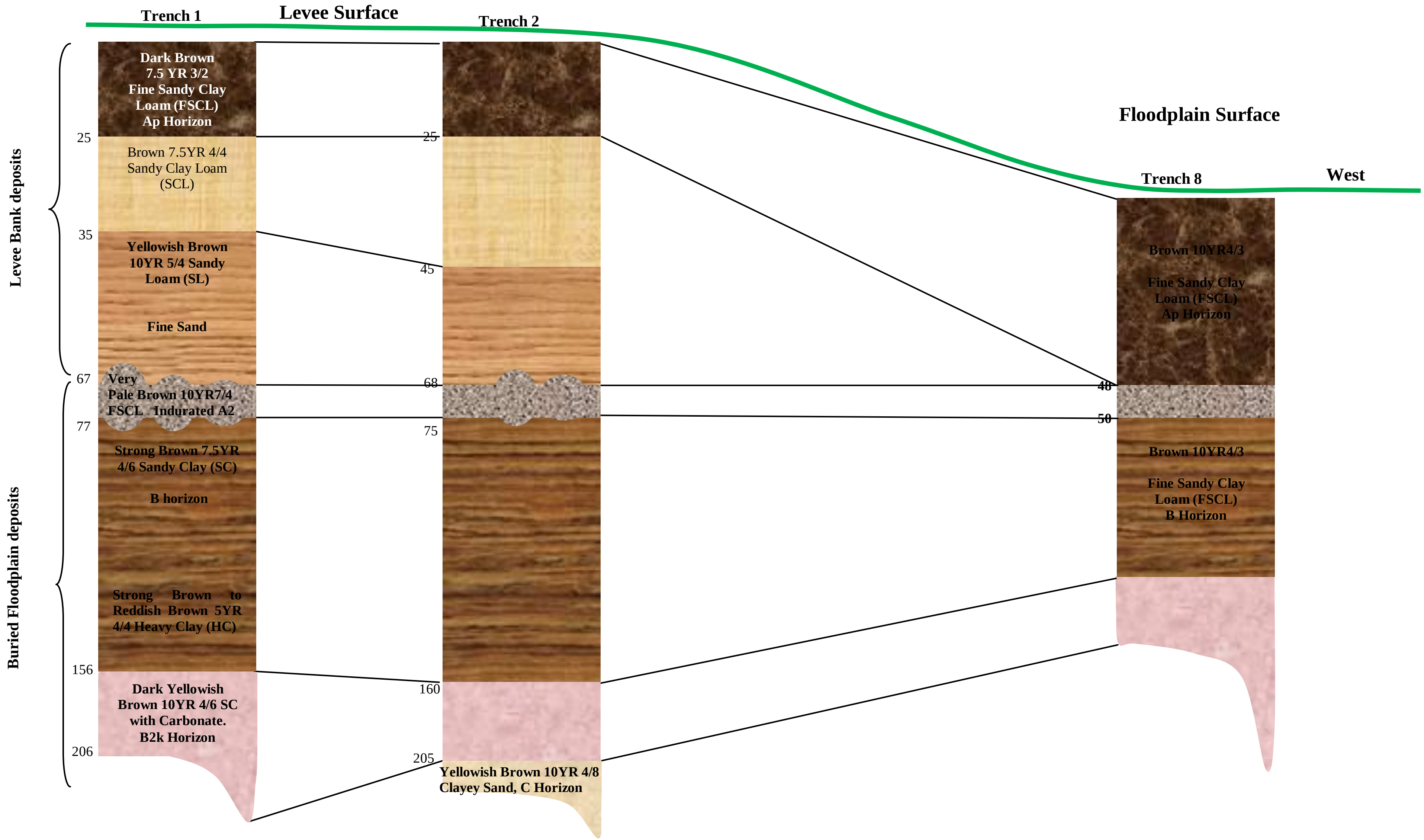


Figure 5.2: Schematic representation of soil stratigraphy, Trenches 1, 2 and 8

Beneath the A_p horizon the sub soil unit comprised an oxidised horizon, which displayed a high level of biological activity as evidenced by numerous root and soil fauna casts (Plate 5.3). Soil mixing within this unit is particularly strong in Trench 2 with the presence of a rabbit burrow from 40cm to 60cm in depth along the northern wall of the trench (Plate 5.4). This unit was the most variable across the site generally constituting a Brown (7.5YR4/4) colour in Trenches 1,2 and 3 (Plate 5.5), and a Dark Yellowish Brown (10YR4/4) in Trenches 4 to 7 (Plate 5.6). The oxidised layer is absent in Trench 8 (Plate 5.7), owing to its landscape position at the distal end of the levee and proximity to a small rivulet. This means that the soil will have been frequently water logged; an environment which is not conducive to oxidization. Soil field texture varied little within the oxidized soil horizon across the site, ranging from a Sandy Clay Loam to a Light Sandy Clay Loam.

Plate 5.3: Detail of soil fauna and root casts in the oxidised zone of the levee soil in Trench 1, eastern section

Plate 5.4: Detail of possible animal burrow disturbance present in Trench 2, at 45cm depth (spit 8)

Plate 5.5: View of northern section of Trench 2 showing contrast between upper A_p horizon and underlying oxidized soil horizon

Plate 5.6: View facing north of Trench 5, showing colour of oxidised soil at 50cm depth

Plate 5.7; View facing west of Trench 8. Note the absence of an oxidised layer

The oxidized soil horizon generally extended in depth from beneath the A_p horizon to a maximum depth of 35cm to 50cm in Trenches 1-5 and steadily decreased in thickness across Trenches 6 and 7, until it became nonexistent in Trench 8. This pattern is understandable in light of the fact that soil depth will be greater closer to the river channel, where maximum deposition took place, and will become increasingly shallower as one moves towards the distal end of the levee. Similarly, the decrease in thickness of the oxidised layer is also understood in terms previously explained, whereby the distal landscape position of the levee will have undergone frequent periods of water logging preventing a high degree of oxidisation.

Beneath the oxidized zone the sediment becomes increasingly lighter and grades from a Light Sandy Clay Loam through to a Sandy Loam and fine to medium unweathered sand at the base of the levee (Plate 5.8). This unit extends in thickness from approximately 35cm to 75cm in Trenches 1 to 3 and 5, from 45 to 85cm in Trench 4 and from 35cm to 55cm in Trenches 6 and 7 (refer to Tables 5.1 to 5.7). This unit is absent in Trench 8. Trench 8 soil stratigraphy comprises a relatively deep A_p horizon overlying the buried floodplain soil (Plate 5.7).

Of stratigraphic interest here is the occurrence of a potentially buried fossil root cast, associated with the base of the levee. This fossil cast was only encountered in Trench 2 at the interface between the basal levee sands and the surface of the buried A_2 horizon (Plate 5.9).

Plate 5.8: View facing south of Trench 4. Note the three distinctive soil units

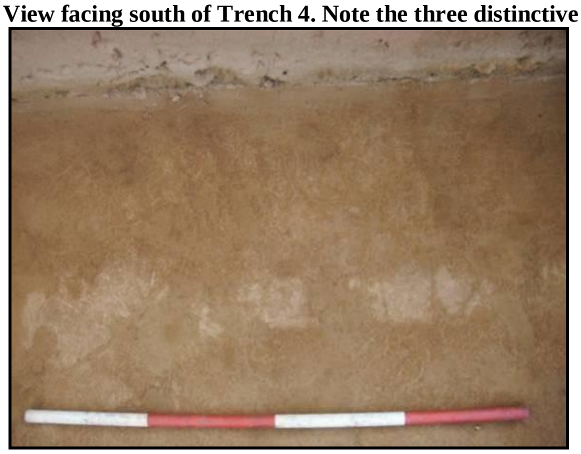


Plate 5.9: Detail of fossil root cast in Trench 2, at 67.5 - 70.5cm

Beneath the unweathered levee bank sands a buried A_2 horizon was encountered at depths ranging from 50cm to 75cm across the site. This soil horizon is the remnant top soil associated with the buried floodplain (Plates 5.10 and 5.11). Texture and colour were uniform across the site, ranging from a Fine Sandy Clay Loam to a Sandy Clay Loam of Very Pale Brown colour (10YR7/4). This buried soil is truncated in various places across the site and ranges in thickness from 1-5cm. The buried soil horizon was easily recognisable in most instances as over time it has become indurated (hardened). This unit was ill defined in Trench 4. From approximately 75cm in depth evidence of the indurated layer was noted, however the induration was weak and sand from the above unit was still predominant, down to a depth of 85cm.

A total of 4 sondage test pits measuring 1m x 1m were excavated from this surface in Trenches 1-4 (Plate 5.12). The purpose of the sondage test pits were to test for cultural material in the buried flood plain soil. If artefactual material was encountered, it was the intention to excavate the entire 2m x 2m test trench. In the instances of Trenches 5-8 only two to three 5cm spits were excavated in to the buried A_2 horizon

The flood plain soil was excavated to a depth of approximately 1-1.1m (Plate 5.10), encompassing 4 to 5 spits of 10cm in depth. From this point, soil auger tests were undertaken in Trenches 1, 2, 3, 4 and 8 in order to define a complete soil profile for the buried floodplain surface. Soil auger tests were undertaken in Trench 8 in order to determine that the Heavy Clay encountered beneath the A_p was in fact the buried floodplain surface. From below the A_2 horizon at 75-85cm depth a B_2 horizon extends to 1.6-1.7m depth. It is comprised of a Strong Brown (7.5YR4/6) Sandy Clay to Heavy Clay with a strongly developed polygonal ped structure. Beneath the B_2 horizon a B_{2k}[4] horizon was encountered, which extended in depth from approximately 1.7-2m in depth. It comprised of a Dark Yellowish Brown (10YR4/6) Sandy Clay with many weak and fine carbonate segregations. From below 2.05m, sediments comprised a Yellowish Brown (10YR5/8) Clayey Sand with very few weak to medium carbonate fragments. Owing to the length of the soil auger we were unable to retrieve sediment samples from below 2.10m in depth. Generally speaking the site displays a high degree of homogeneity, in that soil units are equally represented across the site at comparable depths.

Soil stratigraphic data according to spit and depth for each individual trench is presented in Tables 5.1-5.8 below. Section drawings and photographs of each trench are presented in Appendix 5, while all information recorded on the field context sheets are presented in Appendix 6.

[4] A B_{2k} horizon is simply a second component of the B horizon which contains carbonate. Similarly the denotation Ck Horizon also indicates a C horizon with carbonate.

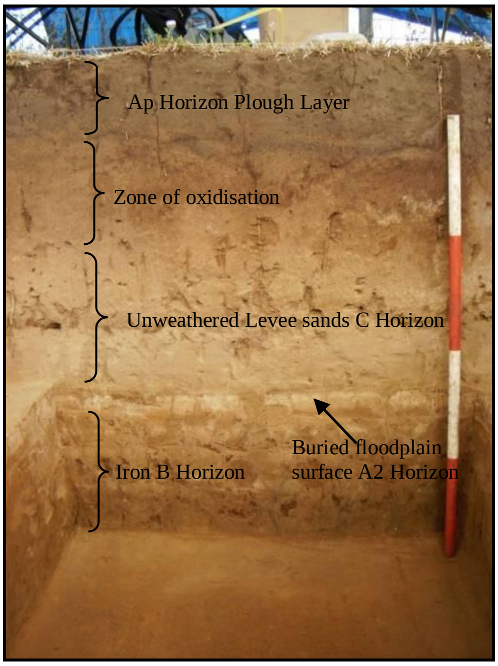


Plate 5.10: Southern section of Trench 2, showing the levee deposit overlying the buried floodplain surface

Plate 5.11: Detail of floodplain surface in Trench 1. Note the polygonal structure evident in the floodplain surface.

Plate 5.12: View facing north of sondage test pit in Trench 4.

Trench 1

Spit	Depth	Soil/sediment texture	Soil Colour	Stratigraphic Interpretation
1-4	0 to18-25cm	Fine Sandy Clay Loam	Dark Brown 7.5 YR 3/2	Ap Horizon Plough Layer
5-7	18-25 to 35cm	Sandy Clay Loam	Brown 7.5YR 4/4	Zone of Oxidization
8-15	35 to 67-75cm	Sandy Loam to Fine Sand	Yellowish Brown 10YR 5/4	Unweathered levee sand deposit
Sondage 16	67-75 to 70-77	Fine Sandy Clay Loam	Very Pale Brown 10YR 7/4	Indurated A2 horizon- buried floodplain top-soil
	70-77 to 77	Sandy Clay	Strong Brown 7.5YR 4/6	Indurated B horizon. Buried flood plain sub-soil
17-19	77 to 103	Sandy Clay	Strong Brown 7.5YR 4/6	Indurated B horizon. Buried flood plain sub-soil
Auger	103 to 156cm	Heavy Clay	Strong Brown7.5 YR 4/6 to Reddish Brown 5YR 4/4	B horizon. Buried flood plain sub- soil
Auger	156 to 206cm	Sandy Clay, with many coarse weak carbonate concretions	Dark Yellowish Brown 10YR4/6	B2k horizon. Buried floodplain sub-soil

Table 5.1: Trench 1 soil stratigraphy

Trench 2

Spit	Depth	Soil/sediment texture	Soil Colour	Stratigraphic Interpretation
1-4	0 to 16-28cm	Fine Sandy Clay Loam	Dark Brown 7.5 YR 3/2	Ap Horizon Plough Layer
5-8	16 to 28-45cm	Sandy Clay Loam	Brown 7.5YR 4/4	Zone of Oxidization
9-13	45 to 68.5-71.5	Sandy Loam to Fine Sand	Yellowish Brown 10YR 5/4	Unweathered levee sand deposit
14	68.5-71.5 to 72	Sandy Loam to Fine Sand	Yellowish Brown 10YR 5/4	Unweathered levee sand deposit- C horizon
	72 to75cm	Fine Sandy Clay Loam	Very Pale Brown 10YR 7/4	Indurated A2 horizon- buried floodplain top- soil
Sondage 15-17	75 to 90cm	Sandy Clay	Strong Brown 7.5YR 4/6	Indurated B horizon. Buried flood plain sub-soil
18-20	90 to 120cm	Heavy Clay	Strong Brown7.5 YR 4/6 to Reddish Brown 5YR 4/4	B horizon. Buried flood plain sub- soil
Auger	120 to160	Heavy Clay	Strong Brown7.5 YR 4/6 to Reddish Brown 5YR 4/4	B horizon. Buried flood plain sub- soil
Auger	160 to 205cm	Sandy Clay, with many coarse weak carbonate concretions	Dark Yellowish Brown 10YR4/6	B2k horizon. Buried floodplain sub-soil
Auger	>205cm	Clayey sand with very few weak to medium carbonate fragments	Yellowish Brown 10 YR 5/8	Interface of B2k horizon and C horizon (floodplain sediment)

Table 5.2: Trench 2 soil stratigraphy

Trench 3

Spit	Depth	Soil/sediment texture	Soil Colour	Stratigraphic Interpretation
1-3	0 to 15cm	Fine Sandy Clay Loam	Dark Brown 7.5 YR 3/2	Ap Horizon Plough Layer
4-7	15 to 35cm	Sandy Clay Loam	Brown 7.5YR 4/4	Zone of Oxidization
8-14	45 to 65-67	Sandy Loam to Fine Sand	Yellowish Brown 10YR 5/4	Unweathered levee sand deposit
Sondage 15	65-67 to 67	Fine Sandy Clay Loam	Very Pale Brown 10YR 7/4	Indurated A2 horizon- buried floodplain top- soil
16-21	67 to 102cm	Sandy Clay	Strong Brown 7.5YR 4/6	Indurated B horizon. Buried flood plain sub-soil
Auger	102 to 110cm	Heavy Clay	Strong Brown7.5 YR 4/6 to Reddish Brown 5YR 4/4	B horizon. Buried flood plain sub- soil.
Auger	110 to 170	Sandy Clay, with many coarse weak carbonate concretions	Dark Yellowish Brown 10YR4/6	B2k horizon. Buried floodplain sub-soil

Table 5.3: Trench 3 soil stratigraphy

Trench 4

Spit	Depth	Soil/sediment texture	Soil Colour	Stratigraphic Interpretation
1-6	0 to 30cm	Sandy Clay Loam	Brown 10 YR 4/3	Ap Horizon Plough Layer
7-10	30 to 50cm	Sandy Clay Loam to Light Sandy Clay Loam	Dark Yellowish Brown 10YR 4/4	Zone of Oxidization
11-14	50 to 70	Sandy Loam to Fine Sand	Yellowish Brown 10YR 5/4	Unweathered levee sand deposit
15	70 to 75	Fine Sand	Yellowish Brown 10YR 5/4	Unweathered levee sand deposit
Sondage 16	75 to 85	Fine Sand mixed with Sandy Clay	Yellowish Brown 10YR 5/4 with patches of Very Pale Brown 10YR 7/4 and Strong Brown 7.5YR 4/6	Unweathered levee sand mixed with weakly indurated A2 horizon and strongly indurated B horizon. Interface between levee and buried floodplain is ill defined
Sondage 17-19	85 to 115cm	Sandy Clay to Heavy Clay	Strong Brown7.5 YR 4/6 to Reddish Brown 5YR 4/4	B horizon. Buried flood plain sub- soil
Auger	115 to 185	Heavy Clay	Strong Brown7.5 YR 4/6 to Reddish Brown 5YR 4/4	B horizon. Buried flood plain sub- soil

Table 5.4: Trench 4 soil stratigraphy

Trench 5

Spit	Depth	Soil/sediment texture	Soil Colour	Stratigraphic Interpretation
1-6	0 to 30cm	Sandy Clay Loam	Brown 10 YR 4/3	Ap Horizon Plough Layer
7-10	30 to 50cm	Sandy Clay Loam to Light Sandy Clay Loam	Dark Yellowish Brown 10YR 4/4	Zone of Oxidization
11-14	50 to 66-68cm	Sandy Loam to Fine Sand	Yellowish Brown 10YR 5/4	Unweathered levee sand deposit
15	66-68 to 70cm	Fine Sandy Clay Loam	Very Pale Brown 10YR 7/4	Indurated A2 horizon- buried floodplain top- soil

Table 5.5: Trench 5 soil stratigraphy

Trench 6

Spit	Depth	Soil/sediment texture	Soil Colour	Stratigraphic Interpretation
1-4	0 to 20cm	Sandy Clay Loam	Brown 10 YR 4/3	Ap Horizon Plough Layer
5-7	20 to 35cm	Sandy Clay Loam to Light Sandy Clay Loam	Dark Yellowish Brown 10YR 4/4	Zone of Oxidization
8-10	35 to 50cm	Sandy Loam to Fine Sand	Yellowish Brown 10YR 5/4	Unweathered levee sand deposit
11	50 to 52	Fine Sandy Clay Loam	Very Pale Brown 10YR 7/4	Indurated A2 horizon-buried floodplain top- soil
	52 to 55	Sandy Clay	Strong Brown 7.5YR 4/6	Indurated B horizon. Buried flood plain sub-soil
12-13	55 to 65	Sandy Clay	Strong Brown 7.5YR 4/6	Indurated B horizon. Buried flood plain sub-soil

Table 5.6:Trench 6 soil stratigraphy

Trench 7

Spit	Depth	Soil/sediment texture	Soil Colour	Stratigraphic Interpretation
1-7	0 to 35cm	Sandy Clay Loam	Brown 10 YR 4/3	Ap Horizon Plough Layer
8-9	35 to 45cm	Sandy Clay Loam to Light Sandy Clay Loam	Dark Yellowish Brown 10YR 4/4	Zone of Oxidization
10-11	45 to 55cm	Sandy Loam to Fine Sand	Yellowish Brown 10YR 5/4	Unweathered levee sand deposit
12	55 to 57	Fine Sandy Clay Loam	Very Pale Brown 10YR 7/4	Indurated A2 horizon-buried floodplain top- soil
	57 to 60	Sandy Clay	Strong Brown 7.5YR 4/6	Indurated B horizon. Buried flood plain sub-soil

Table 5.7: Trench 7 soil stratigraphy

Trench 8

Spit	Depth	Soil/sediment texture	Soil Colour	Stratigraphic Interpretation
1-9	0 to 45cm	Fine Sandy Clay Loam to Sandy Clay	Brown 10 YR 4/3	Ap Horizon Plough Layer
10	45 to 48cm	Sandy Clay	Brown 10 YR 4/3	Ap Horizon Plough Layer
	48 to 50	Sandy Clay	Dark Greyish Brown 10YR 4/2	Indurated A2 horizon-buried floodplain top- soil
Auger	50 to 80cm	Sandy Clay to Heavy Clay	Strong Brown 7.5YR 4/6	Indurated B horizon. Buried flood plain sub-soil.
Auger	80 to 85	Sandy Clay, with many coarse weak carbonate concretions	Dark Yellowish Brown 10YR4/6	B2k horizon. Buried floodplain sub-soil

Table 5.8: Trench 8 soil stratigraphy

5.2 Archaeological Finds

5.2.1 Historic material

Historic artefacts in the form of ceramic, glass, metal and plastic were retrieved from all 8 test trenches. The majority of this material was retrieved from the upper plough unit of the site. Trench 3 showed the highest level of historic disturbance with relatively high frequencies of historic artefacts in comparison to the other test trenches. The artefacts retrieved reflect commonly encountered historic material, such as broken pieces of stoneware, porcelain transfer printed earthenware, metal fragments, including both cut and wire drawn nails, clay pipe bowls and stems, window glass and various glass bottle fragments and pieces (Plate 5.13). Together they represent a time span from c1820 to the present day. Archaeological integrity of the JRL site in light of the historic finds is addressed in Section 8.2.3, while Tables 5.9 to 5.16 summarise the historic finds retrieved from each test trench.

