

Appendix F - Options for archaeological investigation of Thompson Square

Windsor Bridge Replacement Project: Archaeological Options Paper

Prepared for Roads and Maritime Services

20 March 2013

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Biosis Project No.:	14020
Report Title:	Windsor Bridge Replacement Project: Archaeological Options Paper
LGA:	Hawkesbury City

Revision	Prepared	Internal Review	External Review	Amended
1	CRM	Biosis	RMS	CRM
2	CRM	Biosis	RMS	Biosis
3	Biosis	--	RMS	--

Revision	Issued	Name	Signed
1	10/03/2013	Pamela Kottaras	
2	13/03/2013	Pamela Kottaras	
3	20/03/2013	Pamela Kottaras	
3	19/03/2013	Pamela Kottaras	

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Acknowledgements

Biosis Research gratefully acknowledges the contributions of the following people and organisations (listed alphabetically) in preparing this report:

Dalene Amm	Roads and Maritime Services
Jonas Ball	SKM
Matt Faust	SKM
Braith Gilchrist	SMEC
Denis Gojak	Roads and Maritime Services
John Steele	SKM
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Government Departments

Client

- Roads and Maritime Services

Approval Authority

- Department of Planning

Consultation

- Heritage Branch, Office of Environment and Heritage

Abbreviations

c.	Circa
CHL	Commonwealth Heritage List
CMA	Catchment Management Authority
DECCW	Department of Environment, Climate Change and Water
DGRs	Director General's Requirements
DP&I	Department of Planning and Infrastructure
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	Environment Planning and Assessment

REF	Review of Environmental Factors
LEP	Local Environmental Plan
m	Metre
mm	Millimetre
REP	Regional Environmental Plan
RMS	Roads and Maritime Services
SoHI	Statement of Heritage Impact
OEH	Office of Environment and Heritage, Department of Premier and Cabinet
SHI	State Heritage Inventory
SHR	State Heritage Register

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Executive Summary

This document has been prepared to address specific requirements of the Department of Planning and Infrastructure (DP&I) and the Heritage Branch NSW (Office of Environment and Heritage: OEH) with respect to the Windsor Bridge Replacement Project.

Archaeological resources have been identified as one of the major components of environmental heritage that would be affected by the proposed bridge construction project. The EIS prepared for the project concludes that the optimal outcome for the archaeological profile within the project area is for conservation, intact and in its entirety, as it now exists. Conservation will maintain the heritage precinct's cultural value, and preserve the complex physical relationships that constitute the research value of this resource.

Approval of the RMS preferred option would cause substantial damage to the archaeological resource and its cultural significance. Recommendations were made in the EIS (in the event that the project is approved) for an integrated program of archaeological investigation, documentation, and outreach, as a means of salvaging information before it is lost or damaged. However it should be noted that the resulting archive of information would not have the same cultural value as the physical evidence that is now preserved within the project area.

The purpose of this paper is to present options for how an archaeological program could be integrated into the development with respect to the extent of the investigation, collaboration between three disciplines of archaeology, outcomes that would be achieved by the work and its relationship to the construction program.

This paper reviews the scope of analysis and investigation undertaken for the EIS with respect to Aboriginal archaeology and maritime and terrestrial archaeology of the historic period. It has found that there is likely to be a large, complex and very significant archaeological profile within the project area for all three strands of archaeology. It also found that this profile is likely to be so complex that any excavation, either for construction or archaeology, would fragment it and the means of interpreting any sample retrieved would be compromised. Conversely, whatever would be preserved in the ground would also be impacted in its integrity, due to loss of evidence explaining its relationship to the landscape, the processes that have shaped that landscape, and its position in the chronological development of this place.

The options discussed in this paper will not redress or mitigate the impacts of any construction project. They are designed to salvage information that will be lost through the construction works. Three options for the extent of excavation have been considered:

- Option 1 - Excavation strictly within the construction footprint, construction impacted land, and proposed landscaping and ancillary works
- Option 2 - Excavation within the consolidated construction footprint - construction impacted land, and proposed landscaping and ancillary works, plus additional salvage of all areas within the construction footprint
- Option 3 - Excavation of the entirety of the Thompson Square parklands and roads

The selection of these three options or strategies is based on the objective of retrieving the most coherent suite of data from any future investigative program.

These options are not discussed solely in relation to the benefits or otherwise of archaeological salvage. The advantages and disadvantages of each option are considered, from an archaeological perspective and from the perspective of other factors such as constructability, cost, effect on program and other environmental and amenity impacts.

This paper is not a “research design”, as that term is used in archaeological works and conditions in New South Wales. This is a paper concerned with defining which option will deliver the greatest benefit for short and long term objectives. After a preferred archaeological strategy has been identified, the methodologies and staging of the program will then need to be addressed in a specific research design. Several issues that will need to be discussed in that research design are highlighted in this paper.

1 Introduction

1.1 Project Background

The Roads and Maritime Service (RMS) is seeking approval under Part 5.1 of the *Environmental Protection and Assessment Act 1979* to replace the bridge that crosses the Hawkesbury River at Windsor. The project would entail the construction of a new bridge thirty-five metres downstream (east) of the present bridge, realignment of the roads to meet the position of the new bridge, and infilling the current approaches to the existing bridge. The present bridge would be demolished when the new bridge reaches completion. Landscaping works would be undertaken in the parklands.

Heritage resource values, both material and intangible, were identified as key issues to be considered prior to the commencement of the project, and have remained significant factors in the evaluation of this project and its potential impacts. Aboriginal heritage has been addressed in a separate report by Kelleher Nightingale Consultants.¹ Historic period resources have been addressed in two separate strands; those that may be found within or functionally connected to the river, and those that may be found on the land. Cosmos Archaeology Pty Ltd has addressed maritime archaeological evidence within the river in a separate paper.²

Terrestrial heritage resources of the historic period have been addressed in several papers prepared by Biosis Pty Ltd in collaboration with Cultural Resources Management (CRM).³ These investigations have encompassed the following:

- The development of a primary archival analysis intended to provide a framework for understanding the development of the project area and for identifying specific sites, places, associations and events that have contributed to the heritage resources of this place and their significance;
- Specific primary research to document the development and context of the present bridge;
- Identification and evaluation of historic period resources above ground including buildings and other structures, landscapes and views and vistas;
- An archaeological assessment;
- Two targeted programs of excavation for historic period archaeology as a means of testing the conclusions of the archaeological assessment and providing evidence for the potential impact of the proposed work on the archaeological resource;
- Assessments and evaluations of significance for the project areas and individual components;

These studies and others related to different issues including noise, traffic and landscape informed an Environmental Impact Statement (EIS) prepared by RMS. The EIS and the technical studies were publicly exhibited in December 2012. A submissions report is currently being prepared to address the issues raised in the exhibition period. Determination on the project application is anticipated in mid- 2013.

1 Kelleher Nightingale Consulting Pty Ltd (2012); Windsor Bridge Replacement Project Cultural Heritage Assessment Report

2 Cosmos Archaeology Pty Ltd, Maritime Archaeological Statement of Heritage Impact: Final Working Paper Report, October 2012.

3 Biosis Pty Ltd and CRM, Windsor Bridge Replacement Project: Historic Heritage Assessment & Statement of Heritage Impact, November 2012

1.3 Purpose of this Document

Heritage resources have been the subject of consultation between RMS and the Department of Planning and Infrastructure (DP&I) and the NSW Heritage Branch (of OEH) and the Culture and Heritage Division of the Office of Environment and Heritage (OEH) for Aboriginal cultural heritage issues throughout the project duration. The DP&I has advised RMS that an additional paper is required for the submissions report that expands on the heritage management commitments made in the EIS. This is a management document that examines the way in which archaeological procedures could be integrated into the project if approval for it is forthcoming. Consultation with the Heritage Branch and the DP&I was undertaken and it is understood that this document is to address options for management rather than a single strategy.

The purpose of this document is to address the requests from the Heritage Branch and DP&I. This is an options paper that considers several strategies for how an archaeological program could be integrated into the development project and what outcomes could be expected from those options. Further this paper looks at the implications for each strategy.

This document does not establish the “how” of any future archaeology. That is the purpose of a research design and a document of that type will be necessary when an appropriate strategy for any future work is determined; it is the purpose of this report to determine options for the “what”. What is the best program that can be undertaken to address the impacts of the project if it is approved and implemented? To this end the report addresses the following issues:

- Options for archaeological programs that are based on establishing the most comprehensive recovery of information and research objectives within the context of excavation programs of different scales;
- The advantages and disadvantages of each option;
- Issues that need to be addressed in the selection of any option.



Figure 1: Location of the Study Area in a Regional Context

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2 Review of Archaeological Resources

2.1 Historical Framework

The historical analysis undertaken for the project produced a detailed developmental history that described the evolution of the project area from the first European settlement to the present-day. It also discussed influential factors such as environmental change, and the impact of different forms of transport on the material world of Thompson Square and the farming land on the northern side of the river. Specific associations were highlighted including those of Governor Macquarie and Andrew Thompson, which were not only important to the development of the town but continue to resonate with respect to the identity of this place.

A framework was established to place physical evidence within a timeline of development. This timeline and the enables the physical evidence (above or below the ground or within the water) to be valued for its capacity to illustrate that development, and for the substance they provide for this history and town identity. This is especially important when that history or association is not always articulated in the buildings, landscape and other works that can be seen today. This is the basis for evaluating cultural significance.

Archaeological resources, in particular, can be shown to be the primary source of contact between the history contained in archival sources and that which we can now touch and see, particularly for the first twenty years of settlement at Windsor but also for much of the first half of the nineteenth century. The archaeological testing programs undertaken for this project have also demonstrated that evidence in the ground can reveal work that has had substantial influences on the landscape as it now exists but has left no record in primary documentation. Archaeology can help to anchor the past landscape to the present by identifying sites for places only known through images or surveys. Archaeology adds texture and dimension to the history of place and identity acquired from documents. The narrative of archival sources, however, provides a structure. Archives can provide a picture and archaeology can add detail and colour to that picture. It can also change the picture or even draw a new one.

The following broad thematic and chronological sequence was established for the project area:

- The Importance of Topography and Environment
- An Aboriginal Place before and after the historic period settlement
- Mulgrave Place in 1794
- Green Hills settlement from 1795-1800
- The consolidation of a government and regional precinct from 1800-1810
- The incorporation of the precinct within the newly founded Macquarie town of Windsor 1810 - 1820
- The importance of the place as a regional centre from the 1820s to the 1850s
- The changing status of the place in the second half of the nineteenth century
- The emerging status of the place as an “historic” town in the twentieth century

2.2 Archaeological Assessments

Assessments were produced for all three strands of archaeology (historic period terrestrial and maritime and indigenous). These documents describe the physical evidence likely to be left in the ground (or in the water), demonstrating the evolution of the place and the lives of the people there. With respect to Aboriginal life, this encompasses several thousands of years, and over two centuries for historic period settlement. The assessments

are based on many strands of information: archives, physical evidence, identifying environmental models, and similarities to comparable sites amongst other sources. The overall conclusions of the separate fields of archaeological investigation are described in the following sections.

2.2.1 Aboriginal Archaeological Resources

The Aboriginal Cultural Heritage Assessment posed the question regarding the existence of intact sand deposits on Tertiary substrate or non-gravel alluvial sand.

Research was undertaken using geomorphological and archaeological information to inform the predictive model, which was tested with the subsurface test excavation. The indicators to significant archaeological resources (of Aboriginal origin) are reproduced below:

- Intact biomantles, especially sand bodies, on Tertiary substrate have the potential to contain archaeological objects;
- Biomantles containing sand (Aeolian or alluvial) and low level bioturbation may also allow chronologic, stratified cultural deposition;
- Archaeological excavation of Aeolian sands within 100 m of the study area has identified stratigraphic cultural deposit representing possible Pleistocene occupation;
- Significant artefact densities exist above 1:100 flood level along the Windsor – Pitt Town river terraces.⁴

2.2.2 Maritime Archaeological Resources

An assessment undertaken for the maritime resources within the project area identified the following potential sites or features:

- The first settlement wharf built in 1795;
- A second wharf built in c. 1814 and repaired in 1820 and still present up to as late as the 1940s;
- A private punt service commenced in c. 1815, taken over by the Government in 1832, using the wharf as a southern landing place;
- The replacement of the original punt service with one located upstream in c.1835 using a cable system laid across the water;
- The first bridge constructed in 1874;
- A temporary bridge constructed in 1896 as part of the programme of raising the height of the bridge; possibly located upstream from the present bridge site;

2.2.3 Historic Period Terrestrial Archaeological Resources

The assessment prepared for the terrestrial resources of the project area recognised the potential for a large, varied and complex profile that encompassed the full scope of historic period settlement from 1794 to the present day and including sites of seminal importance for the town and the state.

To summarise this potential profile with respect to the project area on the southern bank there may be evidence of the following:

- The pre-settlement environment;

⁴ Kelleher Nightingale Consulting Pty Ltd September 2012: 13

- Evidence of environmental manipulation and change from first settlement onwards;
- Evidence of clearing and the first buildings (store, guardhouse and wharf) from 1794-1795;
- Evidence of the shaping of the landscape by removal of deposits along the George Street ridgeline;
- Evidence of tracks and paths, a boat slip, barracks, granaries, government buildings including domestic residences, a lock-up and Thompson's first house and garden that date between 1795-1800;
- Evidence of more government buildings including a prison and a possible government wharf and tracks and paths dated between 1800-1810; more sites of substantial buildings and works are recognised to lie close to but outside the project area;
- Evidence of a wharf, roads, cuttings, a large brick barrel drain and possible secondary drains and large quantities of levelling fill in the square from the period 1810-c.1820; the potential for significant archaeological evidence in building allotments on the eastern, western and southern sides of the square outside the project area is also recognised;
- Evidence of new road surfaces, punt landings, a watchhouse/punt house on the terrace from the period of c. 1820-1840; evidence of new government buildings on the eastern side of the square is also recognised but this is outside the project area;
- Evidence of extensions to Bridge Street on the eastern side of the square in 1855 and 1874, of other road surfaces on the western side of the square and resurfacing of roads in the centre of the square, evidence of drains and other services, evidence of filling in the approach to the raised bridge level of 1896, cutting down of some levels in the square and its roads from the later years of the nineteenth century; evidence of a summerhouse and pavilion in the reserves and fences along the roads and reserves;
- Evidence of cutting along the western side of the square for the construction of a new approach to the bridge in 1934;
- There is the potential for artefact assemblages from all periods and services from the later part of the nineteenth century onwards.

Many of the buildings and sites recognised by the assessment cannot be specifically identified with a particular location within Thompson Square, meaning that the entire precinct must be treated as one of archaeological sensitivity.

With respect to the northern riverbank within the project area there may be evidence of the following sites and or features:

- Evidence of the pre-settlement environment;
- Evidence of the impact of first settlement on that environment and evidence of the nature of that settlement with respect to clearance and agricultural development;
- The potential for farm buildings, house and fencing from the first grant of 1794; no specific sites can be determined for this period of occupation;
- Evidence of a hotel that was in operation from at least 1839 and may have been continuously occupied to the 1880s. The site could encompass structural evidence, fences, drains and other landscape improvements as well as artefact assemblages. No specific site has been identified but anecdotal evidence suggests that it might be close to the intersection of Freeman's Reach Road and Wilberforce Road;
- Evidence of market gardening and turf farming from the twentieth century.

Although the different types of evidence are analysed and discussed separately it is important to remember that they represent different viewpoints of the same landscape. Aboriginal people had a history of association with this

place for thousands of years before Europeans arrived and they still were a presence in the historic period town. Remnants of an early nineteenth century wharf in the river helps to make sense of the location of roads and buildings on the land that took advantage of this wharf or helped to service it. The landscape above and below the ground and in the water is a complex and connected artefact.

3 Testing the Assessments

3.1 Background

Physical investigation was undertaken to test the validity of the assessments for each strand of archaeology. The fields of historic period terrestrial and maritime archaeology and Aboriginal archaeological investigations were all investigated and analysed via physical evidence acquired from survey and small programs of archaeological excavation. This evidence confirmed the ability of the project area to preserve information about this complex cultural landscape and the activities of the people who have lived in it. A brief summary is presented in the following sections of the results of each investigation.

3.2 Aboriginal Archaeology

Test pits for Aboriginal archaeology were placed on both the northern and southern sides of the river. Five 1x1 metres test squares were hand excavated on the south bank and nine 1x1 metre squares were hand excavated on the north bank. In addition to the nine test squares, the Aboriginal archaeological assessment incorporated the results of geoarchaeological boreholes and geotechnical boreholes. The results of the testing program were reported as follows:

Geotechnical and Aboriginal archaeological investigation was undertaken as part of the EIS for the Windsor Bridge Replacement Project. No significant Aboriginal archaeology was identified on the north bank due to the impact of successive flood events. Significant archaeological information was identified in elevated portions of the south bank. Two test squares on the south bank found moderate to high levels of Aboriginal objects. The most elevated test square in the south-east corner of Thompson Square revealed high numbers of stone artefacts within a thin layer of fine-grained Aeolian-like sands, which offers the possibility of obtaining important cultural dates. A second test square in a lower elevation revealed a disturbed Aboriginal shell midden possibly (re)deposited during historic times.⁵

3.3 Maritime Archaeology

Two maritime archaeological surveys have been undertaken in the river within the footprint of the new bridge from the southern bank to the northern bank. The impact of the new bridge in the river would be through the construction of piles to support the deck of the bridge. The results of these programs of work may be summarised as follows:

- There is intact structural evidence above and below the water level of the c. 1815 wharf; there is rock ballast, and within it, and for at least a five-metre area around this ballast, there is substantial potential for structural components of the wharf;
- There is likely to be structural evidence and artefact deposits associated with this wharf within the southern river bank;
- There is moderate potential for archaeological evidence associated with the c. 1835 punt landing on the northern side of the river upstream from the current bridge site but low archaeological potential for evidence of this crossing within the river;

⁵ Kelleher Nightingale Consulting Pty Ltd (2012); Windsor Bridge Replacement Project Cultural Heritage Assessment Report: 05

- There are timber structural elements on the northern side of the river close to the bank on the eastern side of the current bridge, possibly derived from mooring posts of the c.1950s or a retaining wall: these elements are not considered to have significant research potential;
- Remote sensing identified objects in the river thought to be artefacts; further investigation found this to be not the case.⁶

3.4 Terrestrial Historic Period Archaeology

Two small programs of testing were undertaken; the first on the northern side of George Street within Thompson Square and on the northern river bank and the second on the southern side of George Street. The results of the first program with respect to the northern side of the river may be summarised as follows:

- The majority of the evidence found in these excavations demonstrated the processes of siltation from floods and soil added for specific activities such as the turf farm and road surfaces. Almost all of these events can be identified as twentieth century activities. The soil associated with these processes can be up to two metres in depth;
- There was little specific evidence of historic period occupation or works other than the purposely added soil levels. There were no clear surfaces with one possible exception, no evidence of agricultural works, the impacts of pastoralism and little structural evidence. Specific sites such as the Squatters Arms Hotel could not be identified from this work;
- Only one site provided substantial evidence of historic period activity; this was related to works associated with the development of new approaches to accommodate the increased height of the bridge in 1896. Similar evidence was found on the southern side of the river;
- The almost complete absence of artefacts suggests that the land here was sparsely occupied apart from farming.

The results of the first program of testing on the southern side of the river, north of George Street may be summarised as follows:

- Evidence of the pre-settlement environment was preserved with respect to land-form although it had been modified in the historic period;
- Archaeological evidence dating to the 1830s and possibly earlier is preserved at the north-eastern side of Thompson Square. It encompasses evidence of gardens and what is likely to have been domestic occupation;
- There is the potential for structural evidence that dates back to at least 1800 associated with significant and identifiable occupants including Andrew Thompson or part of the government reserve;
- There was evidence of major land-forming and infrastructure works associated with the extension of Bridge Street in 1855 and improvements made to this road in several later phases of work in both the nineteenth and twentieth centuries. Evidence from an Aboriginal archaeological test pit indicated more extensive cutting further south along George Street probably undertaken late in the twentieth century;
- There was evidence of another major program of land-forming and road construction associated with the changes made to the bridge in 1896; this evidence was similar to that found on the northern side of the

⁶ Cosmos Archaeology Pty Ltd (2012); Proposed Windsor Bridge Replacement, Windsor NSW. Maritime Archaeological Statement of Heritage Impact Final Working Paper Report: i-iii

river including structural components designed to stabilise the steep ground close to the river and support the construction of a new road at a higher level;

- There was evidence to indicate that the archaeological profile at the northern end of Thompson Square close to the terrace and river would be of considerable depth with the potential to preserve important sites and works associated with the earliest settlement;
- Evidence from test pits for Aboriginal archaeology also provided information concerning the development of Thompson Square in the historic period. The upper parkland appears to have been truncated close to George Street in the mid-twentieth century with fill used to level the new surface. The lower parkland contained evidence of nineteenth century fill containing Aboriginal midden material possibly brought from another site and used to shape and resurface the site; this work also appears to have occurred in the mid-twentieth century.

The evidence from the second program of testing on the southern side of George Street in conjunction with evidence taken from several geo-technical cores may be summarised as follows:

- That the topography recorded in the earliest nineteenth century images of the Green Hills settlement is accurate in its depiction of a high exposed ridge line stepping down steeply to the river; it may have been more extreme than those images suggest with gullies cutting through the ridge line and uneven outcrops of rock;
- That the ancient sand bodies recorded in test pits on the northern side of the road do not appear to have covered the peak of the ridge or extended further south than the northern side of George Street;
- That this peak or ridge, the later alignment of George Street, may have been exposed bedrock or only thinly covered with sand or soil. It may have been cut through by a gully at the line of present day Bridge Street;
- That this thin soil cover, if it existed, may have been removed in the earliest days of settlement to provide a hard and impervious surface for both pedestrian traffic and construction projects;
- That the exposed bedrock in this location may have been cut and shaped in places to be used in the construction of building foundations, drains or other structural works. If this is the case then evidence of this work could be found in the roads; the work would have been undertaken before the formalisation of those road corridors;
- That there is no clear evidence of the Commissariat building of 1803 and the impact of road works, paving and the introduction of services in the footpath on the eastern side of Bridge Street make it unlikely that much or any remains here. However, of the technique of cutting and shaping bedrock was used in the construction of this building then some evidence of this work could survive at the face of the bedrock. It is unlikely that evidence of the building will be found in the road because of the impact of road widening and the formation of the most recent road surface;
- That by the mid-nineteenth century the alignment of George Street had been altered at least twice and soils had been imported to build up this area possibly higher at the southern end of Thompson Square than the street level immediately adjacent to the Macquarie Arms Hotel; this conclusion is based on archival evidence;
- That these accumulated soils were comprehensively removed in c. 1893 to allow for a major program of infrastructure that entailed laying service pipes in the street and possibly creating a new road surface comprised of a bedding deposit of locally sourced clay topped with a cobbled stone road. If this is not a road then it might be a linear drainage feature. If so a tar-paved surface found close by and to the south might be evidence of an associated road surface. The evidence suggests that the latter is more likely to be

later twentieth century in origin but there is insufficient physical evidence to make connections between the features in these separate locations;

- The same locally sourced clay found under the stone cobbling may have been used to create a pedestrian area along Bridge Street adjoining the School of Arts but there is no evidence for how it was finished or paved and the sample was too small to make a positive identification;
- By the 1920s the surface of George Street appears to have comprised silty soil that was laid or accumulated over the stone cobbling;
- Asphaltic concrete footpaths were laid in George Street from 1938 onwards and the physical evidence suggests that the work entailed cutting down the existing road, possibly removing much of the stone cobbling if it was a road surface and any later surfaces and introducing fill along the northern side of the road to help level it for the new concrete surface although this fill could have been introduced for an earlier program of works on the road in the nineteenth century; there is insufficient evidence from the sample to date it;
- Three separate resurfacings of this road are shown in geo-technical cores taken along George Street and test trenching also records layers of asphaltic concrete;
- The paved footpath along Bridge Street dates from the middle or later part of the twentieth century;
- By 1978 there was a grass covered strip that projected from the footpath into George Street at the south-western intersection with Bridge Street. This grass strip survived into the 1980s but may have been replaced with a bitumen surface. The present paved footpaths and raised garden behind the hedge on the footpath at this intersection are a product of the c. 1990s. The raised garden is made on 400 mm of introduced sterile topsoil;
- The introduction of services in the footpaths has made a substantial impact on the preservation of archaeological evidence.

Taken together the evidence from these test excavations demonstrates that the project area retains archaeological evidence of the following:

- The original and modified land-form and environmental conditions;
- Evidence of environmental change and the impacts of change on human settlement;
- Aboriginal occupation in the form of objects preserved in the sand body north of George Street;
- Programs of work that have very substantially modified the place from the early years of the nineteenth century, the mid-nineteenth century but particularly from the later years of the nineteenth century onwards. These land-forming works are related to specific projects and while they encompass large portions of Thompson Square evidence of them will not be found across the entire project area;
- Physical evidence that could date back to at least 1800 and may be associated with significant owners or sites both within the river and on the land ;
- The creation of infrastructure in both the nineteenth and twentieth centuries; the testing programs have also revealed the impacts of these works on earlier phases of development.

The southern bank has the largest, most diverse and culturally significant archaeological profile, including deposits in the river. The northern bank and river's edge is less culturally rich.

3.5 Implications

3.5.1 Variation within small areas

Much of the evidence revealed in the testing programs is unknown from archival sources or substantially expands the archival framework for specific events or conditions. It should be understood, though, that this does not represent the full suite of evidence that is likely to be preserved within the project area. Every test trench has produced a completely different result to the others with very few or no common deposits shared between them. It demonstrates the complexity of this profile and the great change that may be found within very short distances.