Plate 5.13: Example of historic material retrieved from Trench 3

TRENCH 1					
Spit No.	**Ceramic**	**Glass**	**Metal**	**Clay Pipe**	**Plastic**
1			1		
2	1	1			1
3	4	4	2	1	
4		1	1		
16	1				

Table 5.9: Historic Finds, Trench 1

TRENCH 2					
Spit No.	**Ceramic**	**Glass**	**Metal**	**Clay Pipe**	**Plastic**
1	1		1	2	
2	3			1	
3	4	1	1		1
4	2	1	2		
18	1				

Table 5.10: Historic Finds, Trench 2

TRENCH 3							
Spit No.	**Ceramic**	**Glass**	**Metal**	**Clay Pipe**	**Plastic**	**Wood**	**Small Finds/ Miscellaneous**
1	17	12	10				
2	31	44	43	1			1
3	25	106	47	1	2		3
4	4	50	14		3		1
5	1	16	6				
5 Clean Up	2	1					
6		3					
7						1	
9		1					
14 Clean Up		1					

Table 5.11: Historic Finds, Trench 3

TRENCH 4						
Spit No.	**Ceramic**	**Glass**	**Metal**	**Clay Pipe**	**Plastic**	**Small Finds/Miscellaneous**
1		1	2		1	
2	5	16	2			
3	2	12	3			
4		9				
5	3	4		1		1
11		1				

Table 5.12: Historic Finds, Trench 4

TRENCH 5					
Spit No.	**Ceramic**	**Glass**	**Metal**	**Clay Pipe**	**Small Finds/Miscellaneous**
1	3	11	2		1
2	2	18	4		
3	1	7	1		
4	2			1	
Post hole			1		

Table 5.13: Historic Finds, Trench 5

TRENCH 6			
Spit No.	**Ceramic**	**Glass**	**Metal**
1	1	4	
2	1	1	1

Table 5.14: Historic Finds, Trench 6

TRENCH 7		
Spit No.	**Ceramic**	**Glass**
1		3
3	2	1
4		1
5		1
6		3

Table 5.15: Historic Finds, Trench 7

TRENCH 8		
Spit No.	**Ceramic**	**Glass**
2		1
3		3
4	1	
5	1	

Table 5.16: Historic Finds, Trench 8

5.2.2 Bone

A small amount of modern animal bone was retrieved from the JRL site. Analysis was undertaken by David Wines.

The assemblage of bones from the JRL site comprised 56 pieces; two pieces came from Trench 1, four from Trench 2, 50 from Trench 3 and 1 from Trench 4. All fragments were contained within spits 1 to 5 (Appendix 7).

Trench 1	Trench 2	Trench 3	Trench 4	Total
2	4	49	1	56

The assemblage consisted of relatively small fragmentary pieces; the average maximum dimension across the entire assemblage is 22.14 mm. Given the high degree of fragmentation, only four bones could be identified to a species level, all from Trench 3.

- Square 3/A, spit 3, sheep mandible
- Square 4/B, spit 2, sheep humerus
- Square 1/B, spit 3, rabbit humerus
- Square 4/D, spit 4, pig molar

An additional eleven elements were identified to a general size category, small or medium mammal. No butchery marks were identified on any of the bones, only one piece displayed evidence of burning (a calcined fragment from Trench 1, square 3/B, spit 1), and 33 bones (57%) displayed evidence of root etching. Root etching is a taphonomic process that alters the surface of bones, and is caused by the decay of roots in direct contact with bone surfaces. This commonly occurs in the uppermost sediments that have supported plant life.

The JRL faunal assemblage displays characteristics consistent of a recent, disturbed assemblage, with all fragments contained within the upper soil unit (spits 1-5). The presence of introduced species, as well as the high degree of fragmentation and the relatively high proportion of bones displaying root etching are all consistent with an assemblage that has undergone some degree of post-depositional disturbance by agricultural activities.

5.2.3 Stone Artefacts

The majority of archaeological finds retrieved from the JRL site comprise flaked stone artefacts. The results and analyses of this material are reported in Section 9 below.

6 Ground Penetrating Radar

6.1 Introduction

A geophysical investigation using Ground Penetrating Radar (GPR) was conducted from the 15th to the 19th February 2010 at the JRL site by GBG Australia. Their report is presented in Appendix 3.

Ground penetrating radar (GPR) has been successfully used in many kinds of non-invasive environmental, archaeological, forensic, and civil engineering sub-surface investigations (NPWS 2003). The method employed uses a radio pulse which creates three-dimensional images and with optimal ground conditions, such as those at the JRL site, the method can detect signs of a skeleton or other signs of a burial.

GPR was employed at the site owing to the fact that the loose sandy deposits which comprise the JRL site have the potential to contain Aboriginal burials. Aboriginal burials are commonly found in loose sandy deposits such as alluvial or aeolian landforms, as sand deposits are easily excavated for the internment of the dead. Non-invasive methods such as GPR can provide subsurface information enabling the detection of potential burials. For the present investigation, the GPR was only used on that portion of the levee within, or near, the proposed road easement.

GPR has been used with much success in the identification of Aboriginal burial sites in Australia. For instance, Randolph *et al* (1994) used GPR to identify burials on Rottnest Island. While the data was open to speculation in the many cases the shapes of the graves were clearly visible. Le'Oste- Brown *et al* (1996) identified a number of probable Aboriginal burials using GPR at the Taroom Aboriginal Reserve, Queensland, with one case successfully identifying Aboriginal skeletal remains. CMP-GBG (1996) identified a number of probable graves at St Patricks Cemetery, Parramatta, NSW. The burials were identifiable according to the GPR response and by the shape of the features across a number of profiles

The GPR method relies on radio waves penetrating the ground and detecting contrasts. Well developed horizontal layering such as is found at the JRL site, is important since breaks between the layers can often be detected. When holes are dug, contrasts develop between the disturbed soil in the hole and the surrounding material. The GPR receives radio wave reflection from the edges of the hole, and can also detect differences between the naturally layered soil and the mixed soil in the grave (NPWS 2003). Figure 6.1 shows the location of an Aboriginal grave as shown on a radar diagram. The soil mixing is clearly visible, compared to the surrounding sediment.

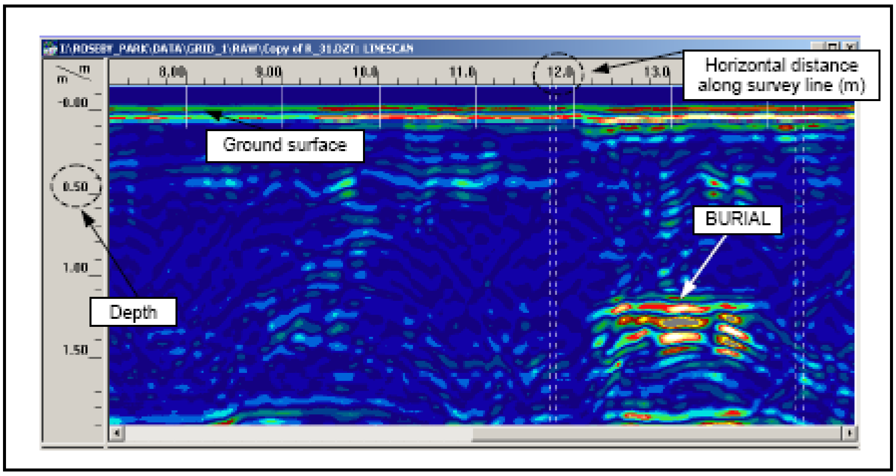


Figure 6.1: An example of an unmarked Aboriginal grave. This figure shows a vertical 'radar section' into the ground along the path of the survey line. It shows a grave at approximately 1.25 m depth (GBG Australia Pty Ltd)

It is not necessary to reiterate the methods and detailed findings of the GPR survey in the body of this report as this information is presented in Appendix 3. Rather, what follows is a brief summary of the findings of the analysis and how the results fit in to the wider archaeological picture identified at the levee.

6.2 GPR Results and Discussion

No conclusive evidence of Aboriginal burials within the levee deposit is apparent in the GPR data. The collected GPR profiles show that the soil stratigraphic units excavated in Trenches 1-8 are uniform across the entire levee deposit and the majority of the features identified in the data appear to be contained to the plough zone or near the interface between the plough zone and fine sand layer. Deeper subsurface features within the fine sand layer were less common, with few targets of potential interest identified below a depth of approximately 70cm.

Numerous small hyperbolic reflections were visible in the GPR profiles, observed at shallow depths within the plough zone. The majority of these findings have been interpreted as small isolated features such as rock floaters or small objects often metal fragments from recent human occupation, whilst others may represent larger objects. Some of the features identified within the plough zone were identified over multiple adjacent profiles and have been interpreted as lateral roots, either from trees outside the survey area or remnants of previously removed trees. A feature identified on numerous profiles has been identified as the buried optic fibre cable running through the site (refer Appendix 3).

Throughout the investigation area a number of anomalies were identified at a depth near to the interface between the plough zone and lower fine sand layer. The majority of these are observable on single or two GPR profiles which suggest that they are of limited size. Anomalies within this class have been interpreted as objects which were deposited within the plough zone but have been pushed into the lower fine sand layer. A number of interpreted fence post holes which have penetrated into the fine sand layer were exposed during the archaeological excavation in Trench 3 and 5, and may be of this type.

The majority of the collected GPR profiles show a distinctive high amplitude reflective layer at an approximate depth of between 20cm and 50cm. This layer has been attributed to the interface between the plough zone and the fine alluvial sand layer, the high amplitude suggesting that there is a marked difference in the composition of the two layers. This finding supports the soil stratigraphic information retrieved from the archaeological excavation. This difference is primarily related to the fact that the lower sandy deposit comprises an unweathered alluvial deposit distinctly different from the overlying soil profile.

The interpretation of the GPR data at the Jordan River Levee site has identified only a few features within the fine alluvial sand layer. Being the layer most probably containing potential Aboriginal burials, detailed analysis of all identified anomalies within this layer was performed. As with anomalies identified at shallower depths, these all appear to be present on either single or at most 2 GPR profiles and therefore are of limited extent. Together with their limited extent, the GPR signal characteristics of the anomalies within this layer indicate that they are unlikely to be Aboriginal burials.

The interface marked by the indurated A2 horizon, between the levee deposit sequence and lower buried soil is not clearly defined as an increased amplitude layer in the GPR data. Rather the interface is marked by drop in the data quality at a depth of over 1m resulting from the high rate of radar wave absorption from clay dominant composition of the buried soil.

A number of features of potential interest have been identified in the GPR data within grids B, C, H, J and K and have been labelled on diagrams (refer to Appendix 3). These probably do not represent Aboriginal burials as they are limited in extent however they do warrant a mention as the signal characteristics of these anomalies are different to others identified in the investigation area. The exact nature of these features is unknown however destructive examination of these features would be straightforward if deemed necessary.

The findings of the GPR survey indicate that the soil stratigraphic units are homogenous across the site, in that each unit is continuous and equally represented. The soil stratigraphic findings and post- depositional disturbances identified throughout the archaeological investigations may therefore be extrapolated across the entire levee deposit. While disturbance to the soil deposits is present across the JRL site it is important to note that these disturbances appear to be limited in extent.

7 Radiometric Analysis

7.1 Introduction

The Jordan River floodplain deposits are ideal for Optically Stimulated Luminescence (OSL) dating. These deposits contain quartz grains that have been subject to ionizing radiation (U, Th, Rb & K) following transport and burial. Electron traps in the crystal lattice of the quartz accumulate this energy over time. The stored radiation dose can be evicted by stimulation with white light and is released as photons or 'luminescence'. OSL dating is based on measuring the radiation dose received by the sediment sample since it was last exposed to sunlight and the dose rate that produced it. Put simply, the age is the palaeodose (or equivalent dose, ED) divided by the dose rate.

The JRL site thus far investigated is composed of two distinct soil stratigraphic units (see Section 5). The upper unit is the levee and the lower unit the older floodplain that the levee has been built on. The basal sediments of the levee and part of the older floodplain have been dated using OSL. The levee dates (n = 3) are from Trench 2 and the older floodplain dates (n = 2) from an adjacent sand quarry, which provides a representative section of this unit (Figure 7.1).

The OSL analyses were undertaken by Dr Matthew Cupper; his report is attached as Appendix 4.

7.2 Methodology

OSL is one of the most effective methods for dating aeolian, fluvial and lacustrine environments (e.g. Stokes 1999; Olley *et al* 2004a). The quartz grains that are deposited accumulate a trapped-charge population that increases in a measurable and predictable way in response to the ionising radiation dose that the grains receive while buried (Huntley *et al* 1985; Aitken 1998). Exposure to sunlight releases the light-sensitive trapped charge and resets the OSL signal. This exposure is commonly referred to as 'zeroing' or 'bleaching'. The accuracy and precision of OSL ages is partially controlled by the proportion of unbleached grains within a sample (Olley *et al* 1999; Murray & Olley 2002). Accordingly, some depositional environments will yield more reliable results than others. For instance, aeolian sediments are usually very well bleached prior to deposition whereas partial bleaching is a common problem for alluvial and lacustrine deposits. Fortunately, new methodologies have emerged whereby alluvial and lacustrine deposits can be effectively dated using single grains of quartz, which provide information on the degree of partial bleaching within a sample (Olley *et al* 2004a).

For the JRL site, single grain and small aliquot OSL dating was used to determine the burial ages of five samples from the alluvial deposits. Samples were collected by hammering 40mm diameter opaque stainless steel tubes into cleaned sections. Sediments were processed under subdued red light, with the 180-212 µm quartz fraction extracted for dating using standard procedures (e.g. Galbraith *et al* 1999). A single-aliquot regenerative-dose protocol was used to calculate ED (Murray & Roberts 1998; Galbraith *et al* 1999; Murray & Wintle 2000). Single grains were dated from Trench 2 (OSL JR03-05). Samples from the quarry (OSL JR01-02) were dating using small aliquots of around 10-20 grains each.

For the single grain analyses of OSL samples JR03-05, 100 aliquots each composed of single grains of quartz were preheated at 240 °C for 10 s and optically stimulated for 2 s at 125 °C by green (532 nm) light from a solid-state laser beam attached to an automated Risø TL-DA-15 apparatus (Markey *et al* 1997; Bøtter-Jensen *et al* 2000). For the multiple grain analyses of OSL samples JR01-02, 24 aliquots each comprising ~10-20 grains were preheated at 240 °C for 10 s and optically stimulated for 100 s at 125 °C by blue (470 nm) light from a light-emitting diode array on the Risø TL-DA-15. Ultraviolet luminescence was detected using photomultiplier tubes with a 7.5 mm Hoya U-340 filter. Samples were then given applied doses using calibrated 90Sr/90Y beta-sources and re-stimulated to record their regenerative OSL signals. OSL sensitivity changes in the quartz crystals between the natural and regenerative cycles were monitored after each optical stimulation using test-doses of 10 Gy (single grains) or 2 Gy (multiple grains) following a 160 °C cut-heat. Recycling tests using duplicate regenerations of known dose confirmed the reproducibility of the laboratory-induced luminescence signals.

Output from the Risøs was analysed using Analyst version 3.21 software (Pirtzel, 2006). For multiple grain aliquots, OSL signals were measured for 100 s (250 x 0.4 s channels) and integrated over the first 4.8 s of illumination with the final 20 s converted to the equivalent number of channels over 4.8 s and subtracted as background. Single grains were measured for 2 s (100 x 0.02 s channels), with data integrated from the five channels 5-9. Integrated data from channels 80-90 was converted to the equivalent signal from five channels and used as background. The OSL data were corrected for any sensitivity changes and dose-response curves constructed using five or six regenerative dose points, depending on the magnitude of the ED. The ED was obtained from the intercept of the regenerated dose-response curve with the natural luminescence intensity.

K, U and Th concentrations were measured using instrumental neutron activation analysis (INAA) by Becquerel Laboratories, Mississauga, Ontario, Canada and converted to beta dose rates using the conversion factors of Adamiec & Aitken (1998). A beta attenuation factor of 0.88 ± 0.03 (Mejdahl 1979) was assumed. Gamma dose rates were measured in the field using a portable spectrometer and converted to dry values by oven-drying sediment from the sample location. Internal alpha dose rates were also assumed to be 0.03 ± 0.01 Gy/ka based on previous measurements of Australian quartz (e.g. Thorne *et al* 1999; Bowler *et al* 2003). Cosmic-ray dose rates were determined from established equations (Prescott &

Hutton 1994) allowing for sample depth, sediment density and site altitude and latitude. Present-day field-moisture contents of the sediments were considered broadly representative of long-term averages and used to correct attenuation of beta and gamma rays by water (Aitken 1998).

7.3 Results

The dose rate data, ED estimates and optical ages for the five OSL samples are presented in Table 7.1. The ages are internally consistent, with all samples in stratigraphic succession. All samples contained quartz with luminescence signals dominated by the fast OSL component and displayed acceptable recycling ratios. The single aliquot ED distributions are displayed in radial plots (Figures 7.2-7.6). These show the distribution of aliquots with their precisions. Statistically concordant aliquots at the 2 s confidence level are within ± 2 units on the y-axis (shaded).