The testing programs have also demonstrated that there is a very large variation in the depth of intact archaeological deposits. The archaeological profile is approximately 500-600 mm in depth at George Street at the southern end of Thompson Square. Whereas the northern end of Thompson Square is likely to be several metres in depth. The same is true on the northern side of the river where introduced soils extend to a depth of up to two metres.

This issue is made more complex by the evidence that illustrates the extremities of the original topography and the unpredictability of that land-form. The evidence suggests that there was a narrow and probably broken ridge line, with a deep cleft and a steep and irregular slope to the river possibly with outcropping rock and deep sand deposits and terraces between. The response of the early settlers to this irregular landscape is likely to produce considerable variation in small areas that cannot be predicted.

3.5.2 Linking the different profiles

The first very substantial programs of land-forming do not appear to have been undertaken until the later years of the nineteenth century, with the exception of the formation of Bridge Street (northern end) in 1855, and the large drainage and levelling works of the Macquarie era. This has significant implications for interpreting archaeological evidence. It reduces our ability to make a reliable prediction, other than in very general terms for settlement of the pre-1850 period. It will also make it difficult to interpret isolated areas of archaeological evidence in relation to each other without the benefits of either common soil deposits within or between them or the ability to comprehensively excavate and thus record the processes, such as cutting and filling that would make sense of the varied profiles in those areas.

The testing program has demonstrated the potential for a chronologically long and diverse archaeological resource within the project area. This program also produced evidence that demonstrates the issues that would arise in further sampling programs whatever the scale. It highlights the pitfalls of excavating a large part of the profile when that portion of excavation has no relationship to the historical landscapes of Thompson Square as far as they are known. These factors may be summarised as follows:

- The original landform appears to have been more extreme and varied than is evident from the limited archival sources and this topography appears to have been very influential in the formation and development of the first settlement. The presence of a small beach at the northern end may have been the factor in selecting this site for a government precinct and the landform influenced the placement of buildings and roads;
- The response of early settlers to the variability of topography and other environmental conditions is likely to have been individual and localised; this means that the archaeological profile is likely to exhibit great variation in its earliest levels and is inherently unpredictable with very few exceptions;
- There is evidence for major programs of land-forming, mostly from the later years of the nineteenth century although with at least two exceptions from 1855 and c.1815 and these could create large horizons that provide common reference points for separate, small or isolated excavation areas as well as chronological markers for the entire profile. However, even these large programs do not appear to have

been consistent across Thompson Square; for example, they appear to have been related to the construction of specific roads or forming the parklands and this will also impact on the ability to reliably interpret any excavated sample;

- The best means of providing a reliable interpretation of the archaeology of this complex and significant period of settlement would be to comprehensively excavate it; this would enable the documentation not only of specific sites but the processes that create the landscape around them and, thus the links, between those sites. Excavating isolated pockets or even large areas of land, essentially a large sample, is unlikely to reveal those links and will make future interpretation of the evidence recorded difficult at best. Conversely, it will create a break in the links and even individual sites that would be preserved and this has long term implications for the viability or integrity of the preserved resource.

4 Cultural Significance

4.1 Terrestrial Historic Period Archaeology

A detailed evaluation of cultural significance for the project area and its individual elements was an important component of the heritage evaluations made for the project. The statement of significance with respect to the archaeology of the project area is as follows:

The historical analysis, archaeological assessment and evidence from preliminary testing and past works demonstrate that there is likely to be a complex and chronologically deep archaeological profile within Thompson's Square and to a lesser degree on the northern river bank. It is impossible to isolate the resource that could exist within the project area and assess its significance. It must be assumed that the evidence contained within the project area will have the same values and significance as the rest of the square even if specific elements within both may vary from each other. The significance of the archaeological resource within the project area is the same as that for the resource across the entire square and this cultural significance must be assessed on several levels.

Windsor is the third settlement in Australia after Sydney and Parramatta. These are the places that made long-term European settlement possible and their histories inform us of the circumstances, the pressures and visions that would shape our history and the way we live. Apart from its importance as one of our first permanent settlements Windsor also has added status as a Macquarie town, one of very few places that were specifically selected and influenced by arguably our most important Governor. A number of the improvements and designs for the square are a direct result of his involvement. Thompson Square also has direct associations with outstanding people in the development of the town and region particularly Andrew Thompson, who lived and worked here. The archaeological resource could provide tangible links or associations with significant historical figures by revealing works or improvements that have been created for, on behalf of or by these figures.

Thompson Square is the single place that links the earliest settlement on the Hawkesbury, Mulgrave Place, with the Macquarie-era town. This site was used as a civic precinct to service Mulgrave Place from 1794. It evolved into a small village in its own right that also provided the services and administration for the region. It is the seminal place of the town's evolution. It was this village that was incorporated into the Macquarie planned town of Windsor; it was the only town to incorporate this earlier layer of settlement. It is unique.

If Windsor and Thompson Square are important then archaeological evidence that can better document or reveal the history of use and development that is unique to this place and provide evidence of its associations is also significant. The below ground resources are likely to provide evidence of the earliest years of settlement, pre-dating the fabric that survives above ground. Archaeological evidence is also likely to provide evidence of events and processes that were specific to the square but are representative of the development of this town.

The principal value of the potential archaeological profile in Thompson's Square is its cumulative value. It has the potential to document events, processes, improvements and places that span the full history of European development in this place from 1794 to the present day. It is likely to be the only place in Windsor or its environs that can do so. The archaeological profile of the project area on the south bank is completely unique to it. Because of the potential chronological depth of the profile it may include sites that are rare beyond the specific history of this place.

Apart from the potential to document and demonstrate the changing town and the place of the square in it over a long period of time the archaeological profile in the square can be evaluated for different levels of significance that are largely relevant to their rarity either through age or singular uses. In particular, evidence that relates to the founding settlement of 1794 up to and inclusive of Macquarie-era works is assessed to be of exceptional

significance for its importance within the town, its rarity and its contribution to documenting the growth of the colony in its formative years. For the earliest years of settlement this resource would be the only fabric that survives in the town; there is no evidence above ground that predates 1811. It is comparable to only a very small number of other places that have the same depth of development such as Sydney or Parramatta.

As well as works from the first decades of the town's growth the project area is also likely to encompass important improvements from the middle and later years of the nineteenth century that reflect the changing status and role of the town and this particular square. These include the development of the bridge across the river to link the two communities. Many of these processes are not evident in above ground resources. These are resources that can make a substantial addition to the evidence that survives above ground; they have value for the town.

Evidence that derives from the early – middle years of the twentieth century is less significant. These processes are still evident in other forms and they have impacted on earlier and more rare resources. Evidence from the later years of the twentieth century onwards which is still largely intact above ground and has acted to remove or disturb older or more rare elements is considered to have little individual significance but is recognized as an integral component in the complex profile.

The northern area of the project area across the river also has a history of settlement that dates back to 1794 with a farm established here by an ex-convict, Edward Whitton, in that year. Apart from his pioneer status Whitton's contribution is representative of the thousands of people who worked to develop the region.

Archaeology in this part of the project area is unlikely to have the same complexity of resources because of the nature of settlement here; largely pastoralism and agriculture. It has value as a comparison to the complex history of Thompson Square but its individual components are likely to be less significant; the exception would be the site of a long-standing landmark inn although its precise location cannot be determined. The resource in the northern part of the project area, with few exceptions, is likely to be more representative of the agricultural/pastoral development that characterized this side of the river.

The archaeological resource is likely to provide a depth of historical layering and sense of place to the acknowledged visual qualities of the square. These are qualities and resources that can be valued by the community. It has the ability to provide unique, rare and representative components for this place and for New South Wales. The cumulative profile records evidence of works and change over two centuries is unique. Within that overall profile evidence of the Mulgrave Place period of development and Macquarie-era works would be of state significance. The remainder of the archaeological profile has local significance.⁷

4.2 Maritime Archaeology

The assessment and testing program for maritime archaeological resources concluded that archaeological evidence associated with the c.1815 wharf would be of state significance. Archaeological evidence of the c.1835 punt would be of local significance.⁸

⁷ Biosis Research & CRM 2012: 229-230.

⁸ Cosmos Archaeology Pty Ltd (2012): i-iii

4.3 Aboriginal Archaeology

It was concluded with respect to Aboriginal archaeological resources that *"the potentially impacted Aboriginal objects offer scientifically valuable information but are not contextually suitable for outright conservation because of the overall high level of disturbance within the project area."*⁹

4.4 Implications of Fragmenting the Resource on Cultural Values

The statements of significance with respect to cultural values identify why these resources have value or potential value as they are now preserved within the ground. This is like a library of books that has not been opened. As long as the library and books are kept intact the information may not be readily accessible but it will always be available.

The impact on cultural values with respect to the excavation required for the bridge replacement project has largely been thought of in terms of the removal of a portion of the profile. To extend the analogy this would be the equivalent of demolishing part of the library, removing the books and in some cases taking off the covers so that the contents of the books are no longer comprehensible. Developing programs to record the information that is removed is intended to document the part of the room lost and catalogue the books. However well this work is carried out it will not redress the damage inflicted by removing parts of collected volumes of works, rare and unique books or cutting some of the books in half.

What has been given less consideration is the impact of fragmenting the resource on what remains or is preserved in the ground. Obviously the positive outcome is that part of the library and its collection is preserved but it is still damaged by the fractures that will be caused by cutting a hole through the room and its collections. The documentation of the portion removed is intended to redress this trauma but there is a large difference between a complete set of volumes on a shelf and half the volumes on the shelf and the rest in an electronic file stored away from site. The differences affect the relationship of the information and its internal structure, the use of that information by the reader and the environment in which the information is used.

⁹ Kelleher Nightingale Consulting Pty Ltd 2012: 05

5 Bridge Options and Impacts

5.1 Introduction

Construction of the replacement bridge has been assessed to have major impacts to heritage resources within the Project Area. Impacts would be most noticeable in Thompson Square in Windsor and would include the removal of significant archaeological evidence, disruption to significant views and vistas, and the current setting of Thompson Square, as well as a cultural landscape that has evolved gradually since Green Hills was established.

The design process has considered the issues surrounding construction of the southern bridge abutment in Thompson Square.

The design team prepared two construction methods:

1. A land bridge comprising seventeen piles at 8 metre centres inserted into the ground around the perimeter to support the side walls and abutment; then from that, building a bridge structure over the void;
2. A concrete abutment comprising of two "L-shaped" walls and abutment wall facing inwards founded on rock, then infilling with material upon which the road is built.

The finished appearance of the two options would be similar.

5.2 Land Bridge

5.2.1 Design

The land bridge design would have five 900 mm piles across the abutment and six 900 mm piles on each side for a total of 17 piles on the southern approach (refer to Plate 2). The land bridge was initially proposed as it has what appears to be a lesser impact on the site. Construction of a land bridge on the southern approach would avoid disturbing or excavation for construction purposes, the area between the walls and would only require drilling 900 mm diameter holes at 8 metre centres along the sides and five closely spaced piles in the front of the abutment structure. The design would however, impact relics within the footprint of the 17 piles without giving the opportunity to extract the archaeological data in the southern abutment further fragmenting and isolating the resource. Moreover, for health and safety reasons it is not feasible to undertake local archaeological excavation at each of the pile locations. Excavation at this depth would require substantial stepped benching around each pier location, resulting in a larger excavation footprint that would negate any advantage that this approach had to localising impact.

5.2.2 Impacts

This proposal reduces the extent of excavation although seventeen approximately one metre-wide holes along the eastern side of Thomson Square in an area demonstrated to have an intact and significant archaeological profile would completely fragment the integrity of this resource. Only a portion of intact profile would be retained between the piles.

The impact of this option is compounded by the inability to acquire any meaningful data from the drilling areas either through inspection of the cores or creating wider but still small excavations in each location. This issue of interpreting isolated fragments of information, particularly small samples, has been discussed in the preceding section. For these reasons this approach results in a major impact, with little or no opportunity to mitigate or redress those impacts.

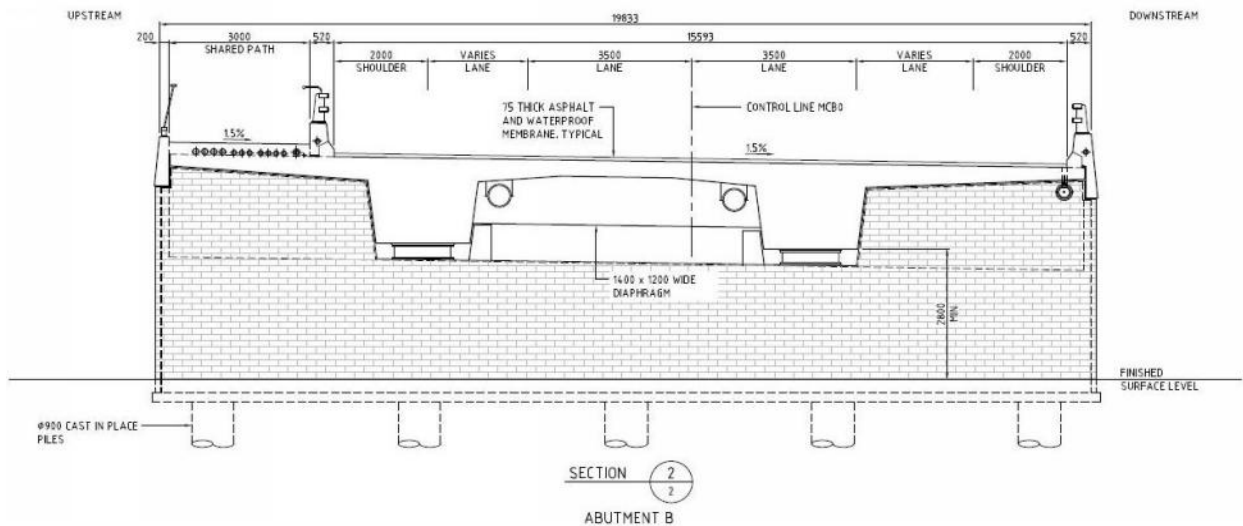


Plate 2: Cross section of the replacement bridge in Thompson Square with the Land Bridge Option showing the piles across the structure. An additional 6 piles on each long side also formed part of this particular design. Source: SKM Plan DS2012/000155 Sheet 3.

5.3 "L-Shaped" Retaining Walls

5.3.1 Design

The L-Shaped Retaining wall design option includes two L-shaped walls facing each other, with a spread footing at the abutment all founded on bedrock with the space between filled-in. The retaining wall option for the southern abutment would need to be built to support the approach road onto the bridge deck.

The L shaped wall would be constructed in the following sequence:

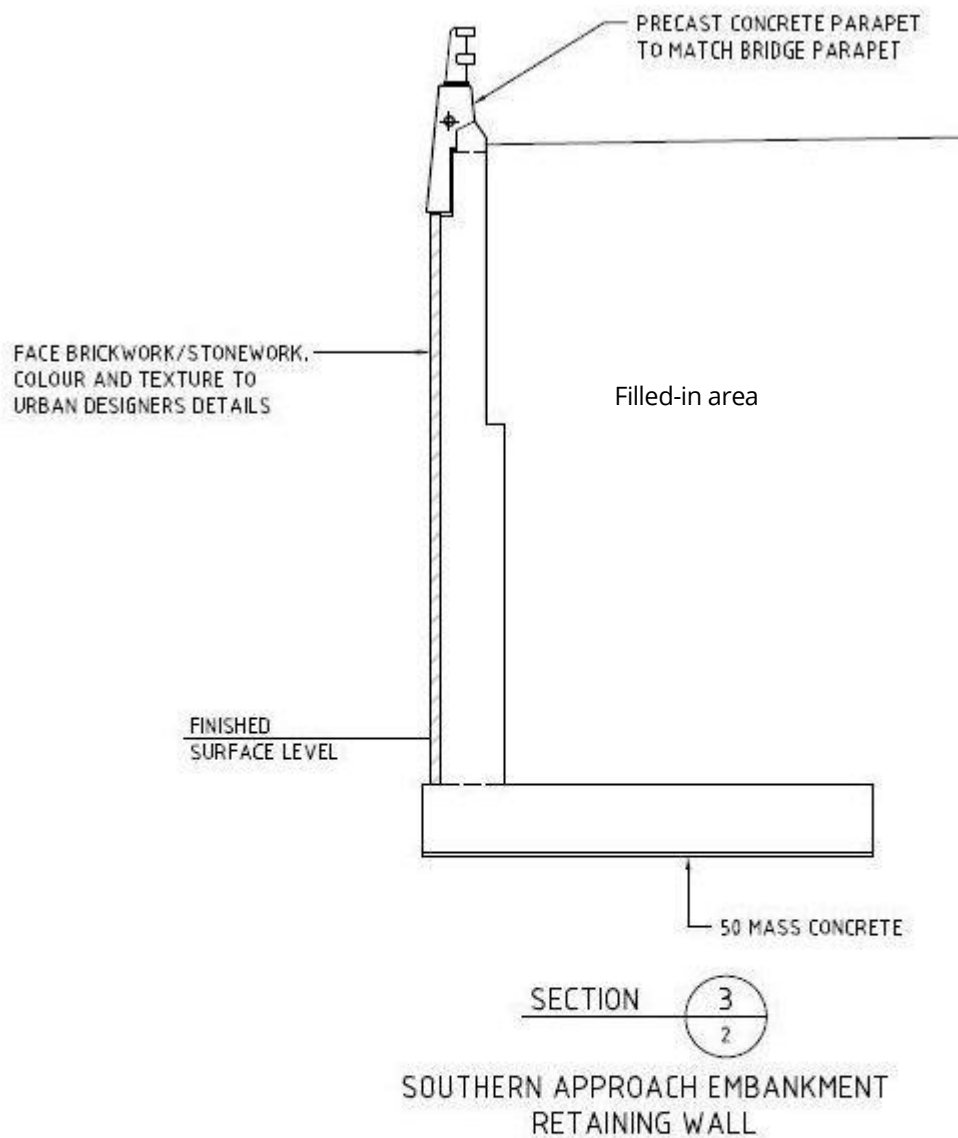
1. Open area archaeological excavation down to base of cultural material
2. Protection and stabilisation of any archaeological material to remain in situ (either for permanent conservation or for later recovery),
3. Further mechanical excavation to bedrock,
4. Stabilising the deep excavated batters to prevent slippage due to surcharge loads,
5. Levelling with approximately 50 mm of concrete base.

The L-shaped wall footings would be cast, followed by the walls themselves. The area between the walls would then be backfilled in layers and compacted and the pavement built. Both options would result in the removal of archaeological resources in the immediate area; these options and their implications are discussed in more detail in the Archaeological Options Report (Biosis and Cultural Resources Management).

5.3.2 Impacts

Construction of this option will remove the entire archaeological profile to bedrock (within the footprints of the abutments) and damage archaeological resources close to the surface. Excavation in this area is required from between two to six metres depth in an area equivalent in size to two Olympic-sized pools (approximately 3600 cubic metres).

Additional impacts are possible due to compression produced by machinery and stockpiling during the construction works. The scale of the work enables a large sample of archaeological evidence to be recorded during the construction program.



GENERAL NOTES

SCALE  OR AS SHOWN
FOR GENERAL NOTES REFER TO SHEET No 2

Plate 3: Diagram of one side of the L-shaped retaining walls proposed for the bridge abutment in Thompson Square. Source: SKM Plan DS2012/000155 Sheet 3.

5.4 Summary of Bridge Abutment Options

The land bridge was initially preferred to the L-shape wall option due to the potential to minimise the excavation and archaeological impact in Thompson Square. The extent of this advantage is dependent on the extent of archaeological excavation required to clear the site for the piling. The land bridge also has some construction program advantages and avoids the need for the engineered backfill material to be brought to site and be compacted between the walls thus reducing the vibratory impacts to the existing heritage structures.

The implication of possible impact to archaeological resources since they cannot be investigated prior to commencing drilling influenced the decision to choose the "L-shaped" wall design.

5.5 Landscaping in the Parklands and Service Roads

The impacts of construction are not limited to excavation works required for the bridge. There are additional works that require excavation of varying depths for access to the car park at the north-eastern end of Thompson Square, along The Terrace, for the realignment of Bridge Street, which will have particular impacts on the lower parklands, at the south-eastern corner of the upper parklands and for the installation of traffic lights and cabling at the intersection of George and Bridge Streets (refer to SKM plans after Figure 4). Other than changes to the south-eastern corner, works associated with the project are not proposed for the upper parkland.

Many of these works encompass excavation to a depth of one metre or less although there are areas of up to two metres depth and very small areas that require excavation to three metres. As the testing programs have demonstrated there is archaeology of differing levels of significance (as close as 500 mm from the surface) in most areas of Thompson Square. Although these works have less impact than the major excavations required for the abutments all would have an impact on the archaeological profile within Thompson Square.

Works also require the movement of heavy machinery and creation of stockpiles. These have potential to create compressive loads, the impact of which on archaeological resources requires consideration.

6 Archaeological Options

6.1 Introduction

The archaeological resource that is preserved within Thompson Square is of state significance. It has the potential to illustrate and inform the present and future people of the state about the origins of settlement in the country; it tells us about frontiers in our past and their change through time.

It is the conclusion of the investigation that the optimal outcome for the archaeological profile within the project area, with respect to conserving its cultural values and the complex physical relationships and evidence preserved in the ground is to conserve it intact and in its entirety as it now exists. This would preclude the construction of the proposed replacement bridge,

RMS undertook an option selection process to determine the site of the proposed new bridge. Option 1 of that study was preferred and approval is being sought for this design, 35 metres downstream of the existing bridge. If approval is given then the optimal outcome for the archaeological resource of preservation in its entirety (as discussed above) is not possible. For this reason options for addressing the loss of evidence through salvage archaeology have been presented in this paper. It is clearly understood, though, that these options do not redress the impact of any approved work, they can only partially mitigate against the total loss of information by preserving it in a different form. The following archaeological options are designed to provide salvage programs to retrieve information before it is lost. The result of that work will not have the same cultural value as the physical evidence that is preserved in the ground.

The options discussed in this section seek to identify a strategy that will retrieve the most coherent suite of data from any future investigative program, taking into account the factors of the complex profile, and interpreting the data from a sample of any scale. The three options selected to achieve this objective are:

- Option 1: Construction Footprint, construction impacted land, and proposed landscaping and ancillary works only
- Option 2 - Excavation within the consolidated construction footprint - construction impacted land, and proposed landscaping and ancillary works, plus additional salvage of all areas within the construction footprint
- Option 3: Salvage excavation of the entirety of the Thompson Square parkland and roads

The advantages and disadvantages of each option are considered, from both an archaeological perspective and from the perspective of other factors such as constructability, cost, affect on program and other environmental and amenity impacts. These considerations are presented in the tables below in terms of archaeological advantages and disadvantages prepared by Wendy Thorp and reviewed by Pamela Kottaras (Table 1, Table 3, Table 5, Table 7 and Table 8). The engineering and environmental advantages are the point of view of RMS and were prepared by RMS and Boulderstone (Table 2, Table 4 and Table 6).

Refer to the sections and 12D model (Plate 7) and cut and fill diagrams (Plate 4, Plate 5 and Plate 6).

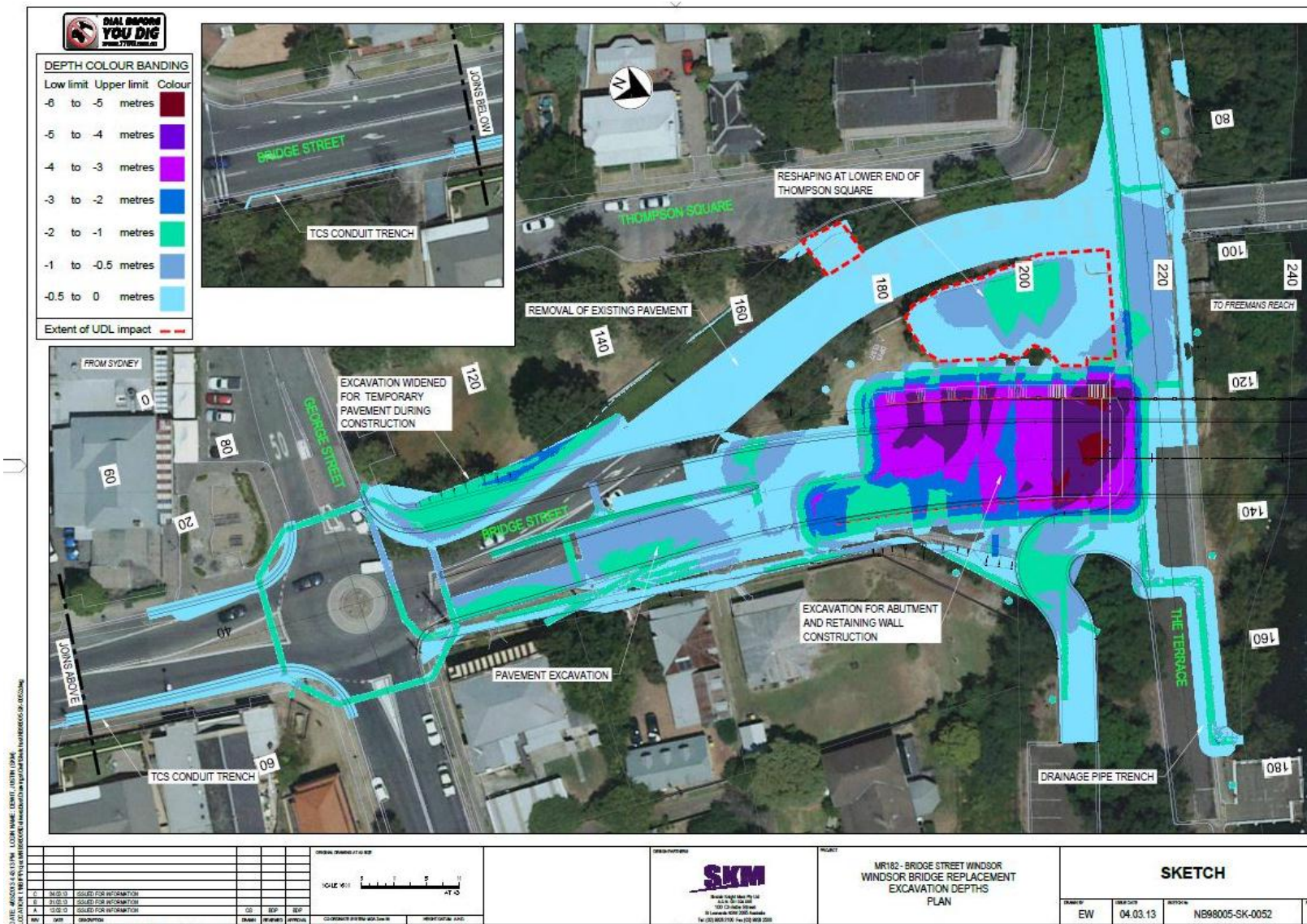


Plate 4: Diagram showing the depth of excavation in Thompson Square associated with the construction program. (Source SKM)