A powerful application of single aliquot optical dating is that ED estimates obtained from individual small aliquots or grains can be compared to identify possible cases of partial bleaching. The degree that aliquots have been well-bleached prior to burial can be assessed from ED frequency distributions (Murray *et al* 1995; cf. Wallinga 2002). Olley *et al* (1998, 1999, 2004a, b) have shown that the more asymmetric the distribution, the more likely that aliquots with the highest ED values have been inadequately reset. In such cases, the lowest ED estimates usually most closely represent the true burial age.

ED values for OSL samples JR01-03 display relatively symmetric frequency distributions, which indicates effective resetting of the luminescent traps prior to burial. Optical ages were thus derived from weighted mean ED using the central age model of Galbraith *et al* (1999). ED values for OSL sample JR04-05 displayed positively skewed frequency distributions, which suggested that those aliquots with the highest ED values had been inadequately reset. Aliquots with the highest ED values (greater than 200 Gy) were therefore excluded from the age calculations (9% of aliquots for OSL JR04 and 35% of aliquots for OSL JR05), with the burial ages derived from weighted mean ED of the remaining, younger aliquots using the central age model of Galbraith *et al* (1999).

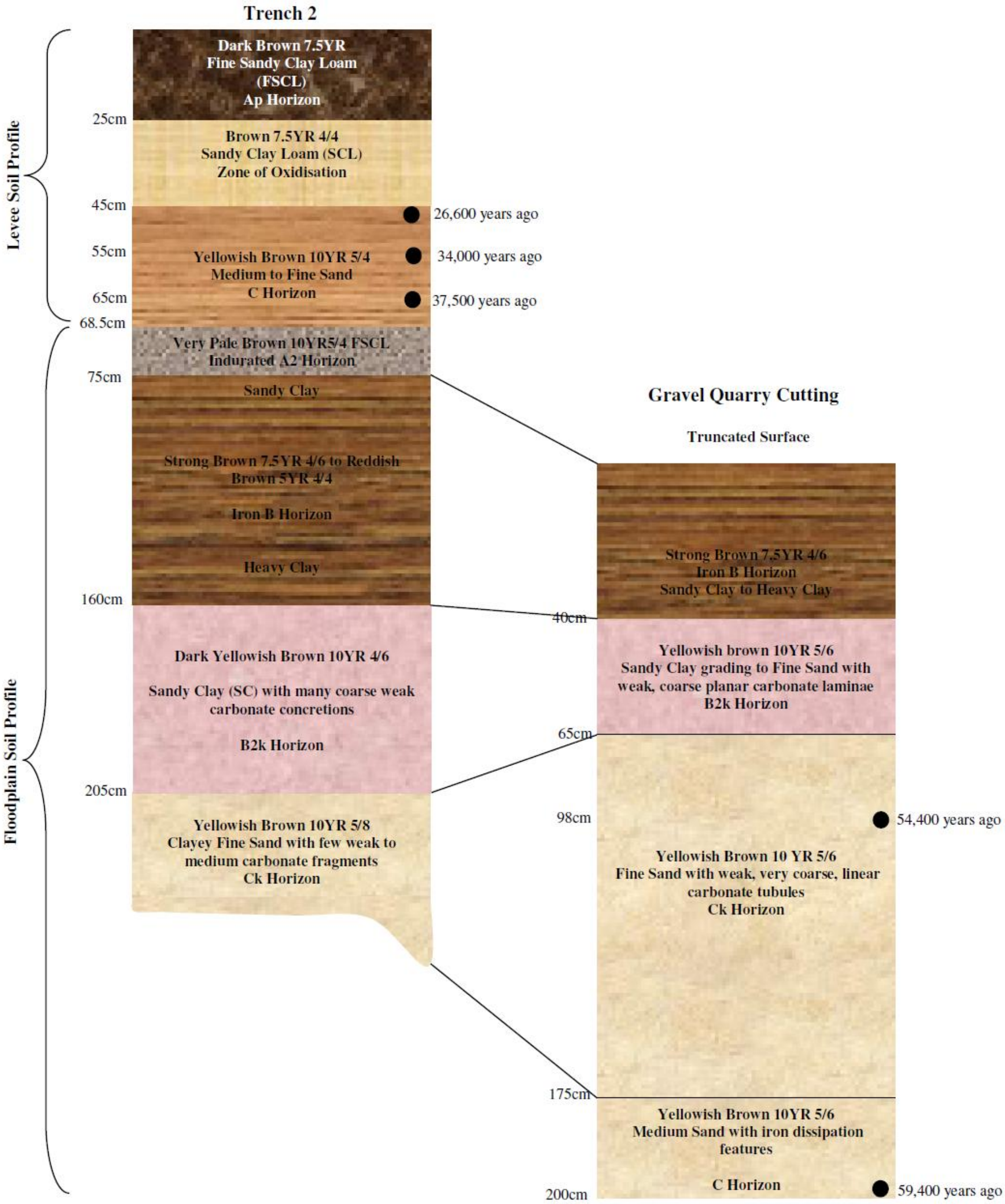
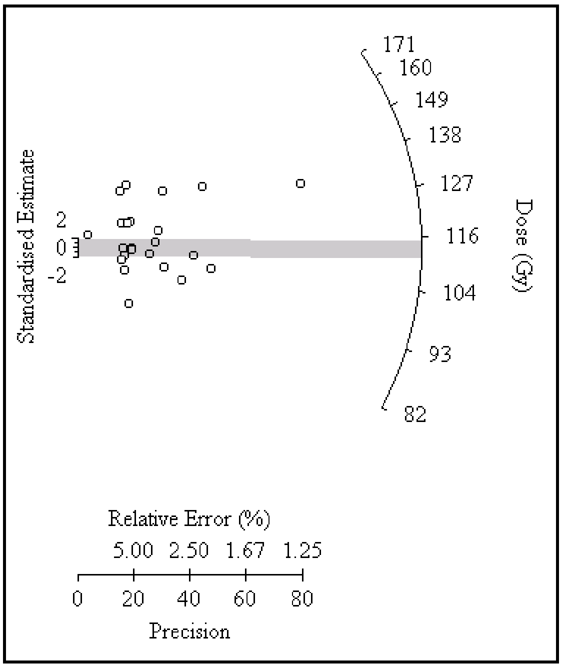


Figure 7.1: Schematic representation of soil stratigraphy of Trench 2 and how it correlates to the soil stratigraphy of the quarry cutting. Radiometric ages of units are indicated

Sample name	Depth (m)	Water[a] (%)	Radionuclide concentrations[b] K (%)	Th (ppm)	U (ppm)	α radiation[c] (Gy ka^{-1})	β radiation[d] (Gy ka^{-1})	γ radiation[e] (Gy ka^{-1})	Cosmic-ray radiation[f] (Gy ka^{-1})	Total dose rate (Gy ka^{-1})	Equivalent dose[g] (Gy)	Optical age (ka)
JR01	0.98	10 ± 2	1.18 ± 0.04	8.99 ± 0.28	1.78 ± 0.06	0.03 ± 0.01	1.11 ± 0.05	0.75 ± 0.06	0.18 ± 0.02	2.08 ± 0.08	113 ± 7	54.4 ± 3.9
JR02	1.90	10 ± 2	0.95 ± 0.03	6.09 ± 0.19	1.13 ± 0.04	0.03 ± 0.01	0.84 ± 0.04	0.66 ± 0.05	0.15 ± 0.02	1.68 ± 0.07	100 ± 5	59.4 ± 3.6
JR03	0.45	5 ± 2	1.11 ± 0.04	14.14 ± 0.43	2.38 ± 0.08	0.03 ± 0.01	1.33 ± 0.06	1.03 ± 0.08	0.19 ± 0.02	2.57 ± 0.10	68 ± 6	26.6 ± 2.6
JR04	0.55	5 ± 2	1.15 ± 0.04	14.29 ± 0.44	2.35 ± 0.08	0.03 ± 0.01	1.35 ± 0.06	1.04 ± 0.08	0.19 ± 0.02	2.61 ± 0.10	89 ± 6	34.0 ± 2.8
JR05	0.65	5 ± 2	1.11 ± 0.04	12.51 ± 0.38	2.15 ± 0.07	0.03 ± 0.01	1.26 ± 0.06	1.04 ± 0.08	0.19 ± 0.02	2.52 ± 0.10	95 ± 9	37.5 ± 3.8

[a] estimated time-averaged moisture contents, based on measured field water values (% dry weight)
[b] obtained by INAA (Becquerel Laboratories, Mississauga, ON, Canada)
[c] assumed internal alpha dose rate
[d] derived from INAA radionuclide concentration measurements using the conversion factors of Adameic and Aitken (1998), corrected for attenuation by water and beta attenuation
[e] derived from field gamma spectrometry measurements using the conversion factors of Adameic and Aitken (1998), corrected for attenuation by water
[f] calculated using the equation of Prescott and Hutton (1994), based on sediment density, depth and site latitude and altitude
[g] central age model (Galbraith *et al*. 1999), including a ± 2 % systematic uncertainty associated with calibration of the laboratory beta-source.

Table: 7.1: Luminescence age results



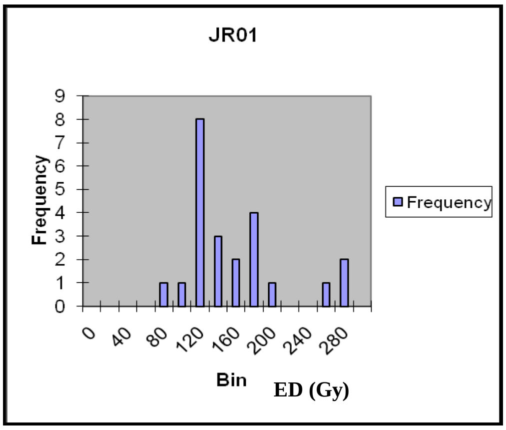
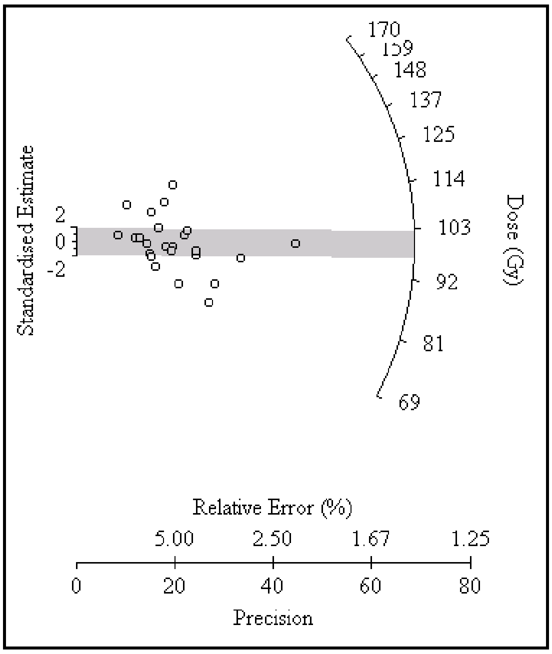


Figure 7.2: Radial plot and histogram of single aliquot ED distributions for JR01



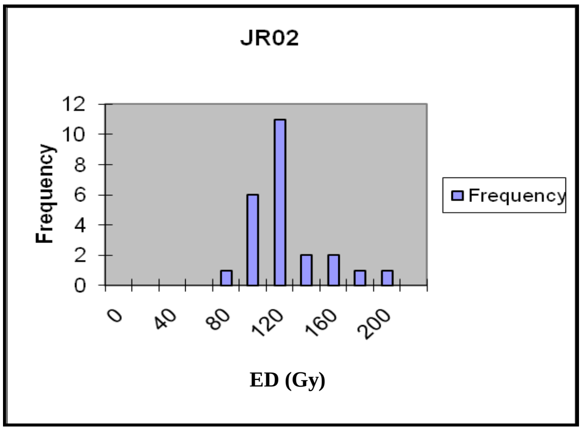


Figure 7.3: Radial plot and histogram of single aliquot ED distributions for JR02

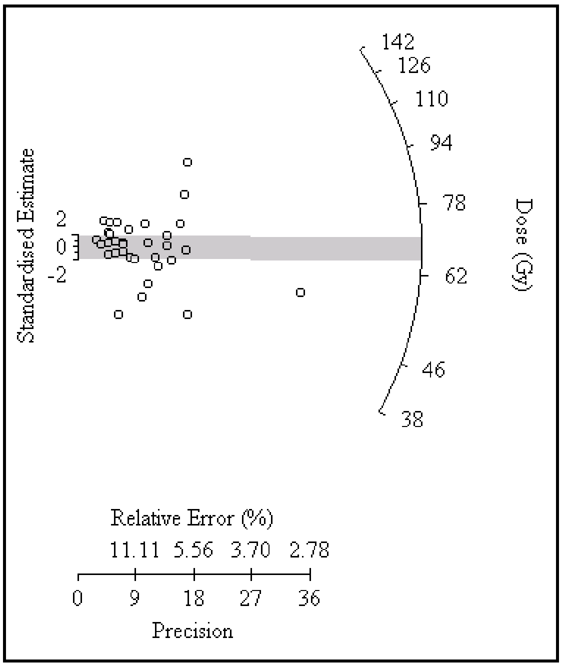
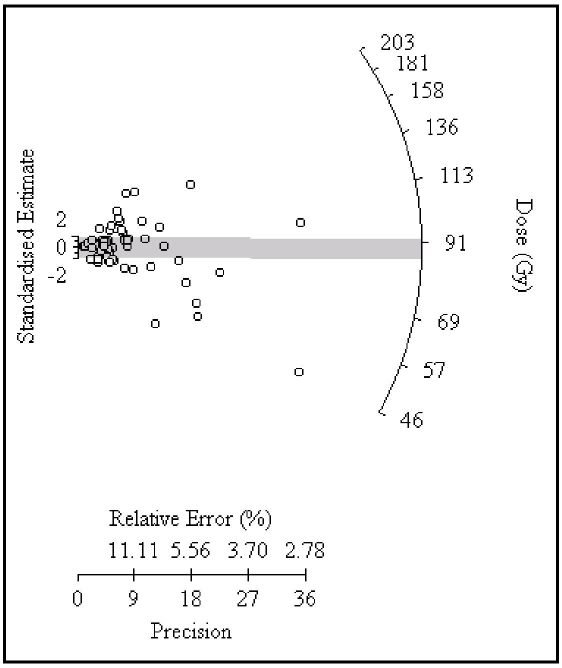


Figure 7.4: Radial plot of single aliquot ED distributions for JR03



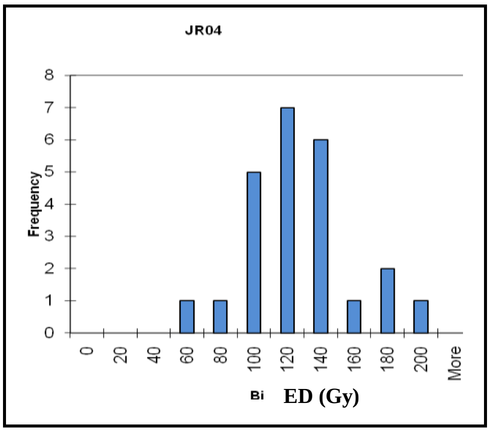
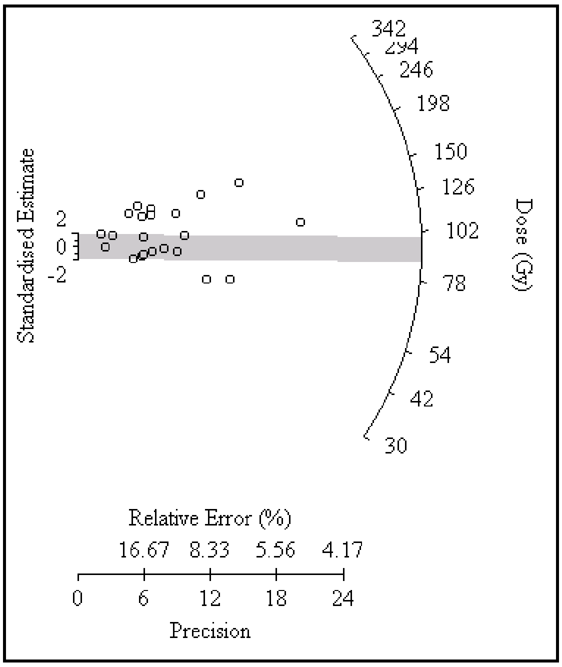


Figure 7.5: Radial plot and histogram of single aliquot ED distributions for JR04



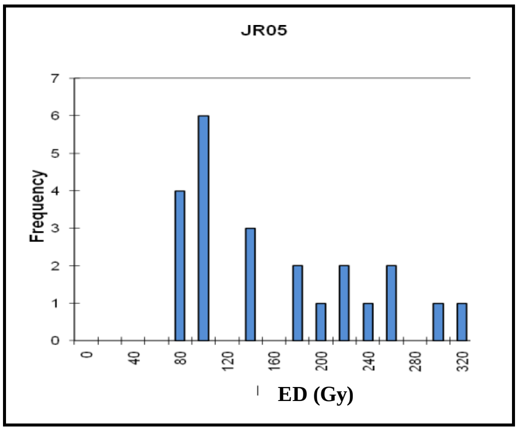


Figure 7.6: Radial plot and histogram of single aliquot ED distributions for JR05

7.4 Discussion and conclusions

The OSL ages, which are the first for an Aboriginal site in Tasmania, show that the alluvial architecture of the JRL site was constructed mostly during OIS 3, a period of average Quaternary conditions (see Section 2.1). The ages from the quarry of 59,400 ± 3600 ka (JR02) at 1.9 m depth and 54,400 ± 3900 ka (JR01) at 0.98m depth show geologically rapid aggradation of the floodplain, although when this commenced would require further OSL ages from the base of the fluvial sequence. Accordingly, a possible cause of this episode of valley fill cannot be assigned. Moreover, riverine valley fill can, as described earlier, be caused by local or regional variables, rather than be attributed to wider climatic/human events.

Trench 2 ages show construction of the levee commencing some time before 37,500 ± 3800 ka (JR05). Ages of 34,000 ± 2800 ka (JR04) and 26,600 ± 2600 ka (OSL JR03) from above the basal levee age are internally consistent and show gradual overbank deposition of levee sediments as recently as the early part of OIS 2. However, when the levee ceased accreting sediment will not be known until the upper part of the stratigraphic sequence is dated.

The OSL dating results are remarkable for not only being in perfect stratigraphic order but also for demonstrating the integrity of the Aboriginal site. Most open sites in Australia are not well-preserved or stratified because of disturbance factors ranging from natural pedogenic processes to European impacts such as the introduction of rabbits. These processes have the effect of mixing artefacts and sediments so that they are no longer in their original position. When OSL dating is applied, ED frequency distributions will be skewed by younger grains as a consequence of this mixing.

The OSL data for the JRL site show no evidence of mixing. This was to be expected of the older floodplain samples, which were taken at significant depths below the surface. The younger levee deposit, in contrast, was vulnerable to post-depositional mixing but returned unusually peaked ED distributions similar to the older sediments. This is significant because it shows that the lowermost levee sediments are undisturbed and the cultural layers *in situ*.

8 Discussion

The following is divided into two subsections. Section 8.1 describes the geomorphological units identified at the JRL site and attempts to reconstruct site formation processes over time. Section 8.2 assesses the integrity of the JRL site and presents multiple working hypotheses to explain artefact distribution at the site. The discussion should be read with reference to Section 2, which laid the foundations for understanding the processes discussed below.