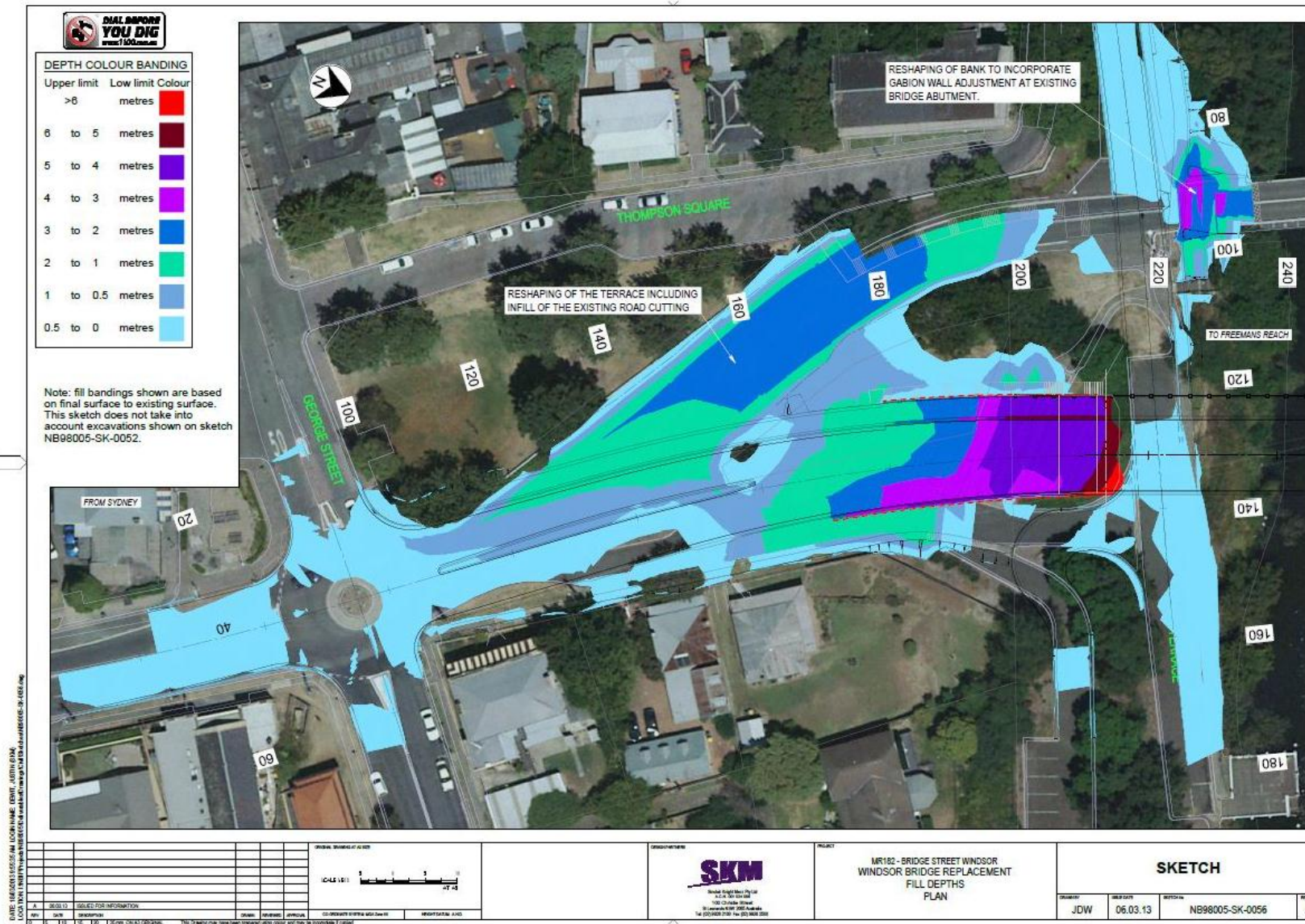


Plate 5: Diagram showing the depth of fill in Thompson Square associated with the construction program. (Source SKM)

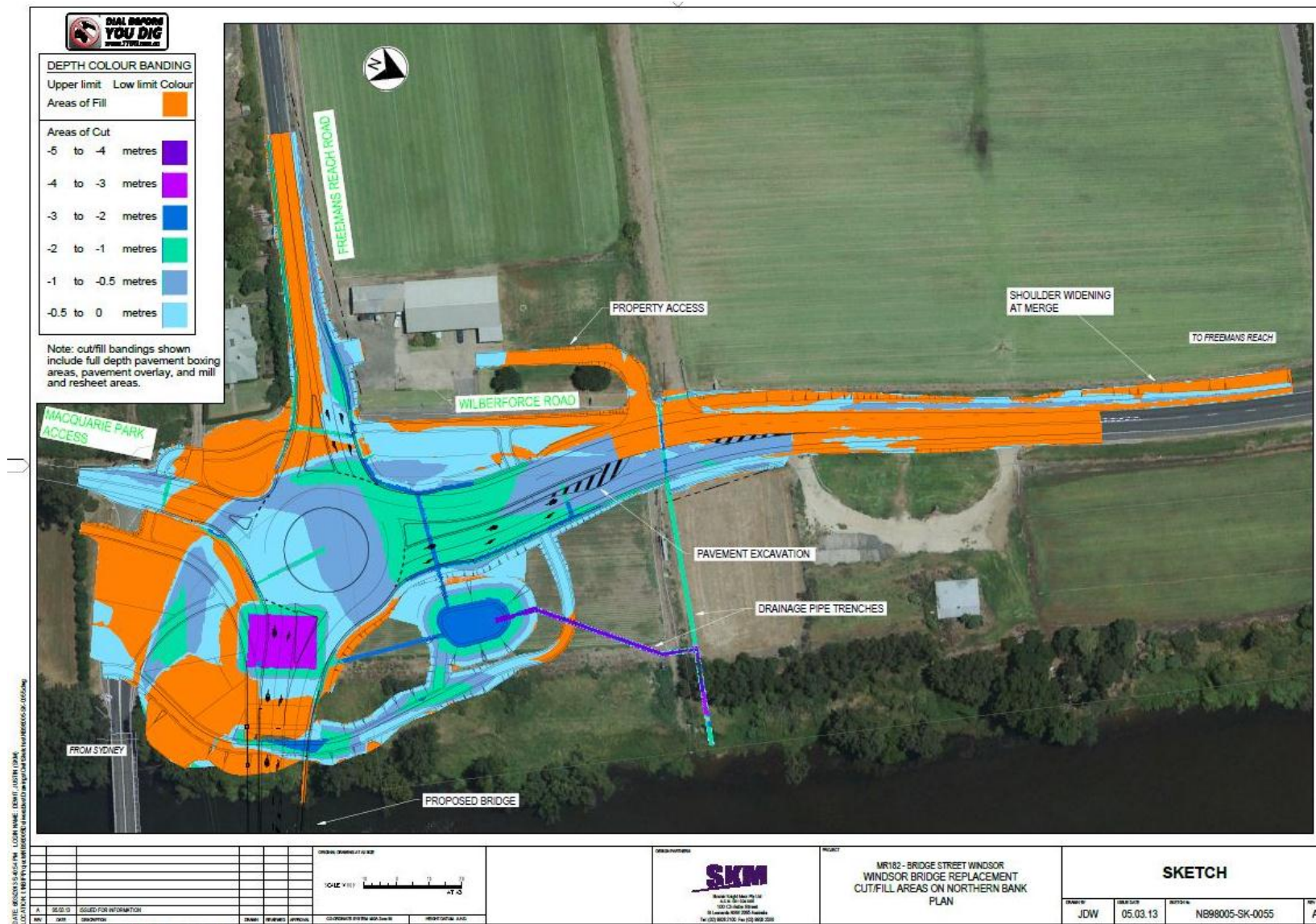
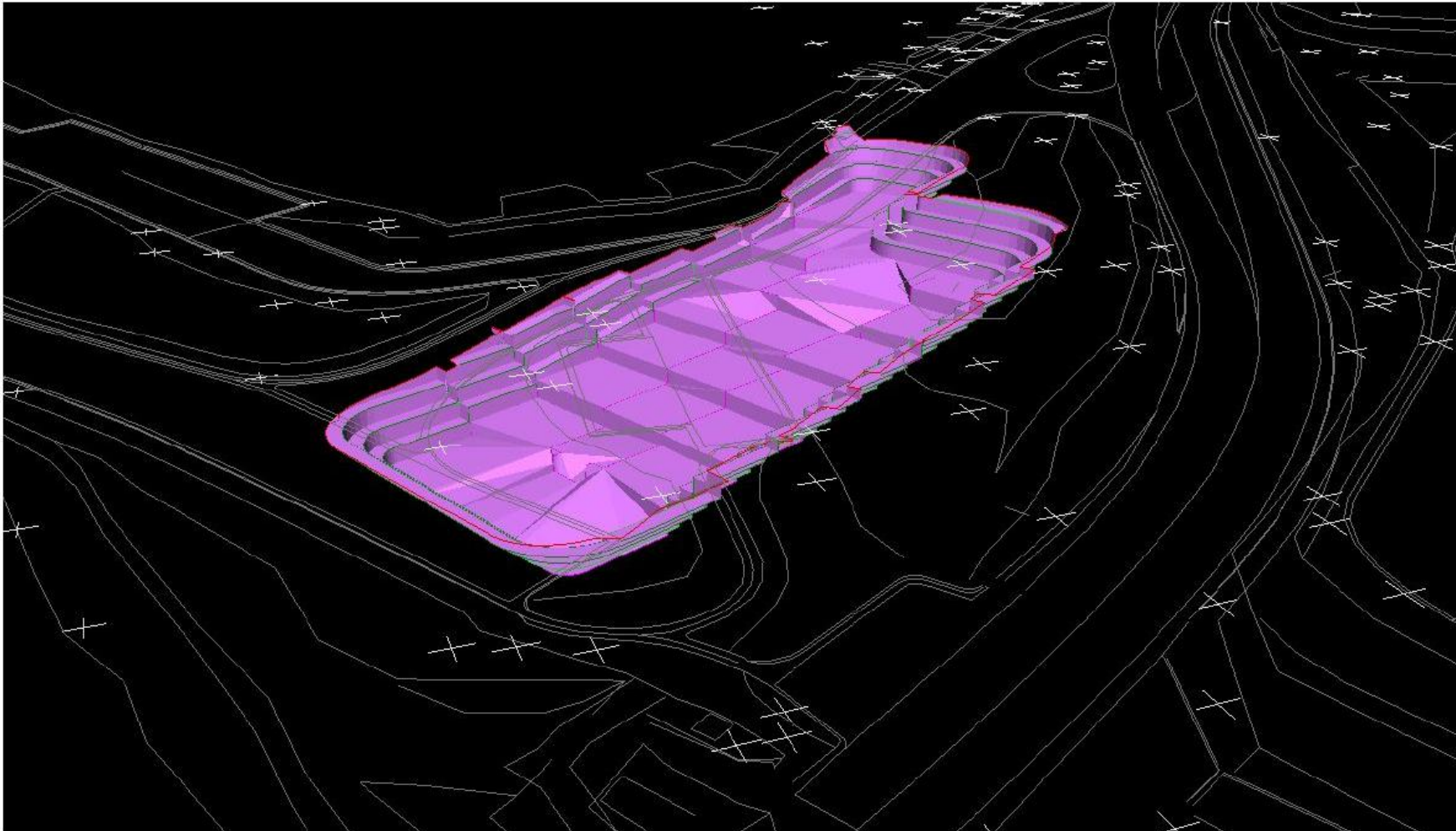


Plate 6: Diagram showing the depths of cut and fill on the north bank in Freemans Reach



Volume of main excavation = 3645m³

Plate 7: 12D model showing construction impacts

The view is to the south east; each contour within the area of impact is equal to 1 metre. (Source SKM).

6.2 Option 1: Construction Footprint

This option is for archaeological excavation of the construction footprint, construction impacted land and proposed landscaping and ancillary works only. Option 1 would entail archaeological salvage of those areas directly impacted by construction works, including excavation, and (if it can be shown to have a detrimental impact) areas where compression will impact on the underlying profile. The outline of these works is shown in the accompanying diagram.

Apart from the excavation required for the road and the bridge abutments, there are many small strips and irregularly shaped excavation areas. The excavation also leaves several isolated and narrow strips of ground as small islands within the excavated areas.

The depths of excavation required by construction within this footprint vary from 0.5 metres to 6.0 metres. Test excavations have demonstrated that excavations to these depths and less will impact historic period archaeology (and Aboriginal archaeological deposits north of George Street).

Table 1: Option 1 - Construction Footprint - Archaeological advantages and disadvantages

Advantages	Disadvantages
Minimises the impact to archaeology to areas to be disturbed only;	The excavation will irreversibly remove a large portion of the archaeological profile within Thompson Square both horizontally and vertically within the landscape;
Retains the majority of the upper parkland as a "bank" of the archaeological profile;	The irregular shape of the construction footprint leaves small, intact fragments of the existing profile completely isolated particularly along the eastern edge of the footprint and at the northern end of the lower parkland, while creating irregular excavation areas that would be arbitrarily retained.
Retains the majority of the upper parkland, which has heritage values in its own right as a landscape and visual component of Thompson Square.	Remaining intact fragments would be further splintered by the introduction of service trenches in The Terrace and George and Bridge Streets. The significance of the remnant archaeological profile in the upper parkland will be compromised because of the removal of the majority of the landscape and the relationships preserved in the ground that give meaning and context to the archaeology contained within it.

Table 2: Option 1 - Construction Footprint- Engineering and environmental advantages and disadvantages

Advantages	Disadvantages
Minimises the impact to archaeology to only those areas that are strictly required for construction excavation;	'Islands' of retained deposit need to be protected and managed during completion of archaeological works and construction stage.
Retains the great majority of the upper parkland as a "bank" of the archaeological profile;	Size and shape of areas to be excavated archaeologically is not optimal, eg awkward for mechanical removal of fill.
Retains the majority of the upper parkland, which has heritage values in its own right as a landscape and visual component of Thompson Square.	Minor design changes may require impact on retained areas close to bridge.
Minimises amount of spoil to be taken offsite which is a positive environmental outcome.	Leaving 'islands' within the excavation area and having to provide batter slopes will complicate the vertical profile of the excavation unnecessarily, making movement of workers and spoil more complex and hazardous.
Reduces the number of trucks for haulages thus reducing noise and traffic impacts.	
Overall minimal environmental impact in terms of noise and vibration, air quality, erosion and sedimentation issues, visual amenity, and flood risks	
Archaeological excavation would be in detail and progress at a very slow rate thus any reduction amount of work will reduce the inconvenience caused to all affected.	
Excavation of the footprint only will reduce the number of trees that would have had to be cut or displaced.	
Overall minimising the amount of excavation will reduce the construction time thus reducing impacts and inconvenience for the community.	



Legend

- Area of archaeological excavation
- Subject to further discussion to include in archaeological excavation

Figure 2: Option 1 -
Boundary of the
construction footprint

0 10 20 30 40 50
Metres

Scale: 1:1,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56



Ballarat, Brisbane, Canberra, Melbourne,
Sydney, Wangaratta & Wollongong

Matter: 14020
Date: 18 March 2013,
Checked by: PBK, Drawn by: IMS, Last edited by: jshepherd
Location: P:\14000s\14020\Mapping\14020_ArcOps_F2_Option1

6.3 Option 2: Consolidated Construction Footprint

This option includes an archaeological salvage program in the same construction footprint as Option 1 but this footprint has been enlarged to incorporate the small, isolated strips of retained profile so that these become part of the salvage excavation program. This option would also include the excavation of the remaining portion of retained lower parkland between the bridge abutment and realigned road. There are also substantial landscape works that will effectively damage a large portion of the profile.

The outline of Option 2 enlarged in at least two areas.

1. On the western side of the realigned road is a roughly L-shaped excavation. Making this a complete square of excavation would engage the trench at the western end into a single unit or zone of excavation.
2. The junction between the lower parkland and the section of Bridge Street that would be retained. The construction footprint requires two narrow and irregularly shaped strips of excavation and Option 2 has these two strips being replaced by a solid zone of excavation. This excavation zone would link the bridge and road. Effectively all the land between the southern portion of Bridge Street (between the bridge and road excavations) would be included to create one large unit of investigation at the northern end of Thompson Square.

The rationale of Option 2 is that by including the small fragments that would be isolated, and slightly enlarging irregularly shaped areas of excavation to make more manageable zones (particularly where they can link the two principal areas of disturbance – such as the bridge and road excavations), provides a better opportunity to salvage and record evidence that has potential for meaningful interpretation.

This option raises the question of how the impacts at the George and Bridge Street intersection should be managed within any archaeological program. In Option 1 the trenches that cross the roads would be the only subjects of excavation. As the program of test trenching has demonstrated there is a very large variation between profiles in this part of the project area, excavating only the trenches required for the project is likely to expand the information retrieved from test pits, and is unlikely to address the questions raised by that work.

Ideally the Bridge and George Street intersection would be investigated, particularly as the profile here is so shallow, approximately 500 mm. It would be a desirable outcome, in terms of recording a cohesive archaeological sample, but it would have very substantial implications for traffic management unless the excavation could be undertaken in stages or portions.

This issue is linked to the retention of the southern portion of the existing Bridge Street, the bridge, and the temporary pavement at the south-eastern corner of the upper parkland. It is planned that this portion of the road will be disturbed only by the excavation of three small strip trenches. However, if it were included in a salvage program it would result in the comprehensive excavation of all of the eastern side of Thompson Square. It is a huge impact on the archeological profile within Thompson Square but, ironically, it is far more likely to result in a meaningful and cohesive picture of the full scope of development. The management of the retained section of Bridge Street, and the George and Bridge Street intersections, can be viewed from two completely different view points (unlike the small fragments proposed for inclusion on the eastern boundary and at the northern end of Bridge Street).

From the perspective of a research objective focused on the investigation of settlement in Windsor, and the influence of the landscape in that settlement, then the inclusion of both the southern portion of Bridge Street and the George and Bridge Street intersection is a logical and necessary inclusion. It provides not only a large sample but one that has some relation to the older landscapes that underlie it. It would add a vast resource of information that describes how settlement commenced and evolved in this town and how that settlement was influenced by the extreme terrain. Balancing this outcome is the loss of some profile that could be preserved although fragmented by the service and other trenches in each place.

From the perspective of the construction program it would involve a large additional cost, substantial disruption to traffic and the community and possibly would require some changes to the construction details.

Table 3: Option 2 - Consolidated Construction Footprint - Archaeological advantages and disadvantages

Advantages	Disadvantages
Creates a sample or area of excavation that has greater potential for meaningful interpretation than the fragmented landscape of Option 1. This enlarged option creates an area of excavation that has meaning to the development of Thompson Square. The records of settlement that emerge from the excavation would provide a fuller picture of human and environmental change that can be related to the archival framework that currently informs our knowledge of this place. The degree of how successful that interpretation would be depends on the inclusion or exclusion of the section of Bridge Street currently proposed for retention and the George and Bridge Street intersection;	The excavation will irreversibly remove an even larger portion of the archaeological profile within Thompson Square both horizontally and vertically within the landscape than Option 1;
Retains the upper parkland area as a "bank" of the archaeological profile;	Small fragments of land that are proposed for retention in Option 1 would be removed; the value of these splinters of land is compromised, though with respect to their research values because of the scale of excavation that surrounds them;
Retains almost all the upper parkland which has heritage values in its own right as a landscape and visual component of Thompson Square.	The significance of the remnant archaeological profile in the upper parkland will be compromised because of the removal of the majority of the landscape and the relationships preserved in the ground that give meaning and context to the archaeology contained within it.

Table 4: Option 2 - Consolidated Construction Footprint - Engineering and environmental advantages and disadvantages

Advantages	Disadvantages
Work planning would be simplified without the need to conserve islands of deposit with stratigraphic integrity within the open area excavation.	Will result in removal or displacement of more trees, spoil creating dust and noise which overall is a negative environmental outcome;
	Increased excavation footprint will increase the number of trees that would have had to be cut or displaced;
	Increases the number of trucks for haulages thus increasing noise and traffic impacts;
	Increases the amount of spoil to be taken offsite relative to Option 1, which is a negative environmental outcome;
	Increased excavation footprint may increase the construction time thus compounding impacts and inconvenience for the community;
	Increased overall environmental impacts in terms of noise and vibration, air quality, erosion and sedimentation issues, visual amenity, and flood risks;
	Additional excavation will add a considerable cost to the project;
	Archaeological work around the Bridge and George Street intersection will affect traffic.



Legend

- Area of archaeological excavation
- Subject to further discussion to include in archaeological excavation

Figure 3: Option 2 - Boundary of the regularised construction footprint

0 10 20 30 40 50

Metres
Scale: 1:1,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56

biosis
Biosis Pty Ltd

Ballarat, Brisbane, Canberra, Melbourne,
Sydney, Wangaratta & Wollongong

Matter: 14020
Date: 19 March 2013,
Checked by: PBK, Drawn by: IMS, Last edited by: jshepherd
Location: P:\14000s\14020\Mapping\14020_ArcOps_F3_Option2

6.4 Option 3: Salvage excavation of the entirety of Thompson Square parkland and roads

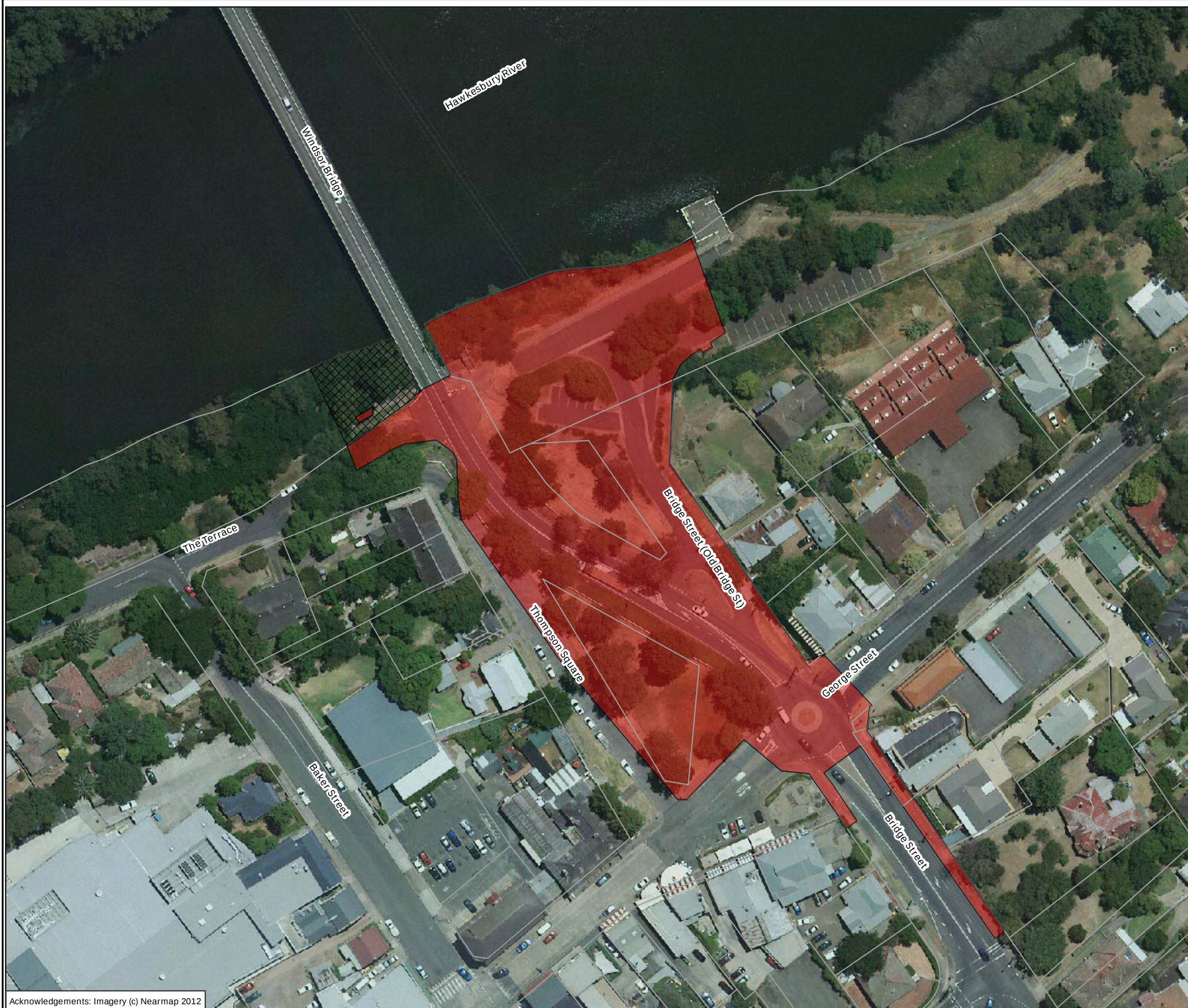
Option 3 is concerned with ensuring the comprehensive documentation of the complex profile that exists within Thompson Square. This option would ensure that the complex processes of land-forming, the relationships between all phases of settlement and all evidence of those phases would be revealed, documented and meaningfully interpreted at any place within this landscape. This option would require complete salvage of all the construction zones and the upper parkland, an area currently intended for preservation.