8.1 Site Formation

8.1.1 Depositional History

The JRL site contains four morphological units: the older floodplain unit, the levee bank and the more recent channel and back swamp deposits (Figure 8.1). The wider TASI 10757 site outside the proposed bypass corridor also contains scroll bar topography intermediate in age between the levee and more recent channel deposits. This topography is an important part of the history of the Jordan River and is discussed here in terms of the lateral extent of the levee (Section 8.1.2).

The two OSL ages from the older floodplain unit show a major and rapid episode of fluvial aggradation in the Jordan River valley commencing before 60,000 years ago. Aggradation ceased presumably ~50,000 years ago and the river began to cut back into the sediments it had deposited in the valley. The incision had the effect of cutting off sediment supply to the older floodplain surface. Consequently, a weakly calcareous red brown alluvial soil developed on the abandoned floodplain. This soil surface would have been an ideal site for early Aboriginal occupation.

Construction of the levee on the older floodplain surface commenced ~41,000 years ago, which allows ~10,000 years for formation of the now buried palaeosol. The three OSL ages thus far obtained from the levee show gradual overbank deposition over a period of ~12,000 years. Figure 8.2 shows the OSL results plotted against time and depth. The dates are shown to within 2 standard deviations. The age depth trend line fitted to the upper three OSL ages suggests that the levee formed from ~41,000 to 12,000 years ago, a period of ~30,000 years. This is a rate of deposition of 0.23 mm/100 years or 2.3 mm/ka, assuming a constant sedimentation rate. With climatic amelioration during the Holocene, the hydrological regime changed and conditions for levee formation are no more.

Floodplain evolution of the JRL site is shown schematically in Figure 8.3. The scroll bar topography preserved downstream from the proposed bypass corridor probably originated during the second period of river aggradation, which was the period of levee formation. TASI 10757 includes this topography.

The nature and extent of the back swamp deposits on the distal floodplain are unknown as these were not the subject of this investigation. The only information regarding this unit comes from Trench 8, which contained up to 50cm of ploughed sediment similar to the plough zone of the levee. The back swamp soil was significantly higher in clay content as expected (see Sections 2.3 and 2.4). The older floodplain unit is present from 50cm below the surface in Trench 8.

The period that the alluvial architecture of the Jordan River, including the JRL site, formed was one of landscape instability under average Quaternary conditions (see Section 2.1). Fluctuating Quaternary climates undoubtedly influenced the behaviour of the Jordan River but the alluvial sequence cannot confidently be tied to broader palaeoclimates without further investigation and dating. In any case, the complex response of fluvial systems to climate change makes correlation of the alluvial sequence to climatic episodes inherently problematic (see Section 2.2). The real value of the sequence is that it provides a rare insight into a period of human history of which little is known, either in Tasmania or on the Australian mainland. This is particularly the case at open sites, with nearly all older Tasmanian sites being rock shelters.

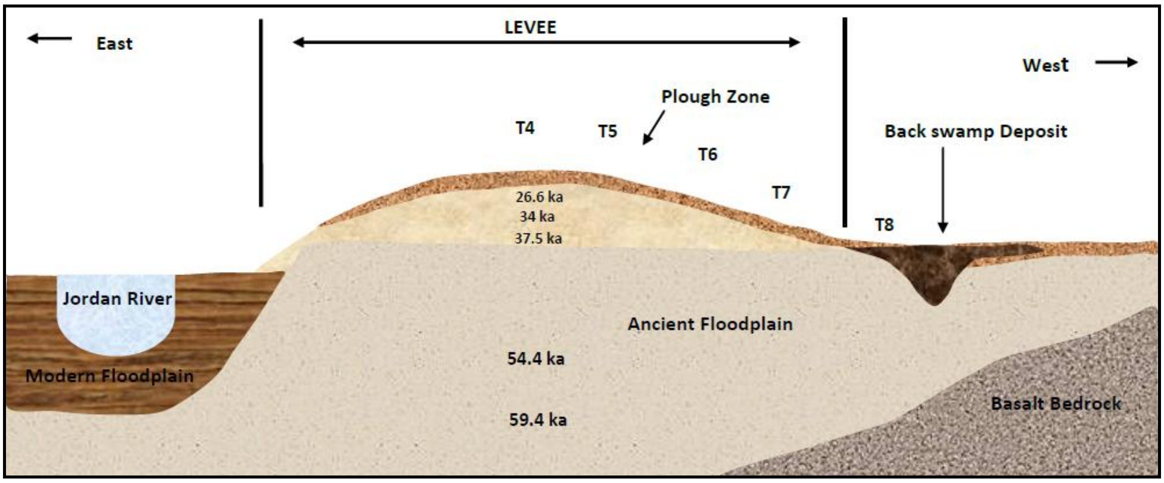


Figure 8.1: Schematic cross section of the JRL site showing the four main morphological units

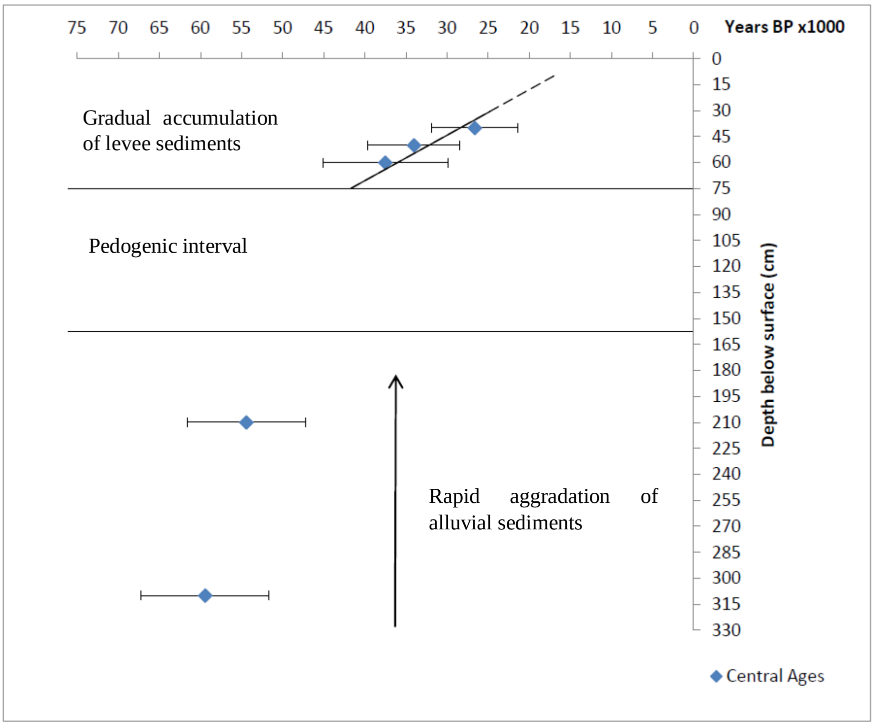
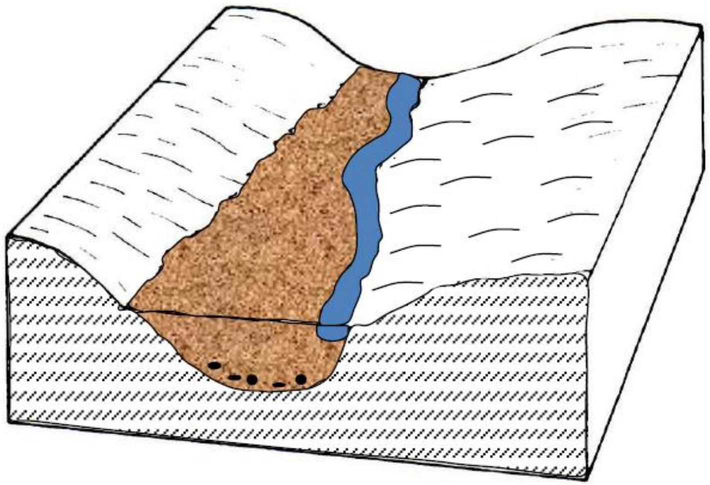
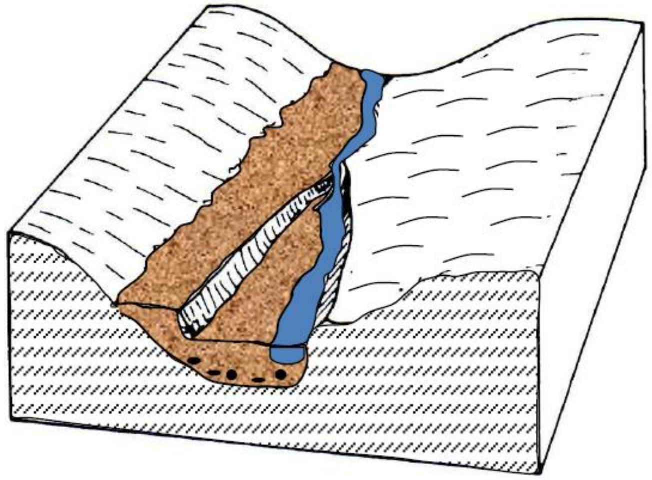


Figure 8.2: Depth age graph showing deposition through time. OSL results are reported to within 2 std

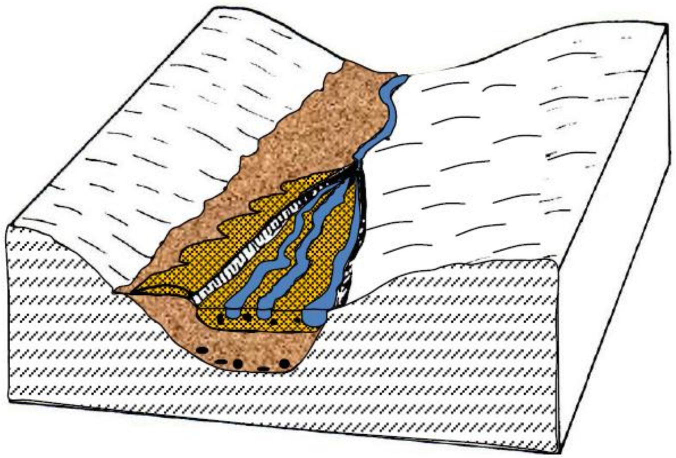
Figure 8.3: Schematic representation of floodplain evolution at the JRL site



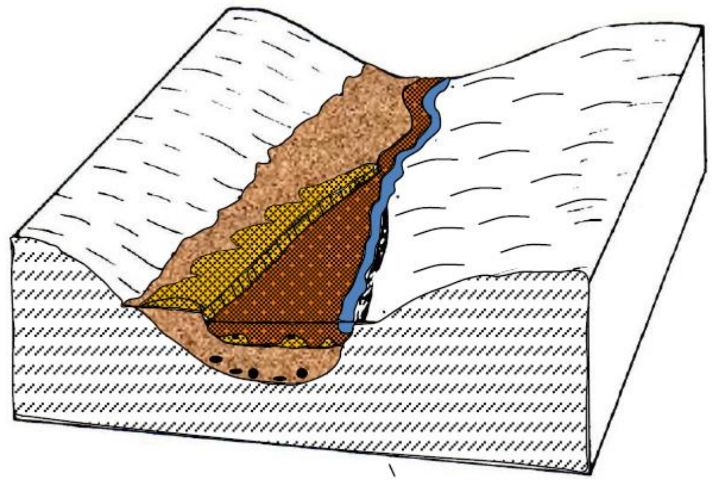
Aggradation of the floodplain unit from before 60,000 years ago



Period of river incision and terrace formation from~50,000 to 40,000 years ago.



Period of river aggradation and levee bank formation from~42,000 to 15,000 years ago.



Onset of the Holocene and modern floodplain construction.

8.1.2 Landscape setting

The TASI 10757 site represents the broader landscape setting of the JRL site (Figure 1.2). The TASI 10757 landscape is known to comprise four landform units; a buried floodplain unit, the levee deposit, and a modern floodplain unit and back swamp deposits to the east and west of the JRL site respectively (see Figure 8.1).

The western component of the TASI 10757 site comprises a floodplain landscape. This landscape is known to have been formed from before 60,000 to 50,000 years ago. From approximately that point in time through to modern times, soil formation has been active in the area. The landscape position of the floodplain to the west also forms the back swamp area of the levee. A small rivulet runs from the north along the back of the levee across this floodplain. This has resulted in the development of swampy areas with deep waterlogged clay soil profiles. The entire area has been subjected to modern ploughing; the depth of ploughing is known to extend from between 25-30cm on the JRL site.

The area west of the levee is known to contain sub-surface archaeological material. Trench 8 contained 32 artefacts, however these cannot be placed within a temporal context. Material found within this trench has been subject to continued soil formation and alluvial deposition from the rivulet. The buried floodplain was encountered in this test trench from below 50cm in depth. The indurated A2 layer was not easily identifiable and was heavily truncated. This unit is likely to extend further west from Trench 8 ending somewhere before the rail line.

Figure 8.4 shows a cross section of the TASI 10757 site as defined by the geotechnical bore hole data (GHD 2009). The locations of the bore holes are shown in Figure 8.5. It is evident from this data that the ancient floodplain landscape is not readily identifiable. Owing to active and continued soil formation and the activity of the rivulet and water logging, the landscape may be considered to hold no temporal context. Artefactual material within this particular setting has been subject to the processes of biogenic burial, as outlined in Sections 2.5 and 2.2, and as such, represents a palimpsest of cultural material. It is not possible to associate any artefactual material with any certainty with the ancient floodplain landscape in this area of the floodplain. The place to look for this association is under the levee bank deposit. Forty thousand years ago the levee sands capped the ancient surface, cutting it off from further soil development processes, resulting in the preservation of an ancient land surface (see Sections 7 and 8.1.1). This ancient land surface would have been an ideal campsite for Aboriginal occupation. However, no evidence of this has been identified in the study area. This statement is based on four 1m x1m test pits which were excavated in to the buried floodplain. Moreover, an inspection of the quarry face to the south where the OSL samples were obtained, showed no sign of human activity. So far this is an interesting geomorphic unit, certainly worthy of some form of investigation if it is to be highly disturbed.

The eastern component of TASI 10757 in relation to the JRL site constitutes the modern floodplain. The bore hole data summarised in Figure 8.4 show deep clayey and silty sediments. Primary alluvial material is evident at depth. Two archaeological test pits measuring 50x50cm were excavated into this unit as part of the wider Northern Bypass test pitting programme (Pits 278 and 279). They comprised of dark black silty clays and both test trenches were abandoned owing to water logging at 45cm depth. No artefactual material was recovered from the test trenches. Furthermore, a dam measuring 4m x 5m was excavated into the modern floodplain unit for the wet sieving of the soil excavated from the JRL site. The digging was monitored by the Aboriginal Heritage Officers and the Principal Archaeologist (Plates 8.1 and 8.2). The sediments comprised of black silty clays, containing no visible Aboriginal artefacts. Of great relevance, however, was the location of a European house stove and several piles of modern brickwork at a depth of about 1m below the surface. This indicates significant disturbance to this landform unit. Lastly, the area is frequently inundated during times of flooding (Plate 8.3) with sediments being continually stripped from the floodplain, and new ones being laid down. The veracity of this flooding is evident in Plate 8.2, whereby tree stumps and branches are being easily carried along the rivers course.

The modern floodplain has a low probability of containing artefactual material and a very low probability of encountering *in situ* artefactual material. Site patterning within the region of the modern floodplain is likely to be representative of sporadic foraging activity. On low lying flats which are frequently inundated and poorly drained, site and artefact densities are predicted to be very low. It is likely that Aboriginal people did sporadically frequent this low lying area foraging for aquatic resources, however they are very unlikely to have stayed within these low lying inundated areas to process their resources, preferring to do this at more convenient and comfortable locales, such as the levee bank deposit.

Plate 8.1: View north east of dam construction

Plate 8.2: View north, detailing the amount of soil excavated for the construction of the dam.

Plate 8.3: View southeast depicting a flooding event at the JRL site. Note the buried silt fencing as compared to Plate 8.1.

8.1.3 The JRL Site Boundary

The boundaries of the JRL site have been determined through the excavation of eight test trenches. The eastern boundary is discernable with a reasonable amount of certainty. This is because the levee is perched on a floodplain terrace. Through time the levee has slumped onto the modern floodplain unit. As such, the provenance of artefactual material found along the western edge of the modern floodplain unit is highly likely to originate from the levee bank deposit. This material represents a secondary context. The original stratigraphy has been altered, with artefactual material shifted from its original position on the levee to the modern floodplain unit. The archaeological finds identified by Stone and Everett (2008) and identified in Figures (1.2 and 4.1) are most likely be of this provenance.

The western boundary of the site was extrapolated from the landscape position of Trench 8. The extent of the levee is unlikely to extend in a straight line and is more likely to be sinuous in nature. This sinuosity is evident in the bore hole data. The bore holes were placed perpendicular to the strike of the levee along three parallel transects (Figure 8.4). Samples D4 and B3 are in approximant alignment with test Trench 6. Test Trench 6 and D4 both picked up the presence of the levee bank, while B3 further north did not. This also stands true for the eastern edge of the levee. For example, while the eastern edge is in general discernable through a change in topographic elevation, the bore hole data also pick up evidence of sinuosity along the eastern boundary as well. Samples B9, A14 and D10 are situated close to the eastern boundary of the site and constitute a north south section of this boundary. B9 comprises levee bank deposits, A14 does not and D10 again picks up the levee bank deposits (Figures 8.4 and 8.5).