Table 5: Option 3 - Salvage excavation of the entirety of Thompson Square parkland and roads – archaeological advantages and disadvantages

Advantages	Disadvantages
Retrieving the research potential of the historical entity of Thompson Square, providing the ability to interpret and document the entire history of settlement and association;	The excavation irreversibly removes the entire archaeological profile – very little would be retained or banked including the majority of evidence of potential state and local significance;
Creates a sample or area of excavation that has greater potential for meaningful interpretation compared to both fragmented landscapes of Option 1 and Option 2;	Complete impacts on areas that would not otherwise be impacted by the bridge replacement project
	The excavation would remove the upper parkland
	The loss of the upper parkland would have other heritage implications; it will be the only remnant element of the landscape of Thompson Square that would remain relatively unchanged by the bridge construction and it has heritage values in its own right as a landscape component and in its relationship to the buildings in its immediate environs.
	The excavation of the upper parkland would be a great loss to the community – it is a valued open space;

Table 6: Option 3 - Salvage excavation of the entirety of Thompson Square parkland and roads – Engineering and environmental advantages and disadvantages

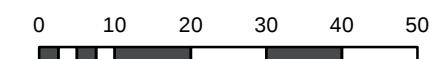
Advantages	Disadvantages
Following removal of all surface deposit within Thompson Square any new landscaping will have less archaeological impact.	Excavation of the Upper Thomson Square will have considerable other environmental impacts that have not been assessed. If we had to do option 3 then it would take considerable time to assess all impacts thus resulting in delay;
	Will result in the removal of all existing trees in the park Will result in the removal and relocation of all plaques and memorials in the parkland;
	Requires the greatest amount of spoil to be taken offsite, which is a negative environmental outcome;
	Requires the greatest number of trucks for haulages, thus having the worst noise and traffic impacts;
	Has the largest excavation footprint , extending construction time significantly, and thus having the worst impacts and inconvenience for the community;
	Has the worst overall environmental impacts in terms of noise and vibration, air quality, erosion and sedimentation issues, visual amenity, and flood risks;
	Archaeological work around the Bridge and George Street intersection will affect through traffic.



Legend

- Area of archaeological excavation
- Subject to further discussion to include in archaeological excavation

Figure 4: Option 3 - Boundary of the comprehensive salvage excavation



Metres
Scale: 1:1,000 @ A3
Coordinate System: GDA 1994 MGA Zone 56



Ballarat, Brisbane, Canberra, Melbourne,
Sydney, Wangaratta & Wollongong

Matter: 14020
Date: 18 March 2013
Checked by: PBK, Drawn by: IMS, Last edited by: jshepherd
Location: P:\14000s\14020\Mapping\14020_ArcOps_F4_Option3

6.5 Freemans Reach - The Northern River Bank

Options 1-3 address the archaeological requirements of the project area within Thompson Square. There will be substantial physical impacts on the northern river bank caused by the construction of the roundabout, road and other works. This area is less archaeologically sensitive than the project area of the southern bank of the river, however, at least one archaeological site associated with the redevelopment of the approaches to the bridge in 1896 has been identified by test excavation. As well, the potential sites identified for this area (Section 2.2.3) could be revealed by those works; it is impossible to more precisely target their locations.

For this reason a combination of salvage excavation and monitoring is proposed for managing the impacts of the construction program on the archaeological profile. A salvage excavation program will be required where the construction program impacts on the site of the nineteenth century bridge approaches. For the rest of the construction zones it is intended to monitor the works. Monitoring will enable two outcomes;

- Profiles of site formation can be recorded from sections revealed in trenches;
- If an intact archaeological site is uncovered by the work, the site can be isolated and excavated in full.

6.6 Depths of Excavation

6.6.1 Introduction

The three options discussed in the preceding sections were focused on the horizontal scope of an excavation; how much of Thompson Square will be included in any salvage program. The depths of excavation required in a salvage program also need to be considered.

The archaeological testing programs for this project have shown that, with respect to historic period archaeological resources, any excavation that has a depth of approximately one metre from the middle of Bridge Street south to and including George Street will effectively remove the archaeological profile. In those areas comprehensive salvage excavation is the only viable option as the excavations planned here will almost universally remove the complete archaeological resource.

Within the area of the bridge abutment depths of excavation will reach between three and six metres. It is almost certain, though not guaranteed, that this excavation will also comprehensively remove whatever archaeology is preserved here. Thus, an archaeological program that encompassed complete salvage excavation is also appropriate.

The situation is less clear in those areas (the road alignment, landscaping in the parkland, service trenches etc) where excavation for the construction program will not or might not completely remove the archaeological profile.

There is a case to be put forward for both the retention of the archaeological profile below the necessary construction impacts as well as for the comprehensive salvage of all areas of impact irrespective of the depths of those impacts.

6.6.2 Salvage only of Impacted Depths

It can be argued that retaining whatever remains of the profile beneath the depths of excavation required for construction adds to the "bank" that would be preserved in the upper parkland if Option 3 is not selected. However, the implementation of this strategy would add even more fragmentation to the profile and multiply the impacts of dislocation and isolation already discussed for the upper parkland spreading this impact over a much wider area. The off-set benefits of preservation in this case are probably reduced by the loss of meaningful interpretation of the evidence recovered and inconsistent preservation.

Secondly, the outcome of adopting this strategy with respect to the objectives of salvage excavation are likely to be a substantial compromise in the ability of the evidence retrieved to address any research objectives.

Table 7: Savage of impacted depth only – advantage and disadvantages

Advantages	Disadvantages
Preserves more of the archaeological profile than just that in the upper parkland.	Imposes even more fragmentation and isolation on what will remain of the archaeological profile;
	Impacts on the successful interrelation of archaeology in those areas and their connection to the rest of the Thompson Square profile;
	Impacts on the successful outcomes of large research objectives for any program of salvage excavation;
	Compaction impacts are likely for any retained archeological deposits below the maximum depth of excavation.

6.6.3 Comprehensive Salvage In all Impacted Areas

The most successful strategy with respect to achieving a useful outcome from what would be a massive program of archaeological intervention would be retrieve all the information from any zone irrespective of whether it would be removed or not as part of the construction program. It is a strategy that greatly increases the ability to interpret individual areas and works and processes as well as achieve a successful outcome for larger research objectives.

However, adoption of this strategy will have implications for the cost of the project and possibly for the design but it will have the biggest implications for the landscape of the lower parkland. If, for example, this strategy were adopted for the lower parkland as part of Option 2 it would effectively mean that all of the lower parkland would be removed; this would substantially alter any proposed landscape options for it.

Table 8: Comprehensive salvage in all impacted areas – advantages and disadvantages

Advantages	Disadvantages
Likely to provide for more successful interpretation of individual archaeological units within those areas and the relationship of those units to the larger profile within the square	Reduces the potential for preservation or banking of archaeological resources
Likely to create a more comprehensive suite of information that can address large research objectives	Possible design changes
	Large impact on the landscape of the lower parkland
	Greater costs for the project

7 The Research Design

7.1 Introduction

This paper outlines three possible options for managing archaeology in the event of project approval. When one of the options is identified as the preferred strategy a specific research design must be prepared that addresses the specific scope of the work. The review and discussion presented in this paper has highlighted a number of issues that will need to be addressed in this research design. These are not the only issues but are important factors that must be addressed by it.

7.2 Integrated Archaeology

The archeological investigations undertaken for the EIS highlighted the complexity of the project area as an environmental and cultural landscape. With respect to archaeology this complexity is effectively managed by three types of archaeological investigation and analysis; indigenous archaeology and terrestrial and maritime archaeology of the historic period.

There must be three programs of archaeological work that manage the different types of physical evidence that inform these strands. It will be important to map out a strategy that not only examines how and when each of those programs of work will be carried out, particularly the relationship of terrestrial historic archaeology and aboriginal archaeology, but how the results of those three programs will be knitted together to produce a single narrative of the evolution of this precinct.

7.2.1 Identifying the Research Objectives

In the first instance all the work that is undertaken within the project area will be salvage and it must be a priority to ensure that the maximum scope of information is retrieved. Ideally under any circumstances it would be possible to derive the answer to the research questions from the data accumulated during the salvage and documentation program.

However, for a program of this scope and in a landscape of this complexity establishing priorities for important outcomes should be considered within the research design. In the simplest terms they could be assigned as evidence that relates to state significance or questions that address local significance. While it is a workable approach, and needs to be a consideration, it may reduce the interpretation of the salvaged evidence to not much more than a catalogue of chronologically related elements.

The excavation and documentation will need to incorporate a more holistic objective. An obvious example is the identification of the pre-settlement environment and an exploration of how this shaped the earliest settlement. This would be followed by an examination of how the modified environment influenced more developed occupation and the appreciation and value placed on that cultural landscape.

Effectively this might not have any direct influence on the excavation strategy but understanding the excavation as a means of recording more than a series of sites of particular periods would be fundamental to this program. This also has important implications as well, for how the three strands of archaeology will be integrated. This aspect of the program should also involve the community. Archaeologists and historians approaching a program of this type will have very specific issues that are related to their fields of research. The community in which this program will be undertaken may have a very different set of questions or issues and the development of the research design should allow for community participation to enable the outcomes of the program to have both scientific and “popular” components. The community must have some ownership of this work.

7.2.2 Direct Community Involvement

Community participation in development of the program is important and there should be opportunities for the community to have an involvement in the work as it is carried out. Excavation is not an option; issues of professional outcomes and safety would be compromised. However, there are other aspects of the work that could benefit from direct involvement. Artefact programs have been used successfully in the past to this end. There are other options that might be considered; carefully trained and informed community guides or “explainers” might be one option. Possibly instead of one or two open days during the course of the program an hour or two each week could be set aside for public viewing.

A number of options should be canvassed in the research design; they will need to be discussed with RMS with regard to safety and other issues before a final program is settled.

7.2.3 Information Exchange

An archaeological program of this type would attract a lot of attention, not just from the local community. Strategies should be put in place to allow information to be regularly accessible for any interested party. Options could include daily update boards on the fences around the site, a dedicated web-page or one associated with the RMS web-site, a small column for the local newspaper and hand-out leaflets amongst others.

7.3 Long Term Outcomes

The first outcome of any program will be the retrieval of information. The second outcome will be reports that document that information and interpret it in terms of the research objectives and historical framework. Longer term objectives need to be considered; some options could include publications, displays in the museum and an outdoor museum component of the parkland.

7.4 Project Integration

A fundamental component of the research design must be to discuss with the Alliance the practical issues of how the archaeological program will work within and next to the construction program. This is a discussion that needs to canvas issues including the size of archaeological zones to be excavated within the overall option areas, the timeline of these excavations and issues of spoil removal or relocation amongst others. This issue also needs to address the timeline and integration of the three strands of archeology with each other as well as the construction program.

7.5 Conservation

At the finest level on site conservation, processing and storage of artefacts that come from any excavation will need to be addressed; consideration might be given to developing a program with the museum that enables this work to be undertaken as a public “display” during the course of the work.

More complex issues of conservation need to be addressed in the event that a substantial and significant structural component is revealed by the work, for example, the 1815 drain. There must be a clear policy in place for this situation but flexibility needs to be allowed in case some components can be maintained in situ.

Consideration also needs to be given to removal of components for relocation or use in future displays and their interim conservation needs.

8 References

Biosis Pty Ltd and CRM, *Windsor Bridge Replacement Project: Historic Heritage Assessment & Statement of Heritage Impact*, November 2012

Cosmos Archaeology Pty Ltd, *Maritime Archaeological Statement of Heritage Impact: Final Working Paper Report*, October 2012.

Kelleher Nightingale Consulting Pty Ltd, *Windsor Bridge Replacement Project Cultural Heritage Assessment Report*. September 2012.

Appendix G - Technical investigations of the structural condition of Windsor Bridge

Windsor Bridge structural condition

The following is a detailed chronology of the key technical investigations related to structural condition that were undertaken for Windsor Bridge between 2003 and 2013.

The information provides a description of the investigations undertaken, the findings of the investigations, and the decisions made on the basis of these findings. These numerous reports and studies on the existing bridge include investigations to determine:

- The realistic load capacity of the bridge.
- The condition state of the bridge superstructure, in particular, the extent of carbonation of concrete and corrosion of steel along with short term and long term repair options.
- The condition of the cast iron piers and extent of their graphitisation.
- The rehabilitation options to restore the substructure capacity.
- Repair cost estimate and Life Cycle Cost Analysis (LCCA) of various rehabilitation options for the bridge to carry current legal loads.