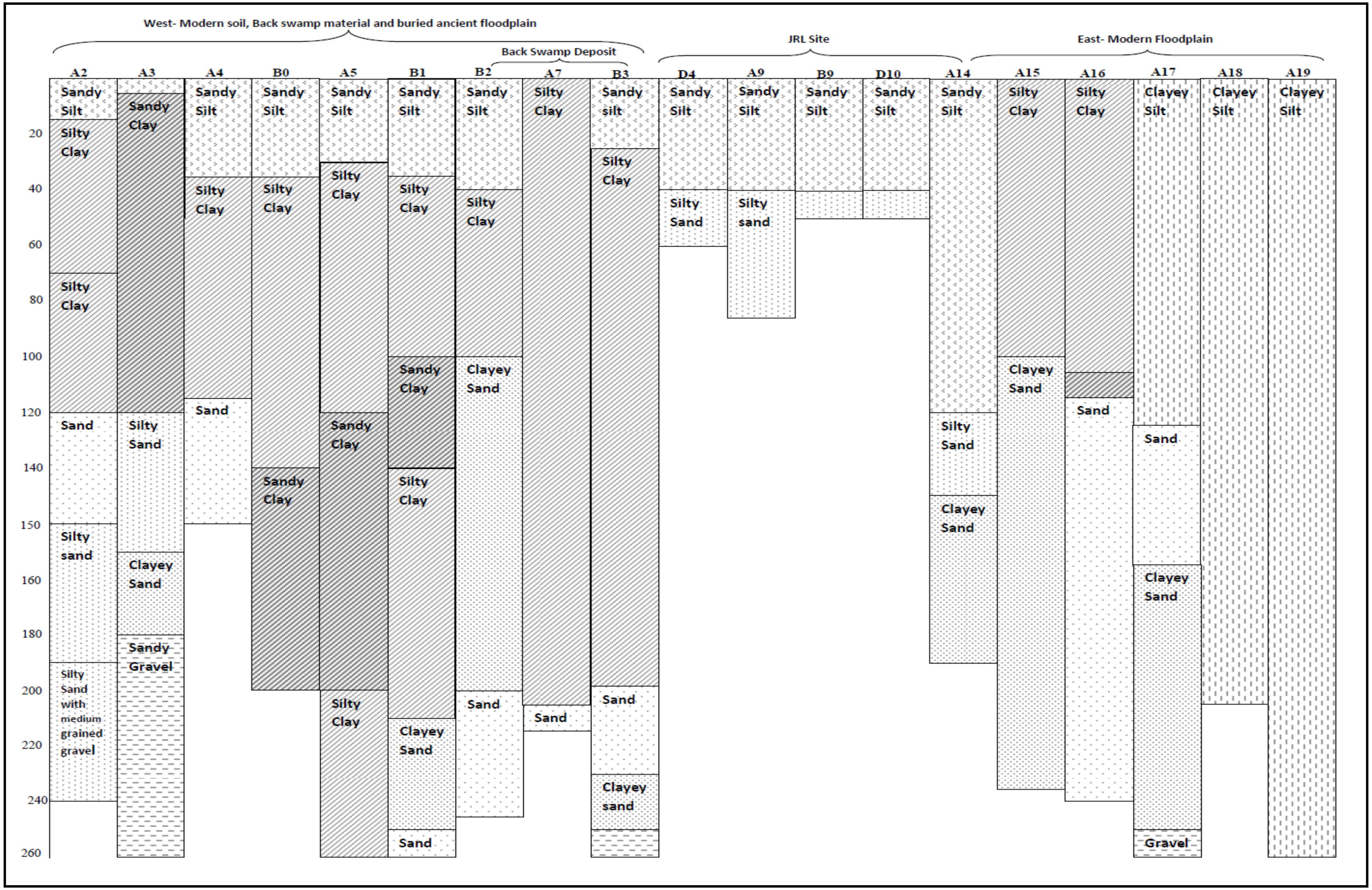


Figure 8.4: Cross section of the TASI 10757 landscape, to be read in conjunction with Figure 8.5

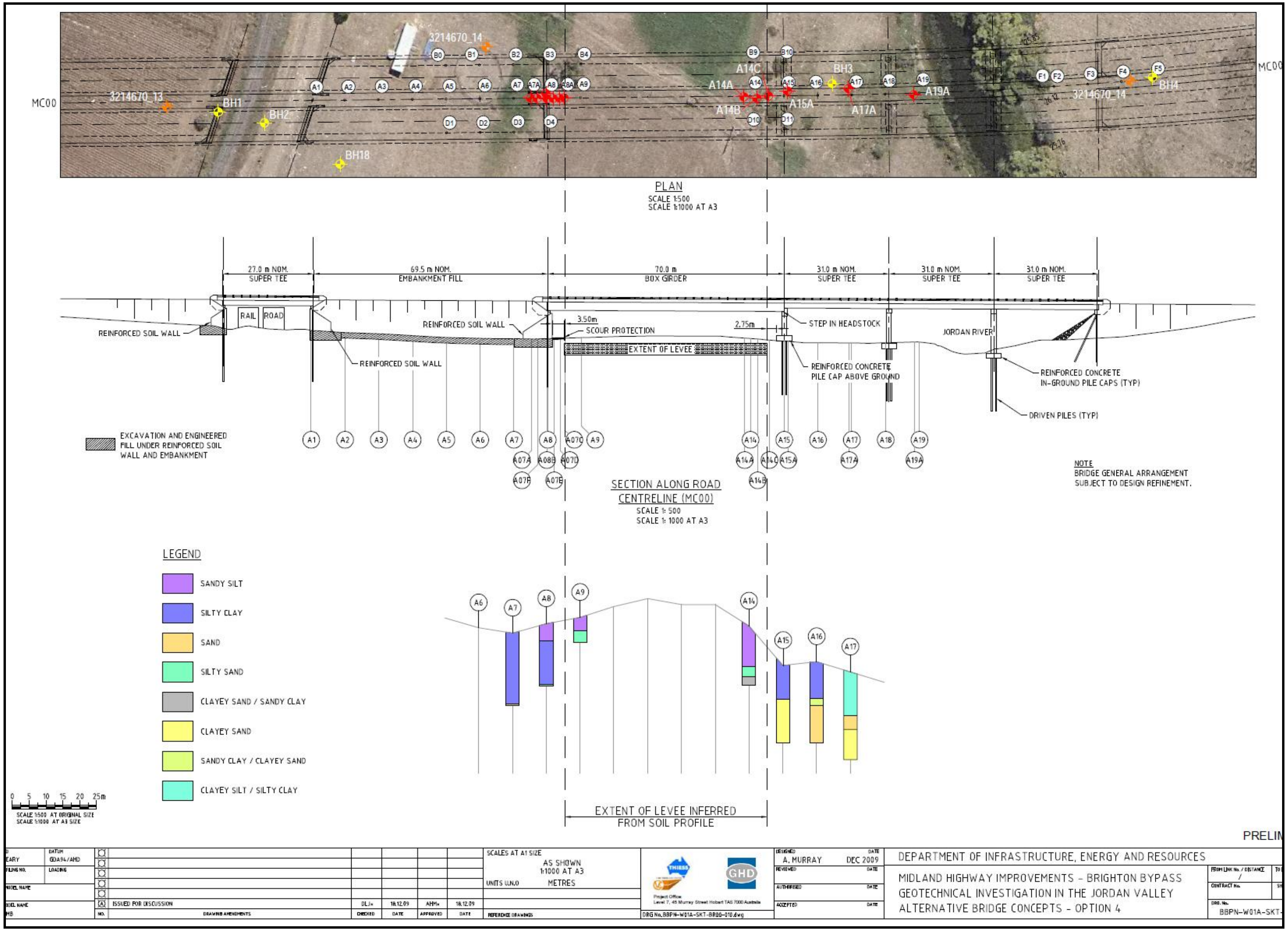


Figure 8.5: Location of bore holes drilled during the geotechnical investigation of the study area

8.2 Archaeological Integrity

Soil formation and historic agricultural practices often result in the vertical and horizontal displacement of cultural material (see Section 2.2). Biological and physical soil processes may disturb and/or alter the original positions of artefacts left on the surface and entire assemblages may be incorporated into the soil profile. Physical processes include the shrink/swell cycle and general erosion, which may shift or move artefacts from their original position. If rates of erosion are low, biomechanical processes will predominate, promoting the formation of stone lines/zones or surface layers.

Erosion is not a factor at the JRL site, although the A horizon of the older floodplain unit has been truncated prior to formation of the levee. Additionally, the levee is composed of well-drained fine to medium sands, which do not respond the way clay does to the shrink/swell cycle.

The categories of post-depositional disturbance that are relevant to understanding the JRL site are:

1. the biomechanical alteration of the primary sedimentary structure and any associated inclusions;

2. historic disturbance to the soil stratigraphic units.

8.2.1 Biomechanical Alteration

Biomechanical mixing includes, but is not limited to, the activity of animals, plants, fungi, protoctists, and bacteria. If not counteracted by physical soil processes, biomechanical loosening causes clasts/artefacts to gravitationally settle downward relative to the soil fine fraction whereby a stone line or zone often forms near the base of the biomantle (Johnson 2002:8-9). The primary question for the JRL site is whether artefact positioning within the deposit is the result of actual discard behaviour or the result of biomechanical soil processes. Two hypotheses are proposed here:

Hypothesis 1) Artefacts were discarded on the surface of the levee after its construction. Biomechanical processes mixed the artefacts into the deposit. This mixing will have either:

a. obliterated the original spatial relationship of the artefacts to each other; or

b. for the most part, preserved the original spatial relationship of the artefacts to each other, because biogenic processes were weak.

Hypothesis 2) Artefacts were buried during construction of the levee and:

a. Have not been subject to biomechanical mixing; or

b. Have been subject to biomechanical mixing.

Hypothesis 1a

The premise of this hypothesis requires identification of a soil biomantle. Under a ‘progressive pathway’ scenario (see Section 2.2.1) this biomantle should be horizonated, with a generally fining-up sequence of soil sediments. Should the soil biomantle contain large clasts (e.g. artefacts), these will form a stone line beneath the fine soil sediments of the A horizon. Soil biota activity will be evident in the soil structure.

Artefact frequency diagrams will show relatively few artefacts in the upper section of the biomantle, a concentration of artefacts at the depth of maximum biological activity and much lower numbers again below the stone line concentration. The distribution of artefacts in the soil profile will be unimodal, with evidence of size sorting. Artefacts below the stone line should be small in size corresponding to a decrease in root diameter. Artefacts in the stone line will generally retain their original horizontal position as translocation is a slow, sinking process. Artefacts from varying depths may conjoin or, if they have moved together down the soil profile, refit from relatively close proximity.

Under the ‘regressive pathway’ scenario, the soil biomantle will be homogenized by repeated mixing of the soil. Horizonation is generally absent and particle size distribution will not follow a predictable sequence. Tree upheaval and agricultural practices generally are the primary catalyst for a regressive soil biomantle. Soil biota activity will not be evident in the soil structure because of constant mixing. If tree upheaval is a regular event, a stone layer may form on the surface. However, no particular stone layer will form if the disturbance is agricultural in origin. Instead, any artefacts will be evenly distributed and randomly-oriented, with conjoins possible from all depths. Size sorting will be negligible.

Hypothesis 1b

The stratigraphic integrity of an archaeological site may be destroyed or preserved depending on the type of bioturbation (Baleck 2002). Large burrowing animals and tree upheaval are obvious bioturbation agents that destroy stratigraphic integrity. However, smaller-sized soil fauna such as worms, beetles and ants may actually preserve cultural sequences by depositing layers on surface cultural material (Baleck 2002; Van Nest 2002). When it happens, this is useful stratigraphic ordering, at least during the intermediate stages of biomantle formation.

The original horizontal and vertical relationships of cultural material may be preserved if artefact layers separated in time move down the soil profile at a constant rate. The eventual outcome of this process is the formation of a ‘time-averaged’ stone line at the maximum extent of biomechanical influence.

Of particular relevance is that the translocated artefacts are not associated in time with the surrounding soil sediments. Consequently, any radiometric dating of the sediments will not date the artefacts. However, the overall spatial relationships of the artefacts may be preserved, despite the lack of chronological control.

According to this hypothesis, the artefacts will not form a stone line as predicted in Hypothesis 1a. Instead, artefact distribution should closely approximate the original internal site pattern. Whether this is the case at the JRL site can be tested and resolved with additional OSL data.

Hypothesis 2a

Artefacts buried by depositional events are said to be *in situ*, if there has been no subsequent disruption to their original position by soil formation or any other disturbance factor. Sedimentary structures such as bedforms or laminae should be visible in place of soil horizons, with artefact frequencies and size not influenced by biomechanical sorting. The majority of artefacts would be horizontal to the surface and conjoins from similar levels is to be expected.

Hypothesis 2b

A combination of Hypothesis 1 and Hypothesis 2 is a likely scenario depending on the degree of soil formation on the levee deposit. For this to be tested, the nature, extent and degree of post-depositional disturbance would have to be measured and analysed using a range of techniques. The evidence for site integrity would have to be carefully weighed against the evidence for post-depositional disturbance to fully determine the scientific significance of the JRL site.

8.2.2 Post-depositional Disturbance at the JRL site

Soil formation and historic farming practices have disturbed the top 50cm of the JRL site and altered the original positioning of the artefacts. The critical question is whether the artefacts were discarded during construction of the levee or after its formation. Diagnostic criteria that identify biomechanical sorting as an agent of site formation (reviewed in Section 2.5) are applied to artefact distribution patterns and physical soil properties at the JRL site.

The diagnostic criteria of Johnson (1990) and Peacock and Fante (2002) for silt and sand soils are considered to be applicable to the JRL site, although the soil biota of the site is quite different to American examples. However, the model proposed here is based on universal soil formation principles no less relevant to the JRL site.

The following interpretation is based on the results from Trenches 1, 2 and 4. The other trenches are excluded because not enough artefacts were uncovered to form a meaningful pattern for discussion. Moreover, Trench 3 had a high level of historic disturbance and was excluded for this reason also.

Regressive Soil Formation at the JRL Site

Regressive soils display no horizonation or bio-fabric structures. Particle size distributions will be uniform and the artefacts will form either a surface stone layer or be evenly distributed throughout the soil profile. If the latter, the artefacts will eventually become oriented at random angles. Artefact frequency distributions by depth and artefact size will be uniform throughout the biomantle, if the soil profile has been mixed by regressive factors.

Soil formation in the top 25cm of the levee is dominated by regressive soil forming factors. The top of the deposit has been disturbed by ploughing, which has resulted in a high degree of soil and sediment mixing creating an undifferentiated soil horizon. Particle size is consistent throughout the mixed horizon, with the same texture class uniformly represented in each trench. No distinct bio-fabric was evident in section with all evidence of root/worm voids and casts obliterated through the mechanical mixing of the soil. Artefacts located within this horizon are uniformly distributed according to depth and there is no evidence of size sorting (Figures 6.1, 6.3 and 6.5). Moreover, the artefacts were generally oriented at random angles to the horizontal plane in both Trenches 1 and 2 (Figure 6.7).

Progressive Soil Formation at the JRL Site.

Progressive soils display horizonation, bio-fabric and a fining-up sequence within the biomantle. Larger clasts/artefacts will form a stone line at the extent of maximum biological activity. Artefacts will generally be oriented horizontal to the surface. Artefact frequency distributions will be unimodal and there will be evidence of size sorting.

The levee displays some evidence of progressive soil formation, with the presence of a distinct oxidised horizon (or zone of rubefaction) where soil fauna is at its most active (see Plate 5.3). However, progressive soil formation is weakly-developed and limited to the oxidised horizon. A bio-fabric is present but there is no prominent fining-up sequence within the soil profile. The most likely reason is that the zone of biotic deposition has been mixed and obscured in the plough layer. Importantly, there is no evidence of a pedogenic stone line.

Artefact frequency distributions from Trenches 1, 2 and 4 vary significantly according to depth, despite biomechanical processes that would have operated across the site at a consistent rate (Figures 6.1, 6.3 and 6.5). Of particular significance is that peak artefact frequencies do not correspond to the maximum extent of bioturbation in Trenches 2 and 4, although this is the case for Trench 1. The Trench 1 result is more coincidence than cause and does not demonstrate a pedogenic stone line. This would require very different and localised biomechanical activity at the Trench 1 location, which is not supported by the field evidence. Furthermore, there is no evidence for size sorting above or below the peak artefact frequencies in Trenches 1, 2 and 4 (Figures 6.2, 6.4, 6.6).

No less significant is the number of artefacts that were conjoined during the cataloguing process. The conjoined artefacts were all located within 50cm of each other and vertically separated by less than 5cm. These artefacts are contained within the plough layer in Trenches 3 and 4 and the oxidised unit in Trench 1 (see Section 9).

The sinking of artefacts as soil material is slowly translocated upwards by soil biota as predicted by the progressive soil formation model is not distinctive at the JRL site. The majority of *in situ* artefacts excavated from the oxidised unit were predominantly horizontal in orientation, which shows that soil mixing has been minimal and that artefact movement, if any, will only have been in the vertical plane (see Section 2.2). Future application of OSL techniques to the oxidised unit will determine the degree of soil mixing within this unit and whether the artefacts are indeed *in situ*.

In lieu of corroborative OSL data, the evidence for subtle bioturbation at most, conjoins and no evidence for size sorting of the artefacts strongly suggests that the spatial relationships of the artefacts at the JRL site have for the most part been preserved. However, this conclusion is based on a very small sample size, the product of a *test* excavation. Notwithstanding the small scale of this investigation, **Hypothesis 2b** is the most tenable for the oxidised unit.

Evidence of *in situ* Stratified Cultural Material

The basal levee sand unit contains no evidence of soil formation and is unweathered. Soil fauna activity is less than 5 percent in this unit in Trenches 1-7, with biomechanical activity clearly confined to the oxidised unit above (see Appendix 6). The only exception was a possible burrow along the northern wall of Trench 2 extending from spits 5-11 in squares 3/A and 2/A. The artefacts contained within these squares have been excluded from the artefact analysis. The majority of artefacts excavated *in situ* from the basal levee sand unit were uncovered horizontal to the surface.

Root activity (and diameter) also decreases in the basal levee sand unit. Size sorting of artefacts as a consequence may be apparent (see Figures 6.1, 6.2 and 6.3) but not supported by the OSL data, which show no downward movement of younger grains (see Sections 7.3 and 7.4). Furthermore buried fossil root casts were encountered at the very base of the levee deposit in Trench 2, which suggests that significant root activity took place prior to burial. The survival of this fossil cast supports the argument that more recent root activity has not disturbed the deposit at depth.

A further, and compelling line of evidence, is the comparison of the weights of artefact and non-artefactual material according to all three formation layers (plough, oxidised, basal sands). Table 8.1 shows ratios of artefact weights relative to 2 categories; artefacts measuring less than or equal to 1gm and artefacts weighing in excess of 1gm. The top row shows that when complete artefacts only are examined, 30% more of the larger weight categories occur in the plough layer than in the basal sands. The second row shows that when all other materials from the site are weighed, excluding complete artefacts, this weight pattern is reversed and 60% more of the smaller size categories occur in the plough layer than in the basal sands. The third row includes all the lithic items recovered from the site, whether artefactual or not, and shows that in combination, the effects of formation layer on weight disappear. These results are vital in that they show that size sorting has not occurred at the site. If size sorting had occurred we would expect the same significant effects of weight with formation layer regardless of whether the items were artefactual or not. The fact that the pattern for artefactual material is the opposite to that of the non-artefactual/broken material shows that the artefactual patterns are accurate distributions and not the product of post depositional movement.

Current data strongly suggests that **Hypothesis 2a** is the most tenable for the unweathered basal levee sand unit. The single most important factor is that gradual overbank deposition provides a real mechanism for the stratification of cultural material. Subsequent soil formation has had no impact on the stratified cultural sequence at this depth. Greater numbers of stratified artefacts can be expected at this depth with further excavation. Continued OSL dating will further refine the sequence and potentially push it back much further in time.

The Older Floodplain Unit

The older floodplain unit buried by the levee has a strongly developed soil profile. Soil formation within this unit has followed a progressive pathway. The buried soil profile displays distinct horizonation, structural development and a predictable particle size sequence. Sediments have been differentiated to the extent that their primary sedimentary structures are no longer recognisable, apart from in Trench 2 where primary sediments were encountered at 2.05 m depth.

Trenches 1 and 2, and 5 to 8 did not contain any artefactual material within the buried floodplain unit. Trench 3 contained some artefactual material in the indurated A2 horizon (spit 15). The evidence from Trench 3 must be disregarded entirely. Trench 3 contained the highest level of historic disturbance down to depths which penetrated the floodplain unit. Within Trench 4, spit 16 contained some evidence of the floodplain unit. That is, the interface between the levee and the buried floodplain was sinuous with the boundary between these two units varying over a depth of 10cm. In the case of Trench 4 the floodplain unit may only be identified with certainty from below 85cm (spit17) in depth. It would be premature to associate the material in spit 16 to the buried floodplain unit as the surface of this unit was ill defined and the presence of levee sands still predominated. Artefacts may be present in the buried soil profile, particularly as its surface was available for occupation between ~50,000 and 40,000 years ago. The fact that no artefacts were uncovered in this unit probably reflects the limited size of the test excavation.

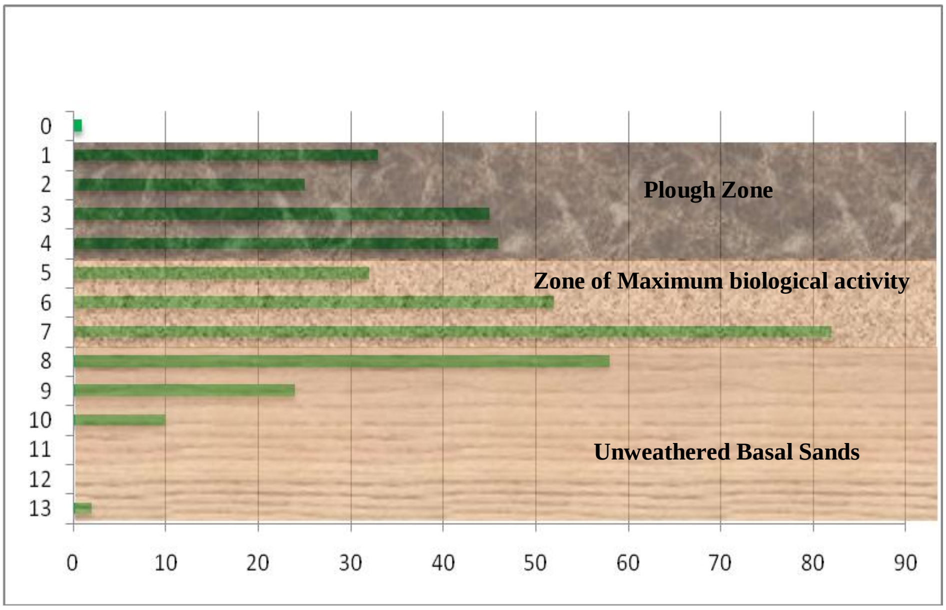


Figure 8.6: Artefact frequency by spit, Trench 1

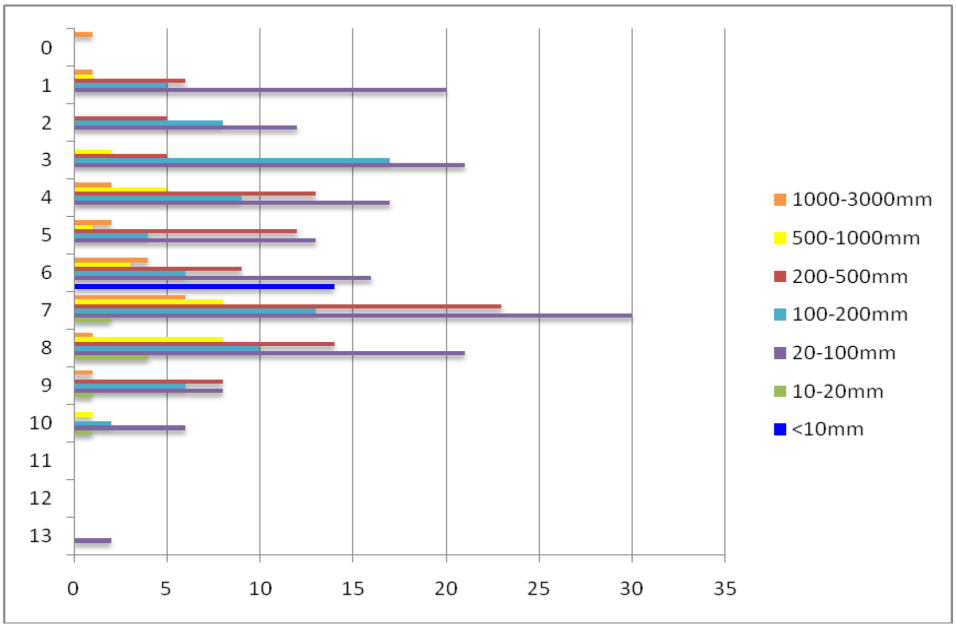


Figure 8.7: Artefact area by depth, Trench 1

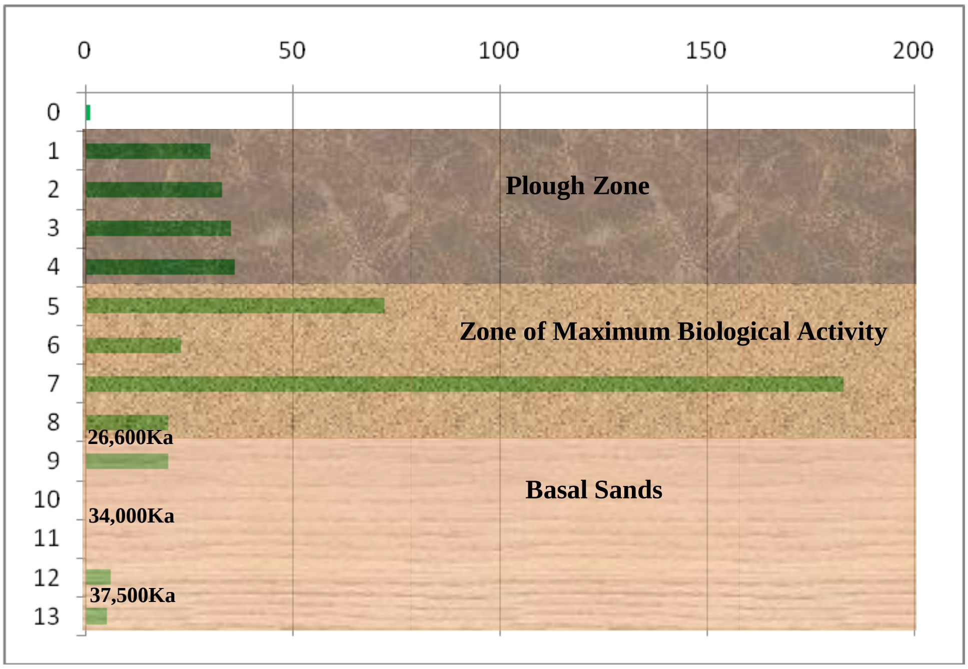


Figure 8.8: Artefact frequency by spit depth, Trench 2

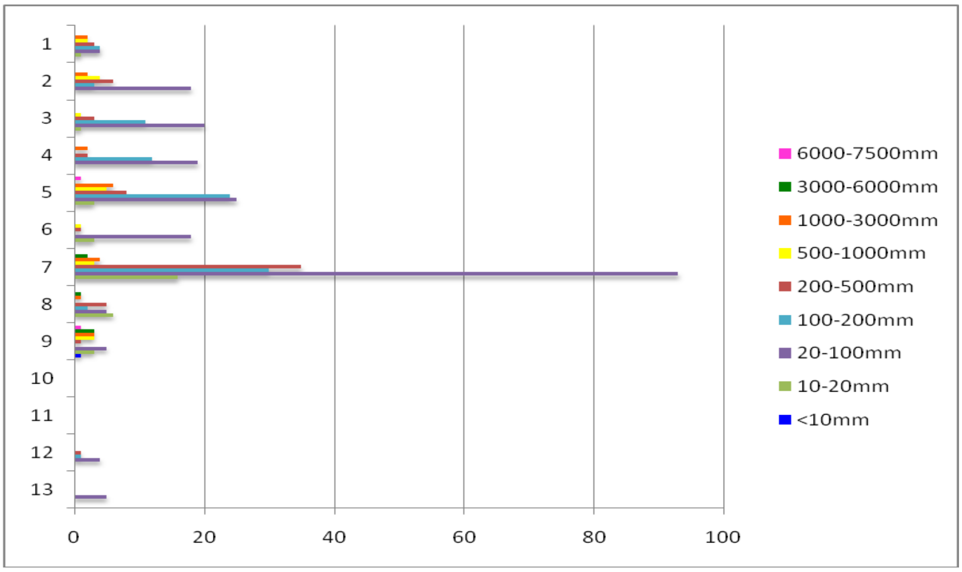


Figure 8.9: Artefact area by spit depth, Trench 2

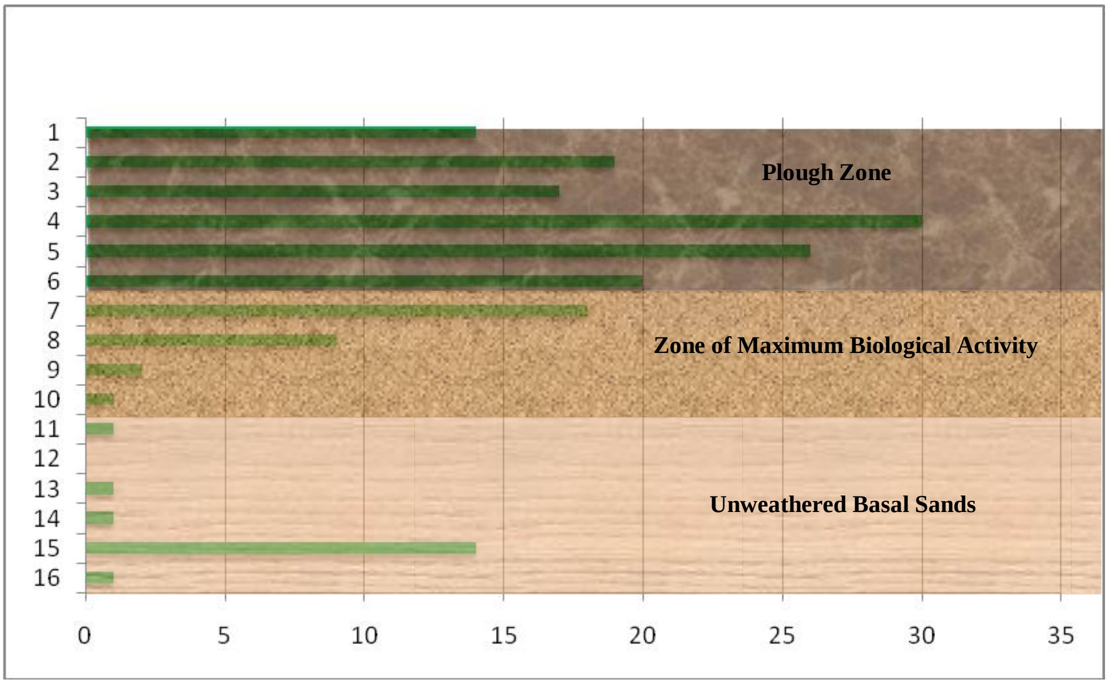


Figure 8.10: Artefact frequency by spit depth, Trench 4

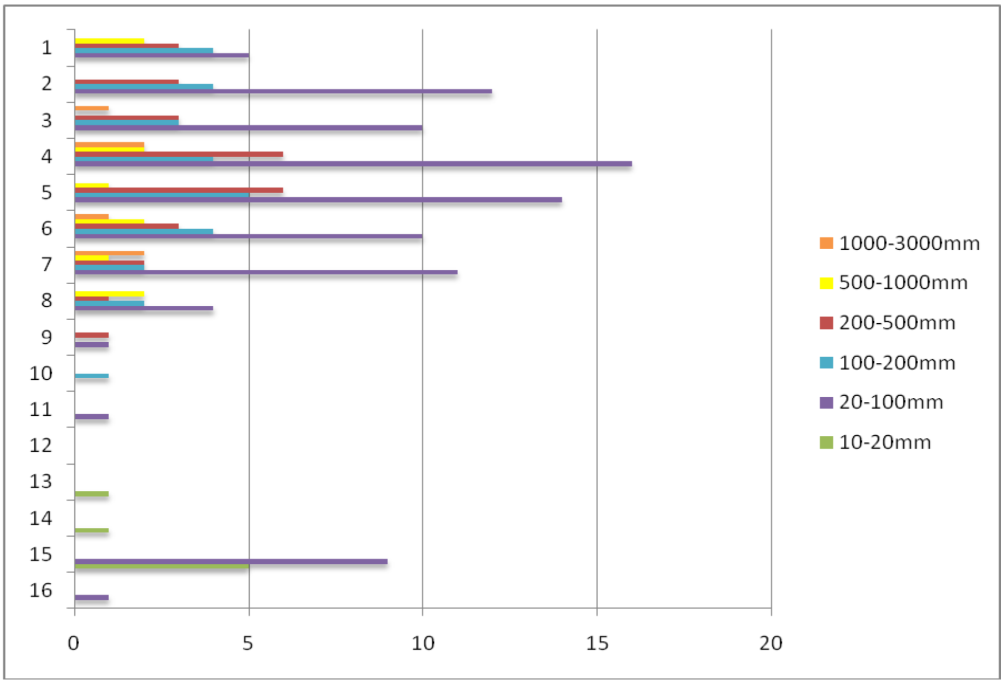


Figure 8.11:Artefact area by spit depth, Trench 4.

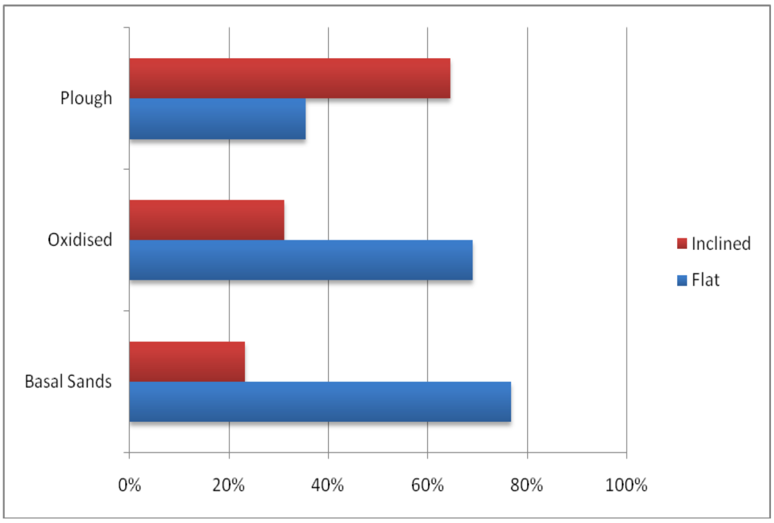


Figure 8.12: Depositional orientation by spit depth and frequency, Trench 1 and 2

Complete Artefacts	Plough/ Oxidised	Oxidised/Basal Sands	Plough/ Basal sands
<=g	0.80	3.52	2.81
>1g	0.94	3.89	3.67
Others	Plough/ Oxidised	Oxidised/Basal Sands	Plough/ Basal sands
<=1g	1.00	3.33	3.32
>1g	0.69	2.96	2.04
All Lithic Items	Plough/ Oxidised	Oxidised/ Basal sands	Plough/ Basal sands
<=1g	0.91	3.42	3.09
>1g	0.82	3.36	2.74

Figure 8.13:Comparison of artefactual and non-artefactual material by weight, according to formation layer

8.2.3 Summary

Artefactual material contained within the plough zone at the JRL site may or may not once have been stratified. All contextual evidence for this unit has been obliterated and artefact positioning is a result of post depositional disturbance.

Present data indicates that it is probable that the artefactual material contained within the oxidised unit was deposited during levee construction. There is no evidence for the strong development of pedogenic artefact patterning. However a more subtle pedogenic affect within the oxidised layer cannot be discounted. Based on present data this affect is predicted to be minimal owing to the current spatial distribution patterns, artefact orientation and the presence of conjoin material in Trench 1 Spit 6. Evidence that will determine the extent of the pedogenic affect is OSL dating of the upper levee deposit and artefact conjoin analysis.

Artefactual material contained within the basal levee sand deposits is argued to have been deposited during levee construction. The unweathered levee sand unit is stratified as the OSL results indicate the gradual build up of alluvial sediments over time. The OSL single sand grain analyses also confirm a peaked palaeodose distribution, indicating no sediment mixing. If artefactual material had been shifted down through the deposit the results of the single sand grain analyses would show evidence of sediment mixing.

8.2.4 Historic Disturbance

Historic disturbances to the JRL site are evident across all excavated trenches. The top 20 to 25cm of deposit represents a plough zone, and is the most disturbed unit across the site. Furthermore, several post holes have been identified in Trenches 1, 3 and 5. Trench 3 contains a total of 9 post hole cuts, while 2 identical cuts were identified in Trench 5, and one in Trench 1 (Plates 8.4 and 8.5). These post holes have been cut in to the unweathered basal sediments of the levee deposit and in the instance of Trench 3 have been cut in to the buried flood plain surface. Soil mixing in Trench 3 is considered to be high and the extent of disturbance too great to separate out from the surrounding deposits. Contamination in Trenches 1 and 5 was, however, much easier to control. In this instance the post holes were excavated separately (Plate 8.6 and Plate 8.7), with the mixed and disturbed soil removed and sieved separately.

A small amount of bone was retrieved from the JRL site (56 fragments in total). While the assemblage is highly fragmented, it is consistent with domestic use of the site during the historic period. All fragments of bone were confined to the plough zone (spits 1-4) or the interface of this zone with the underlying oxidised unit (spit 5). The majority of the bone fragments retrieved (88%) were contained in Trench 3, which is consistent with the high degree of disturbance to this trench already identified.

Historic artefacts have been found in all 8 trenches. Table 5.1 outlines the historic finds according to trench and spit depth. The majority of these finds are confined to the top 30cm of deposit comprising the plough zone. The presence of historic material in this soil unit requires no further discussion as the entire top soil deposit has been interpreted as being anthropogenic in origin. Four of the historic finds do however require further discussion owing to their location in what have been interpreted as potentially undisturbed deposits.

A small piece of European green bottle glass was recovered from Trench 3 at 65-67cm depth. This unit is the unweathered levee basal sands. Its presence is, however, considered irrelevant as it comes from soil collected when the trench walls were scraped back during cleaning for photographs. It is obvious that this piece of glass could have come from any depth in the trench and thus it has to be disregarded. Furthermore, Trench 3 has undergone the highest degree of historic disturbance down to depths which penetrate the buried floodplain soil.

In Trench 4 a single piece of colourless glass, 1cm in size was found in spit 11 between 50cm and 55cm in depth. In Trench 4 this spit lies immediately underneath the oxidised layer which has already been interpreted as potentially disturbed, with evidence of maximum soil mixing. It is situated at the upper most extent of the unweathered basal sands and its presence does not cast doubt on the integrity of the underlying stratified deposit. It simply denotes that this layer is likely to have undergone a degree of disturbance and any artefacts associated with this layer should be interpreted with this finding in mind.

The historic material found in sieve material from Trench 2 at 90-100cm consists of a ceramic fragment <3 mm in size. This piece is highly likely to be the result of contamination during the excavation process. The artefact comes from within the sondage excavated down in to the buried floodplain surface. This unit could not be excavated by hand owing to the high degree of induration. Consequently a pick and mattock were required to excavate the soil, resulting in a lower degree of control over the sediments extracted from the deposit. Furthermore, the floodplain in all instances proved to be sterile. Sieved material extracted from the floodplain soil primarily comprised of tiny iron nodules and quartz grains <3mm in size. It is unlikely that root activity carried this piece of ceramic from higher units. First, there is a distinct absence of root activity in the buried floodplain soil, which is due to the high degree of induration. Second the unweathered sands situated on top of the buried floodplain show no evidence of sediment transport from higher layers. The presence of this item in the floodplain deposit should not cast doubt on the integrity of the deposit. Its presence is in all probability a result of contamination during the excavation process.

Disturbance to Trench 1 was identified in sieve material from the indurated A horizon, at 67-77cm depth. Similarly, this material is highly likely to be the result of contamination during the excavation process and the same line of reasoning applied to the historic fragment retrieved at depth from Trench 2 may also be applied. However, as sediment from this trench has not been subjected to a single sand grain analyses, the integrity of this deposit at depth rests entirely on the results from Trench 2. However, in light of these results, it is probable that if disturbance is identified in Trench 1 it will be highly localised and will therefore not cast doubt on the integrity of the entire levee deposit.

Overall, post-depositional disturbance across the levee site is not significant. The great weight of evidence suggests intact cultural stratigraphy from the lower levee deposits

Trench Id.	Historic Finds / depth cm	Soil Stratigraphic Unit
Trench 1	Spits 1-4 (0-25cm)	Plough Zone- Ap Horizon
	Spit 16 (67-77cm)	Indurated A2 horizon- buried floodplain soil
Trench 2	Spits 1-4 (0-25cm)	Plough Zone- Ap Horizon
	Spit 18 (90-100cm)	Iron B Horizon- buried floodplain soil
Trench 3	Spits 1-3 (0-15cm)	Plough zone- Ap horizon
	Spits 4-7 (15-35cm)	Bio-sphere, zone of oxidisation and soil fauna activity
	Spit 9 (40-45cm)	C horizon- unweathered levee sand deposit
	Spit 14 (65-67cm)	C Horizon- unweathered levee sand deposit
Trench 4	Spits1-5 (0-25cm)	Plough Zone- Ap Horizon
	Spit 11 (50-55cm)	Interface of bio-sphere and C Horizon
Trench 5	Spits 1-4 (0-25cm)	Plough Zone- Ap Horizon
	Post hole	Historic Feature
Trench 6	Spits 1-2 (0-10cm)	Plough Zone Ap Horizon
Trench 7	Spits 1-6 (0-30cm)	Plough Zone Ap Horizon
Trench 8	Spits 2-5 (5-25cm)	Plough Zone Ap Horizon

Table 8.1: Historic finds according to depth and soil stratigraphic unit

Plate 8.4: Detail of post hole in Trench 5, view facing west

Plate 8.5: Detail of three post holes evident along the northern wall of Trench 3

Plate 8.6: Trench 5, showing 2 post hole cuts after the removal of the disturbed soil

Plate 8.7: Trench 1, showing a possible post hole cut. The mixed soil has been removed

9 Stone Artefact Analysis

The essential goal of stone artefact analysis is to provide a detailed understanding of the prehistoric technology of a site and its relationship to the hunter-gatherer populations responsible for its manufacture and use. Its purpose is to increase our understanding of prehistoric behaviour by examining and understanding the tools that made subsistence and survival possible.

A detailed technological analysis was undertaken by Dr Sophie Collins on the entire stone assemblage excavated from the JRL site. Before discussing the methodology and results of this analysis it is first necessary outline the limitations placed upon the analysis by the data itself and to give context and meaning to the results generated in light of these limitations. We cannot construct valid interpretations of the past without identifying and accounting for weaknesses in the data upon which they are based. The only valid interpretation is one that has not asked questions of the data that they simply cannot or are not designed to answer.

9.1 Limitations to Stone Artefact Analysis

The following discussion of the stone artefact assemblage recovered from the Jordan River levee is a detailed analysis of all the material recovered from the site. It must be remembered that these results are the product of an *exploratory test-pitting programme* and are by no means conclusive. The actual testing area of the JRL site represented less than 1% of the landform and the site within it. Any data gleaned from such a small sample can only be regarded as preliminary, regardless of the level of detail in which it has been researched and analysed.

Further limitations have been placed on this analysis by the inability to conduct conjoin analyses. It is the decision of the Aboriginal Community, at this time, not to allow the process of conjoin analysis to be undertaken owing to concerns that conjoin analysis requires the individual marking of each artefact causing permanent damage/alteration to the artefacts. As such, it has not been possible to identify many individual knapping floors and the ability to determine the extent to which artefacts may have moved spatially or temporally within the matrix has been restricted.

Where possible, statistical analyses have been performed on the data with the help of statistician Dr Glen McPherson. However, the small size of the assemblage recovered and the wide range of variables to be compared and analysed meant that these statistics are very coarse in nature. In many cases there simply is not enough data to allow reliable or meaningful comparisons to be made and as such, only those results considered to be statistically valid have been included in this report.

It must, therefore, be understood that the following summary and interpretation of the stone artefact assemblage from the JRL site has been limited by the nature of the excavation programme (the fact that it is a test-pitting programme only), the size of the assemblage recovered and analyses that have been able/are suitable to perform. Large, open area excavation, employing higher resolution excavation techniques, will be required to gain a full understanding of prehistoric use of the JRL site and to identify greater spatial and temporal changes in site use.

9.2 Attribute Analysis

The range of attributes recorded on the stone artefacts from the site reflect the various areas of inquiry explored in the analysis. In addition to simple size characteristics (such as length, width, thickness, weight and elongation), measurements relating to platform size, external platform angle and platform preparation were also taken. These attributes allow analyses to be performed relating to artefact manufacture and reduction techniques and to raw material conservation.

The following attributes were recorded for each artefact:

Provenance the trench, square and quadrant from which each artefact came was recorded in detail. Where possible, X,Y and Z co-ordinates were also taken.

Spit Number each 5cm spit was numbered sequentially.

Raw Material a large range of raw materials were identified at the site.

Basalt is a common volcanic rock that is low in silica content. It ranges in grain size but can be quite coarse and porphyritic with comparatively large crystals visible in its matrix (Mayer 1976). Unweathered it is black or grey in colour. It is not an ideal flaking material.

Ceramic in this context, refers to historic ceramic plates and bowls made from glazed earthenware/stoneware/porcelain.

Chert is a very fine grained sedimentary rock composed entirely of microscopic crystals of silica. It is a dense, hard rock, usually opaque and appears in a wide range of colours (Mayer 1976). It is a well used raw material for stone artefact manufacture across Australia due to its homogeneity and superior flaking qualities.

Cortex is the weathered outer rind which occurs on natural cobbles or nodules of raw materials. Cortex differs greatly from the material beneath it and is therefore removed as the first stage in the core reduction process.

Fine Grained Siliceous is a very broad category referring to fine grained rocks composed of exceptionally high amounts of cryptocrystalline silica (mainly quartz), that cannot be more definitively assigned without petrological analysis. These materials have fracture properties similar to chert (in fact chert is a type of fine grained siliceous material) and are regularly flaked in Australian archaeological sites.

Fine Grained Volcanic is another broad category referring to igneous rocks that are so fine grained that individual crystals cannot be distinguished with the naked eye. Like basalt, these materials can be porphyritic with larger crystals occurring within the very fine surrounding matrix. As with fine grained siliceous materials above, these materials cannot be more definitively classified without petrological analysis.

Glass in this context, refers to historic glass bottles and windows that have been worked by Aboriginal people in the historic period. Glass is composed of amorphous silica and is an ideal flaking material.

Hornfels is a fine grained sedimentary rock, such as shale and slate, that has been metamorphosed by heat, creating new metamorphosed minerals. Hornfels often possess a characteristic spotted appearance due to some of the new minerals formed and are generally grey in colour (Mayer 1976).

Petrified Wood is wood that has become fossilised over time by the replacement of organic materials with minerals (mostly silica) (Mayer 1976). Petrified wood retains its original appearance of wood but fracture like a siliceous stone.

Quartz is a mineral consisting entirely of silica dioxide occurring crystals that are commonly prismatic in shape. It is mainly colourless or white (though varieties of colours do exist) and is easily identified by its lack of cleavage (no consistent pattern when it breaks). Quartz occurs in a variety of qualities ranging from coarse and heavily flawed to transparent crystal quartz (Mayer 1976).

Quartzite is a hard metamorphic rock that was originally sandstone, converted to quartzite through metamorphic processes of heating and pressure (Mayer 1976). As such, it is extremely variable and consists of interlocking quartz grains cemented together with silica. Quartzite tends to be coarse and not ideal for flaking, though its use is prolific throughout Australia.

Sandstone is a sedimentary rock composed of sand sized grains and minerals (generally quartz and feldspar) cemented together with minerals such as silicates (Mayer 1976). As such, it has a coarse, granular texture depending upon the size of the grains.

Silcrete is a fine grained siliceous material formed when silica dissolves and then resolidifies. It is clearly distinguished by the presence of visible grains floating in a fine grained siliceous matrix. Silcrete occurs in variable grain sizes from fine to coarse and is one of the most common materials utilised for stone artefacts across Australia due its conchoidal flaking properties.

Silicified Mudstone is a fine grained sedimentary rock made from compacted and lithified silica rich clay and silt particles. They are commonly finely bedded or laminated appearing as fine layers (Mayer 1976).

Artefact Type A range of different artefact types were identified during analysis. These are defined below:

Flake A flake is a piece of stone struck from a core and exhibiting a range of diagnostic features that indicate that the removal of the flake was deliberate and of human origin. Flakes are most commonly removed through percussion which involves using a hard hammer to direct the force of the blow onto the surface of the core. Percussive flakes commonly bear the following diagnostic characteristics: a ring crack (visible as a semi-circular protuberance on the ventral surface of the flake and located exactly where the blow was struck), a positive bulb of percussion on the ventral surface of the flake and possible eraillure scar (a small flake detached beneath the impact point caused by the force with which the main flake was removed).

Flakes may also be produced by pressure and produce different characteristics than those detailed above for hard hammer percussion. Pressure flakes are known as ‘bending’ initiated flakes and occur when the pressure that causes the flake to separate from the core is applied further away from where the fracture initiates – usually at a point of weakness or where flaws already exist in the stone. Bending flakes do not have a ring crack or bulb of percussion and instead can be identified from a small lip protuberance extending the platform from the ventral surface.

All complete flakes will have a proximal, medial and distal component, a dorsal and a ventral surface, a point of initiation, two lateral margins and point where the fracture terminates.

Core Cores represent the nucleus piece of stone from which flakes have been removed. Cores will always retain negative flake surfaces showing negative bulbs, ring cracks and so on. Each negative flake scar shows the location of a flake previously removed.

Retouched Flake Retouched flakes are flakes that have been modified following manufacture. That is to say that, subsequent flakes have been removed from any of the flakes margins or in any way impacted upon the ventral surface.

Flaked Piece This category includes those pieces that are clearly man made but which for various reasons cannot be clearly assigned as flake, retouched flake or core. Diagnostic features are often removed or compromised by processes of heat affect/weathering causing items to be classed as flaked pieces.

Heat Shatter These are pieces of flakeable stone that have been fractured through non-human agency such as extreme heat (through fire) or the natural processes of heating and cooling with the weather. Heat shatter is identifiable by the irregularity of the shattered surfaces, colour changes to the materials, crazing of the surface or the presence of potlid fractures.

Unworked Manuport These are large pebbles/rocks that do not occur naturally at the site and are too large to have been transported by wind or water. These items show no signs of having been worked or flaked, but must have been transported to a site by human agency.

Weight Weight was measured using an electronic balance to the nearest 0.01g.

Length In this study length was measured in accordance with percussion length – that is, the length along the direction of the blow stretching from the point of initiation at the ring crack to the distal end. Length was recorded to the nearest 0.01mm using digital callipers.

Width Width was measured perpendicular to the line of percussion and was taken at the midpoint of the flake to the nearest 0.01mm using digital callipers.

Thickness Thickness was measured at the point where the length and width measurements met – the midpoint of the flake in line with the percussion line. It was measured to the nearest 0.01mm using digital callipers.

% Cortex Cortex forms as an outer layer or skin on the surface of raw materials due to weathering. In most cases the fracturing properties of cortex differ greatly from those of the raw material itself. As such, decortication or the removal of the cortical layer is usually undertaken as a preliminary step in the manufacture of stone artefacts. The presence/absence of cortex and the amount remaining is therefore an indicator of the raw materials stage of reduction. % cortex was a visual estimate in this study based on the proportion of the item considered to still retain cortex.

Platform Width The platform width measures the distance between the two lateral margins of the flake at the platform where the fracture was initiated. Platform width and thickness are used together to give an idea of platform area, which in turn informs about the amount of force required to initially cause the flake to come away from the core.

Platform Thickness Platform thickness refers to the distance between the dorsal and ventral surfaces across the striking platform. Platform width and thickness were measured to the nearest 0.01mm using digital callipers.

Overhang Removal The presence or absence of overhang removal was recorded for all flakes. Overhang removal is a form of platform preparation which comprises removing excess stone from the platform of a core prior to removing the flake. The process reduces the total area of the platform allowing a large flake to be manufactured without requiring too great an increase in the force of the blow. Platform preparation is visible in the form of a series of small flake scars on the dorsal surface of the platform.

External Platform Angle The external platform angle refers to the angle between the platform and the dorsal surface, and it records the shape of the core immediately before the manufacture of the flake. This angle affects the amount of force required to detach a flake from a core; the higher the angle, the greater the force required and the larger the flake produced, the lower the external platform angle the smaller the force required and the smaller the flake produced. Platform angles were measured to the nearest degree using a goniometer.

Retouch The existence and type of retouch was recorded for each artefact and was examined using a 10x hand-lense. Retouch is identified as a series of deliberately removed small flakes from along the edge of an artefact. The location of retouch and its orientation was recorded in all cases. In the absence of access to high magnification microscopes no suggestion of artefact function has been made.

Retouch Length The area of the flake affected by retouch was recorded to the nearest 0.01mm using digital callipers.

Retouch Angle The angle of the edge produced by retouch was recorded to the nearest degree using a goniometer.

9.3 Data Selection

9.3.1 Artefacts Classes

A total of 1403 lithic items were recovered from the 8 trenches excavated at the JRL site. However not all of these items are regarded as suitable for inclusion in analysis. The inability to unequivocally identify some items as the products of human agency necessarily means they should be excluded from investigations into human behaviour. For example, raw material shatter may be the by-product of stone artefact manufacture, but it may also occur through natural processes such as heating and cooling or through mechanical agency such as ploughing. Similarly, unworked pebbles cannot be proven to be the product of human agency because they lack any of the features of identification necessary to categorise them as artefacts (e.g. hertzian initiation, positive or negative flake scars etc). While it is highly likely these items were brought to the site my humans as manuports for working or other subsistence activities, the inability to state this with certainty means that the inclusion of these materials in the artefact analysis may artificially inflate the human component of the assemblage. A third category of material has had to be excluded despite its being artefactual; these are flaked pieces. Flaked pieces show signs of having been worked and are clearly not naturally occurring but they no longer retain any diagnostic features that allow them to be classified as either a flake or a core. These items therefore provide very little useful information in analysis other than to record their presence.

For completeness, the distribution of these items across the trenches is included in Table 9.1. However only those items that are clearly artefactual have been included in the detailed technological analysis discussed below.

9.3.2 Broken Artefacts

Broken artefacts have been removed from the technological analysis and are discussed separately in this report. This is because a single artefact can be broken into any number of pieces, through treadage, ploughing or any number of post-depositional processes. This means a single flake may be represented by 5 fragments in one spit, and by a single complete flake in another. Direct counts of each piece would therefore show 5 times the densities in one spit than in the other, despite the fact that a single flake was present in each case. As such, broken artefacts have the potential to dramatically and artificially alter assemblage counts/weight counts in any site and should be removed from discussions of assemblage size and content. The extent to which broken artefacts may have an effect on assemblage structure is illustrated in Figure 9.1, which shows that more than 50% of some assemblages are comprised of broken artefacts.

Trench	Core	Flake	Historic Flake	Worked Glass	Retouched Flake	Shatter	Flaked Piece	Unworked Manuport	Total
Trench 1	5	363			8	9	25		410
Trench 2	6	304	2		8	64	52	13	449
Trench 3		202	13	4	4	12	19	7	261
Trench 4		150	3	1	3	3	8	6	174
Trench 5	1	21	4	1	2	1	4		34
Trench 6		7				1	1		9
Trench 7		30			1	1	1		33
Trench 8		24			2	3	3	1	33
Total	12	1101	22	6	28	94	113	27	1403

Table 9.1:The distribution of lithic items by trench at JRL

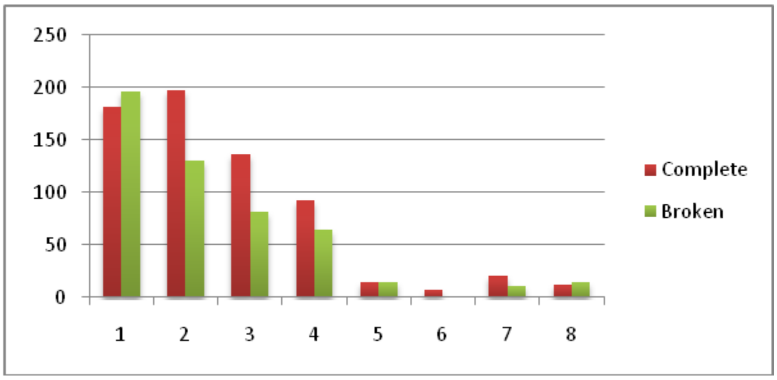


Figure 9.1: Proportions of complete and broken artefacts by trench

Broken artefacts do, however, have a significant contribution to make to interpretations of the site itself and they have not been ignored in this report. They have simply been separated from the general analysis and reserved for discussions relating to post-depositional damage and estimates of minimum numbers of artefacts present, in preference to misrepresenting actual artefact numbers.

9.3.3 Stratigraphic Integrity

Trenches 3 and 8 have also been removed from the analysis due to extensive disturbance within the deposits. The disturbance caused to Trench 3 through the intrusion of 9 historic post holes and historic material found to penetrate levels of the lower flood plain. Soil mixing and disturbance is considered to be extremely high in this trench and the data from it is considered to be unreliable (see Section 8.3). Trench 8 was excavated to a depth of 10 spits (50cm) and revealed a plough zone immediately overlying the floodplain. All artefact bearing spits in this trench (spits 1-8) were recovered from the plough zone and are therefore highly disturbed. The data obtained from these two trenches were considered too unreliable to include in the analysis with the remaining 6 stratified trenches. Consequently, discussion of the contents of these two trenches can be descriptive only and are discussed separately below.

9.3.4 Statistical Validity

In order to generate meaningful data from the assemblage the decision was made to group artefacts according to the stratigraphic formations in which they were situated, rather than by spits. This meant that similar depositional layers and therefore periods of time (although gross) could be examined together. Those trenches that are not disturbed (Trenches 1, 2, 4, 5, 6, and 7) show identical stratigraphy, and allow the artefacts to be grouped and discussed in relation to the sites depositional layers; plough, oxidised and basal sands.

This decision was based on low frequencies of artefacts recovered from each spit and the lack of comparability between the levels of each spit, which meant that valid comparisons between equivalent spits in each of the trenches could not be made (e.g. Spit 1 in all 6 trenches). Figure 9.2 demonstrates that only 5 spits across the entire site contain more than 20 artefacts and many spits contain less than 10 artefacts each; comparisons between such small numbers are not meaningful in this context. In addition, the excavation of the JRL site using a test-pitting and exploratory strategy meant that each of the trenches was given their own datum. This means that while each test-pit was excavated in strict 5cm spits relative to its datum (and the surface of the levee at that location), the relationship between each of the datum points across the landscape is unknown. The levee surface itself is not flat. As such, comparisons between the same spit across 6 trenches are not possible, due to the fact that they may relate to different depths across the landform.

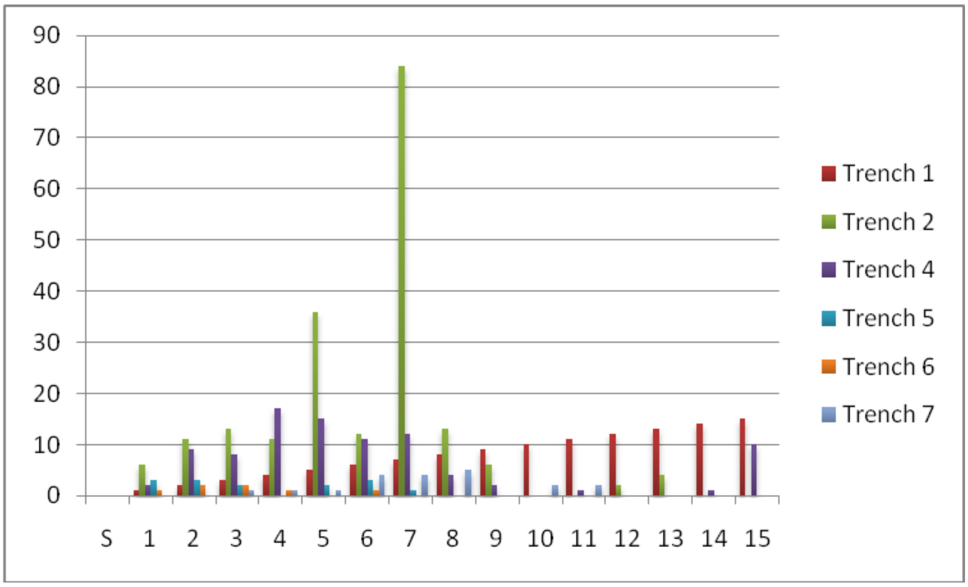


Figure 9.2: Complete Artefact Frequencies by Spit and Trench.

A further decision regarding data selection was to group all the remaining stratified trenches together and analyse the assemblage as a whole. This decision was made for two reasons. The first reason is that the assemblages from the 1m x 1m trenches (Trenches 5, 6 and 7) were simply too small to be compared either with the larger Trenches (1, 2 and 4) or with each other. Table 9.2 demonstrates how the small sizes of the assemblages recovered from Trenches 5, 6, and 7 make it impossible to legitimately compare assemblages across trenches, by detailing artefact class numbers and proportions for each trench. A single core in Trench 5 is shown here to represent a greater proportion of the assemblage (7.14%) than do the 5 cores located in Trench 2 (2.59%). Analyses attempting to compare the contents of individual trenches to explore differences between raw material use, artefact sizes and reduction measures were simply invalid due to the lack of data available from the smaller trenches and from some artefact characteristics in the larger trenches. The assemblage is simply too small for this type of analysis.

Trench	Core %	Core No	Flake %	Flake No	Retouched Flake %	Retouched Flake No	Total %	Total No
1	1.67%	3	95.00%	171	3.33%	6	100.00%	180
2	2.59%	5	93.78%	181	3.63%	7	100.00%	193
4	0.00%		97.83%	90	2.17%	2	100.00%	92
5	7.14%	1	85.71%	12	7.14%	1	100.00%	14
6	0.00%		100.00%	7	0.00%		100.00%	7
7	0.00%		95.00%	19	5.00%	1	100.00%	20
Total	1.78%	9	94.86%	480	3.36%	17	100.00%	506

Table 9.2:Numbers and proportions of artefact classes by trench

The second reason is that all 6 trenches were excavated on the same landform; they are not testing differences between landforms but rather seeking to explore variation within it. As such, they all represent duplicates of the same test, which allows their data to be legitimately combined regardless of the differences in the sizes of the trenches themselves. By combining the data from all trenches, it has been possible to perform a range of analyses including raw material use, artefact sizes and weights and reduction strategies, which could not have been legitimately carried out on a smaller assemblage.

The inability to make valid comparisons between trenches means that exploring variation within the JRL site is simply not possible. The single exception to this is exploring difference with distance from the river. The orientation of the trenches in a linear fashion moving away from the Jordan River allows us to make some comparisons between trenches close to the river and those that are further away from it. By grouping the data from Trenches 5, 6 and 7 it is possible to compare the relative proportions of different artefact characteristics with those recovered from Trenches 1, 2 and 4. The dramatic differences between assemblage and trench sizes between the two groups (i.e. 1, 2 and 4 against 5, 6 and 7) prohibit the meaningful comparison of actual artefact numbers, however the relative proportions of each measure; such as raw material, artefact weight and measurements of reduction, can be undertaken. The results of this comparison are also detailed in the following discussion.

The final decision regarding data selection relates to the number of categories/groupings selected for statistical analyses. Again, due to the small assemblage size available, it has only been possible to compare data in two groupings. For example, artefact weights, though ranging from less than 0.1g to more than 500g in some cases have had to be discussed in terms of artefacts weighing less than 1g and those weighing more than 1g because the range of variation in weights combined with the limited numbers of artefacts present made it impossible to create meaningful data out of a larger number of weight categories. In the majority of cases, finer resolution weight categories would be represented by only 1 or 2 artefacts; a sample size which eliminated that category from valid statistical interpretation. By reducing groupings to two in each case, it has been possible to generate discernible patterns in the material. However it must be noted that these comparisons are necessarily somewhat coarse in nature and a larger scale excavation would allow much finer resolution interpretations to be made.

It is vital to note that the need to combine trench data in this analysis does not negate the possibility that inter-site variations exist across the levee landform. This report is not a declaration that variation in site use does not exist at the JRL site, but that the data produced through the test-pitting programme currently conducted were not sufficient to allow for the legitimate identification of such variation. A larger assemblage, such as that provided by open area excavation of a larger proportion of the levee deposit would allow such comparisons to be made and may alter the interpretations made here. This report recognises the inherent limitations in the data and has sought only to make claims or interpretations that the data can legitimately support. This is has resulted in a reasonably coarse understanding of the site: an inevitable outcome of a first stage test-pitting strategy.

9.4 Results

In order to answer the research questions for stone artefact analysis outlined at the beginning of this section, it is first necessary to characterise the assemblage at the site. Variations in the physical characteristics of the artefacts over time including metrics and raw material usage, along with reduction strategies and approaches to raw material provisioning are essential to understanding how the JRL site has been used over time and how it compares with other sites of similar age. The following discussion is the results of the technological and statistical analysis of the assemblage recovered from the levee. These results form the basis for subsequent interpretations of site usage, cultural sequences and comparisons with other sites in Tasmania.

9.4.1 Trenches 1, 2, 4, 5, 6 and 7 Combined

Following the removal of non-artefactual material (flaked pieces, shatter and manuports), the separation of broken artefacts and the combination of all 6 trenches, the total size of the assemblage being discussed here is 506 complete stone artefacts. This assemblage is composed of 480 unretouched flakes, 9 cores and 17 retouched flakes (see Table 9.2 for distributions across trenches). These artefacts are distributed over the three artefact bearing formation zones: ploughed layer (N=201), layer of oxidisation (N=239) and basal sands (N=66).

Artefact Size

Artefact size has been calculated here by two means: weight and area. The length or width of an artefact alone is insufficient to provide a feel of its overall size, given that not all artefacts are proportionate. A flake may be very thin but also quite long and vice versa. Area has therefore been calculated on a basic measure of orientated length multiplied by orientated width.

<u>Weight</u> Categories Used: <=1g and >1g

Artefact weights were calculated to the nearest 0.01g, with artefacts ranging in size from less than 0.01g to 557g. For the purposes of statistical comparison weight was divided into 2 categories: <=1g and >1g and allowed comparisons in artefact weight to be made between formation layers. Table 9.3 details the numbers of artefacts falling within each weight category and formation. From this table it is clear that just under 70% of the assemblage weighed less than or equal to 1g, indicating that the assemblage itself is generally very lightweight.

Formation	<=1g	>1g	Total
Plough	135	66	201
Oxidised	169	70	239
Basal Sands	48	18	66
Total	352	154	506

Table 9.3: Weight frequencies by formation layer

Formation	<=1g	>1g
Plough/Oxidised	0.8	0.94
Oxidised/Basal Sands	3.52	3.89
Basal Sands/ Plough	2.81	3.67

Table 9.4: Ratio of weight frequencies by formation layer (significant differences are highlighted)

Table 9.4 compares proportions of each category relative to formation in the form of a ratio. The only significant variation (highlighted in orange) between weights for each formation layer is the ratio of artefacts in basal sands to plough, which shows that there are 30% more artefacts weighing more than 1g in the plough zone than there are the basal sand levels. Importantly, the proportions of artefact weights do not differ substantially between the plough to oxidised layers or between oxidised and basal sand layers.

<u>Area</u> Categories Used: <=100mm^2 and >100mm^2

Artefact area was calculated to the nearest mm^2 with artefacts ranging in area from 1mm^2 more than 7500mm$^{2.}$ For the purposes of statistical comparison area was divided into 2 categories: <=100mm^2 and >100mm^2 and allowed comparisons in artefact area to be made between formation layers. Table 9.5 details the numbers of artefacts falling within each area category and formation. From this table it is clear that almost 50% of the assemblage has an area equal to or less than 100mm^2, indicating that the assemblage itself is not only very lightweight but also quite small. The discrepancies in frequencies of artefacts between the smaller weight and size categories suggests that many of these artefacts are very delicate, weighing less than a gram but exceeding 100mm^2 area. These results show that delicate, lightweight and small artefacts dominated the JRL assemblage.

Formation	<=100mm^2	>100mm^2	Total
Plough	89	112	201
Oxidised	116	123	239
Basal Sands	36	30	66
Total	241	265	506

Table 9.5: Area frequencies by formation layer

Table 9.6 compares proportions of each category relative to formation in the form of a ratio. Two significant differences (highlighted in orange) occur in the ratios of artefact area with formation. A significantly higher proportion of larger flakes (27%) occurs in the oxidised formation than occur in the basal sands, while 51% more of the assemblage will occur in the larger size categories in the plough layer than in the basal sands. The larger flake category is therefore proportionately more common in the plough layer than in either the oxidised or the basal sands layers, and more common also in the oxidised layer than in the basal sands.

Formation	<=100mm^2	>100mm^2
Plough/Oxidised	0.77	0.91
Oxidised/Basal Sands	3.22	4.10
Basal Sands/ Plough	2.47	3.73

Table 9.6: Proportions of area frequencies by formation layer (significant differences are highlighted)

Artefact Reduction

A number of measurements of artefact reduction were taken for this assemblage including flake elongation, decortication, platform area, platform preparation (identified through the presence/absence of overhang removal), exterior platform angles, dorsal scar numbers on flakes and evidence of rotations of the core prior to each flake's manufacture. These are discussed in order below.

<u>Flake Elongation</u> Categories Used: <=1.5 and >1.5

Flake elongation measures the extent to which knappers are regularly producing flakes of a particular shape, by providing a length to width ratio for the flake. It provides some measure of whether a particular technology is being consistently utilised or whether a specific shape is being targeted by the knapper. Flake length, width and thickness were all measured to the nearest mm before converting the measurements into a ratio of length: width. Elongation measures for the JRL site ranged from 0.2 to 3.5. However for the purposes of statistical comparison elongation measures were divided into 2 categories: <=1.5 and >1.5 (represented here as ratios). Table 9.7 details the numbers of artefacts falling within each area category and formation. A flake with an elongation ratio of 1.00 is as wide as it is long making it somewhat rounded in shape. By comparison, a flake that's length is more than 1.5 times its width is elongated. Table 9.7 indicates that more than 70% of the assemblage is either not elongated or minimally so.

Formation	<=1.5	>1.5	Total
Plough	162	36	198
Oxidised	182	53	235
Basal Sands	52	12	64
Total	352	154	497

Table 9.7: Elongation frequencies by formation layer

Formation	<=1.5	>1.5
Plough/Oxidised	0.89	0.68
Oxidised/Basal Sands	3.50	4.42
Basal Sands/ Plough	3.12	3.00

Table 9.8: Ratio of elongation frequencies by formation layer (significant differences are highlighted)

Table 9.8 compares proportions of each category relative to formation in the form of a ratio. A significant difference in flake elongation was only identified when the oxidised and basal sand layers were compared, indicating that more elongated flakes are 26% more likely in the oxidised layer than they are in the basal sand layers. These data, suggests a slight trend towards the manufacture of elongated flakes may have occurred during the oxidised layers, however the consistent manufacture of a particular blade size or shape does not appear to have occurred at this site.

Decortication Categories Used: Primary, Secondary and Tertiary

Decortication levels are extremely high at the JRL site (see Table 9.9), with more than 82% of the assemblage no longer retaining any cortex (that is, representing tertiary reduction) and a further 16% of artefacts retaining secondary cortex (that is, showing scars from previous working but retaining some cortex). Only 5 of the artefacts recovered were primary cortex flakes (the first flakes removed from a core and covered 100% with cortex on the dorsal surface). These measures strongly indicate that onsite manufacture was minimal at the JRL site. The extremely low levels of cores (N=9) recovered from the site supports this assertion and indicates that in general, raw materials were arriving on site having already been decorticated elsewhere and were then carried on for future use. Significant differences cannot be detected in the levels of decortication with formation layer.

Decortication Stage	Plough	Oxidised	Basal Sands	Total
Primary		2	3	5
Secondary	31	39	12	82
Tertiary	167	194	49	410
Total	198	235	64	497

Table 9.9: Decortication frequencies by formation layer

Platform Area Categories Used: <=5mm^2 and >5mm^2

Platform area was calculated to the nearest mm^2 by multiplying platform width by platform depth. Platform area serves as a guide to reduction by acting as a measure of raw material conservation. The smaller the platform, the smaller the amount of raw material removed from the core, the less material removed from the core and the higher the levels of raw material conservation possible. For example, focal platforms where the percussive blow is struck as close to the edge of the core as possible, results in immeasurable platform dimensions and allows for the creation of a flake with fresh edges whilst removing the least possible amount of raw material (Clarkson and O'Connor 2006). Conversely, the larger the platform and the greater the distance between the edge of the core and location of the blow, the greater the amount of raw material that needs to be accelerated from the core. This accordingly results in the generation of larger flakes and the use of greater amounts of raw materials. Platform area measures for the JRL site ranged from 0 (focal platforms) to 1400mm^2, however for the purposes of statistical comparison platform area was divided into 2 categories: <=5mm^2 and >5mm^2. Table 9.10 details the numbers of artefacts falling within each area category and formation. Included in the analysis are all broken flakes that retained a complete platform. It is clear that larger platforms are more common in all 3 formation layers, with more than 64% of the assemblage falling into the larger platform category

Formation	<=5mm^2	>5mm^2	Total
Plough	180	170	250
Oxidised	101	171	272
Basal Sands	31	44	75
Total	212	385	597

Table 9.10: Platform area frequencies by formation layer

Formation	<=5mm^2	>5mm^2
Plough	32%	68%
Oxidised	37%	63%
Basal Sands	41%	59%

Table 9.11: Proportion of platform area frequencies by formation layer (significant differences are highlighted)

Converting these raw numbers into proportions for comparability; Table 9.11 shows that larger platforms are two times more likely than smaller platforms within the plough layer, 69% more likely within the oxidised layer and 42% more likely within the basal sands. The probability of larger platforms therefore subtly decreases with depth across the site but consistently remains the more dominant size category. The differences in the proportions of larger platform areas with depth are not significant.

<u>Platform Preparation (overhang removal)</u> Categories Used: Presence vs Absence

Overhang removal is a technique used by knappers to alter the shape and size of the platform and therefore adjust the amount of force required to create a flake as well as the size of the resultant flake (Macgregor 2005). Overhang removal also has the ability to alter the free surface of the core (the shape of what becomes the dorsal surface of the flake). Recent controlled studies in fracture mechanics (Macgregor 2005) have shown that the morphology of the free face directly affects the morphology of the resultant flake. By modifying the free surface through overhang removal, the knapper gives themselves greater control over the production of the flake itself. As such, the presence of overhang removal at a site gives an indication of raw material conservation, by reducing platform depth and therefore reducing the amount of material used in each flakes' production, and by allowing greater control over flake production and raw material usage. Table 9.12 shows that more than 58% of the assemblage exhibited platform preparation. Proportions of platform preparation remained consistent throughout the sites history irrespective of formation layer.

Formation	Present	Absent	Total
Plough	160	90	250
Oxidised	145	127	272
Basal Sands	33	33	75
Total	347	250	597

Table 9.12: Frequencies of overhang removal by formation layer

It can be shown here that frequencies of larger platform sizes are very similar to those of overhang removal, which suggests that overhang removal was used to decrease platform depth while allowing slightly larger flakes to be removed at a lower applied force.

Exterior Platform Angle Categories Used: <=70º and > 70º

Exterior Platform Angle (EPA) refers to the angle made at the point where the platform and dorsal surface meet. EPA dictates the shape of the flake produced by affecting the amount of force required to detach a flake and in turn the size of the flake produced. A high EPA will require a greater amount of force to detach the flake and results in the production of a large flake. Conversely, low EPAs require a lesser force to cause flake detachment but result in the production of smaller flakes. A high EPA can be offset, however, by overhang removal which reduces the platform thickness, allowing a flake of equivalent size to be removed without increasing the amount of force required (Speth 1972, 1982; Dibble and Whittaker 1981, Dibble and Pelcin 1995, Clarkson and O'Connor 2006). In this study, EPA was measured to the nearest degree using a goniometer. EPAs for the JRL site ranged from 29º to 142º, however for the purposes of statistical comparison EPAs were divided into 2 categories: <=70º and > 70º. Table 9.13 details the frequencies of platforms falling into the two angle categories by formation layer. For ease of comparability these numbers have been converted to proportions in Table 9.14, and show that higher EPAs are 21% more likely to occur in the plough layer, while lower EPAs are 87% more likely in the basal sands.

The fact that differences in EPA occur in the formation layers while no differences in overhang removal could be detected in these same layers may be due to a number of reasons. The first is that overhang removal at the site may be being used more to shape the free surface and control flake production than as a means of reducing the EPA. The generally very small sizes of the flakes recovered from the site would support this interpretation as very little force would be required to produce these flakes, to the extent that reducing the amount of force required may not be an issue. It may also be that raw materials are being treated differently at the site; this is discussed later.

Formation	<=70º	>70º	Total
Plough	129	116	245
Oxidised	151	114	265
Basal Sands	63	35	88
Total	343	255	597

Table 9.13: EPA frequencies by formation layer

Formation	<=70º	>70º
Plough	38%	45%
Oxidised	44%	45%
Basal Sands	18%	10%

Table 9.14: Proportion EPA frequencies by formation layer (significant differences are highlighted)

Dorsal Scarring Categories Used: <=3 and >3

The number of dorsal scars and dorsal rotations on a flake records the number of flakes removed from that portion of the core prior to the manufacture of the flake and the number of times the core was rotated to create a fresh platform. As such, they provide a measure of how much reduction the core had experienced prior to the flakes' manufacture. Dorsal scarring ranged from 0 to 11 scars at the JRL site, however for the purposes of statistical comparison scarring was divided into 2 categories: <=3 and > 3. Complete flakes only could be used for these counts. Table 9.15 details the frequencies of dorsal scarring into categories by formation layer. It is clear from this table that 3 scars or less is most common across the site.

Table 9.16 compares proportions of each category relative to formation in the form of a ratio. A significant difference in dorsal scar frequencies was identified between oxidised and basal sands with 3 dorsal scars or less found to be 29% more common in the oxidised layer than in the basal sands. Significant difference was also detected between the basal sands and the plough layer with 3 or less scars found to be 35% more common in the ploughed layer than in the basal sands. A greater proportion of flakes with more than 3 dorsal scars therefore occurs in the basal layers with 3 scars or fewer more common in the upper formation layers of the site.