Each report is discussed in order below. For completeness, the date during which wider community consultation was undertaken on alternative options is also included in the chronology.

The findings of these investigations led to conclusions about the deteriorating condition of Windsor Bridge.

Durability Condition Assessment – October 2003 by GHD

The purpose of the durability condition assessment was to map the defects of the bridge and recommend repair methodologies.

The assessment included a visual inspection of the above water elements of the bridge and using a boat for the underbridge elements. A delamination survey of approximately 30 per cent of the bridge beams and headstock was undertaken using a cherry picker mounted on a barge. Diagnostic testing was undertaken at three detailed areas and included a cover meter survey, depth of carbonation measurements, chloride content analysis, alkali silica reactivity (ASR) testing, reinforcement thickness measurements and concrete compressive strength testing.

Three options to remediate the identified defects were assessed.

- Conventional patch repair
- Realkalisation
- Cathodic protection

The condition assessment identified significant visible spalling on the soffits of the external beams concentrated around drainage hole locations. It also identified regular vertical cracking at stirrup locations on the majority of the beams, significant quantity of horizontal cracking at the level of the longitudinal reinforcement and diagonal cracking at the end of beams radiating from dowel supports.

Approximately 250m² of the bridge surface area was spalled, delaminated or cracked. The investigation also showed that exposed primary longitudinal reinforcement exhibits significant section loss for the external beams near the drainage holes.

Carbonation (concrete cancer) was identified as the deterioration mechanism with the average carbonation depth exceeding the minimum concrete cover. The report found that damage is likely to increase with time as the carbonation front advances.

The assessment recommended re-alkalisation as the most technically appropriate repair method for the bridge. This was considered to be the most cost effective repair option over a future service life of 25 years.

The report further recommended that, prior to final selection of the repair option, a life cycle cost analysis for the repairs should be undertaken so that the most appropriate repair option may be chosen on both a technical and economic basis.

The preferred remedial option should be implemented as soon as practical.

Inspection & Assessment Report – December 2003 by RMS Bridge Assessment and Evaluation Section (BAE)

This inspection and assessment report detailed the findings of a detailed “Level 3” visual inspection of the above water components of the bridge to assess the condition of the bridge.

It assessed the load carrying capacity of the bridge elements using analytical methods based on original bridge drawings (“as new” rating) and the impacts on the load carrying capacity due to deterioration of the elements (“as is” rating)

A visual inspection of the above water elements of the bridges was undertaken to record, cracks, settlements, movements, deformation, defects and corrosion, which could impact on the load carrying capacity of the bridge. Observation of the bridge under normal traffic loading was also undertaken, as well as analytical assessment of the bridges for “as new” and “as is” condition of the materials.

The report also drew on the specialist materials engineering consultant findings (GHD, 2003 above) for the durability condition assessment.

The structure was assessed to be in poor condition in view of the extensive spalling due to carbonation of the concrete in the longitudinal beams and headstocks. The report advised that the structure requires extensive repairs, as also identified in the inspection and durability reports.

The report also considered live load factors. The “as new” rating live load factor (LLF) for current semi trailer and B-doubles vehicles was 1.87 which is less than a value of 2.0 required by current design standard AS5100.7. Furthermore, the “as is” rating was found to be around 1.5 which is significantly less than the 2.0 required by the standards.

Options considered to address the poor condition of the bridge included:

- Replacement of the existing bridge with a new bridge
- Provision of new bridge deck on existing piers pending inspection and assessment of the bridge piers
- Re-alkalisation and other repair works of bridge superstructure as recommended by GHD in their durability report

The recommendation of the report was to replace the bridge within five years. It also recommended that remedial works be carried out to prevent further deterioration, as

identified in the inspection, and underwater inspection of the piles and piers be undertaken to determine the nature of damage if any.

Repair Cost Estimate and Life Cycle Cost Analysis – February 2005 by GHD

This analysis was undertaken to provide cost estimates for two scenarios including ongoing maintenance commitments:

- A short term solution that comprises repairs needed to operate the bridge for five years
- A long term solution to operate the bridge for more than 25 years

The analysis involved the preparation of cost estimates, including life cycle cost analyses, for repairing the bridge in its entirety. Two repair options were identified for consideration to address the two scenarios above:

- Patch repair and coat the identified defects
- Application of re-alkalisation repair techniques to beams and headstocks, and patch repair and coat to other defects

As discussed above, service lives of five years and 25 years were considered. The five year option assumed the bridge would be replaced. The cost estimate assumed the cast iron piers are in good condition from above water inspections and only required repainting.

The life cycle cost estimates for the two repair options for a 25 year service life *in 2005 dollars* were found to be

- Option 1 - conventional patch repair around \$4.1 to \$5.3m
- Option 2 - re-alkalisation around \$2.9m.

The report noted that these repair works would only restore the bridge to its original “as new” rating that is less than current design standards. Strengthening would be required to meet current design standards.

The report recommended further underwater inspections to assess the condition of the cast iron piers below water.

Underwater Graphitisation Survey – April 2005 by CTI Consultants Pty Ltd

As recommended by the GHD (2005) study above, this survey involved an investigation of four bridge piers with an emphasis to determine the condition of the immersed section and on determining the extent of graphitisation. Graphitisation is a deterioration mechanism of cast iron that has similarities to rusting in steel.

Above water inspections involved cleaning of the cast iron surface, ultra sonic wall thickness measurements and the taking of small 10mm diameter core samples of the cast iron.

The underwater work involved a visual inspection, sampling of marine growth layers and cast iron nodules for laboratory inspections. The surface was then cleaned and re-inspected and localised “plug defects” depths were measured using a pin profile gauge. Small diameter core samples were taken at selected locations to establish residual wall thickness.

Five of the core samples were analysed to determine the metallurgical properties of the cast iron.

The investigation identified significant uniform (layer) graphitisation up to 13mm and localised plug graphitisation up to 28mm depth during the inspections. The original wall thickness of the immersed cast iron piers was 40mm. The above water sections of the cast iron was reported to be in good condition, with minor localised defects. Bracing between the piers at the water line was shown to be undergoing significant corrosion

Due to the significant section loss of the cast iron casing a structural assessment of the piers was recommended to determine current capacity.

If the piers were found to be structurally adequate, installation of cathodic protection to prevent further graphitisation was identified as necessary to be considered. If strengthening was required, strengthening of the piers using concrete sleeves or other methods to restore capacity will be required.

The report further recommended that a structural assessment of the piers be undertaken to determine current capacity, taking into account the significant section loss due to graphitisation in the below water sections of the cast iron piers.

Report on Rehabilitation of Windsor Bridge – May 2005 RTA Bridge Rehabilitation Projects Section

The purpose of this report was to develop concepts and costing for a long term solution to rehabilitate the bridge, including strengthening of the bridge to meet a minimum T44 design standard capacity.

The report involved modelling of the bridge structure using analysis software. Three strengthening options were developed for the deck as follows:

- Installing steel girders
- External post tensioning
- Carbon Fibre Strengthening

An assessment of structural capacity (rating) of the substructure was based on the condition of the cast iron piers from the findings of the CTI underwater inspection (April 2005), discussed above. Strengthening options were identified for the cast iron piers along with cost estimates.

The cost estimates for the three deck strengthening options (in 2005 dollars) were estimated to be around \$7.67m to install steel girders and \$7.26m for external post tensioning. The carbon fibre strengthening approach was not considered viable at that time due to the extent of carbonation identified in the cover concrete. An allowance of \$3.6m was made for strengthening the cast iron piers based on similar types of work.

The report concluded that the cost of rehabilitating and strengthening the existing substandard bridge to meet T44 minimum design standard was extremely high and not cost effective and safe. This was due primarily to the very poor condition of the bridge, narrow width and poor alignment. Therefore, it was recommended that the bridge be replaced with a new bridge within five years.

In the interim it was necessary to closely monitor the bridge for propagation of cracks, further concrete deterioration, adverse movement or excessive deflection until the bridge is replaced. Quarterly monitoring of the bridge deck levels was also identified to detect any movements.

The report also identified the need to record actual stresses in the bridge beam using strain gauges to establish actual live load factors under current traffic

Performance Load Testing of Windsor Bridge – August 2006 RTA Bridge Assessments and Evaluation Section

The performance load testing of Windsor Bridge was undertaken to determine the live load factor for the deck using performance load testing for comparison against earlier calculated values. It also determined the dynamic load allowance for a fully laden semi trailer.

The investigation involved recording the strains in the reinforced concrete bridge beams under different loading configurations of the test truck by fixing strain gauges at the middle of each deck beam in spans 4 and 5 of the bridge. The bridge was closed to traffic and the test truck was taken across the spans at crawl speed in both directions. Strain gauge readings were recorded for three configurations of the test truck:

- Level 3 – 43.14 tonne gross vehicle mass (GVM) semi trailer (ST).
- Level 4 – 46.34 tonne GVM.
- Level 5 – 49.54 tonne GVM.

The recorded strain was compared against the calculated values for each.

The dynamic load testing consisted of travelling the Level 3, 43.14 tonne configuration of the test truck over the bridge at speeds up to 60km/h in 10km/h increments and recording the results. The results were compared against the calculated values. The strains were also recorded in the gauges over a one week period with the bridge open to normal traffic.

The findings from load testing were:

- The strains on the concrete beams were less than calculated for the three test truck configurations at crawl speed.
- The recorded dynamic load allowance (DLA) was 17% for the test truck travelling in southbound at a speed of 40km/h. This is less than value of 40% from the design standards.

The report concluded that the bridge in 'as is condition' is capable of carrying General Access Vehicle (semi-trailer) ST42.5 and Restricted Access Vehicle (B-doubles) BD62.5 in the short-term until the planned replacement of the bridge provided that a risk management strategy to monitor the performance and condition of the bridge is in place.

Internal RMS Memo: Review of all past reports to extend the life of structure – April 2008 RTA Bridge Assessment and Evaluation

A high level review was undertaken of previous studies to assess the safe capacity and remaining life of the structure. All previous studies and condition reports were reviewed.

The review delivered the following conclusions:

- General Access Vehicle (semi trailer) ST42.5 and Restricted Access Vehicle (B-Double) BD62.5 would be allowed to continue travelling across the bridge in the short-term until the planned bridge replacement.
- The bridge must be closely monitored for propagation of cracks, further concrete deterioration and any adverse movement of piers.

As a result, the decision was made to allow General Access Vehicle (semi-trailers) ST42.5 and Restricted Access Vehicle (B-Doubles) BD62.5 to continue to cross the bridge subject to the following:

- The bridge must be closely monitored for propagation of cracks, further concrete deterioration and any adverse movement of piers until bridge replacement in 2010.
- Measures should be taken to ensure that over mass and oversized vehicles do not cross the bridge.

Community consultation report and options assessment RMS 2008 to November 2011

In 2008 the project received broader consideration within RMS. At around the same time, the NSW Government announced that it would provide funding to rehabilitate or replace the bridge, identifying four alternatives for the river crossing at Windsor including:

- Do nothing and continue to maintain the existing bridge – This option would involve doing nothing except continuing the ongoing regular maintenance of the existing Windsor Bridge.
- Refurbishment of the existing bridge – this alternative would involve temporarily closing the existing bridge and refurbishing elements of the bridge and approach roads to meet current design standards where possible.
- Bypass of Windsor – this alternative would involve constructing one or more bridges and associated roads to bypass the town centre of Windsor.
- Replacement bridge – this alternative would involve constructing a replacement bridge either up or downstream of the existing bridge, with traffic still being able to access the town centre directly.

RMS subsequently began investigating potential route options and, in July 2009, ten potential options were identified: two for refurbishment of the existing bridge, two for a bypass of Windsor and six for a replacement bridge. While two bypass options were identified, it was recognised that a bypass would substantially exceed the project budget. However bypass options were further developed to provide a comparison to other alternatives.

A detailed options assessment report was prepared by RMS (available on the RMS website), which presented information on the location, performance, potential environmental impacts and costs/benefits of each option. Project objectives and criteria were also developed to allow an assessment of each of the options.

In 2011 the options assessment report was presented to the community, stakeholder groups and government agencies and their feedback on the options was obtained. The issues raised during the consultation process were documented in Chapter 6, the “Windsor Bridge over the Hawkesbury River Options Report” (RTA, 2011) and the “Windsor Bridge over the Hawkesbury River Report on Community Consultation” (RTA, 2009), which are available on the RMS website (www.rms.nsw.gov.au/roadprojects).

The Heritage Council of NSW was consulted in 2009 and identified refurbishment of the existing bridge as its preferred option. Their second preferences were the bypass options of Windsor. They also recommended that detailed heritage investigations and a Statement of Heritage Impact would be required especially for those options that impacted Thompson Square.

Based upon feedback from the consultation process on the options, RMS short-listed and further developed three options, namely:

- Option 1 - Replacement high-level bridge via Old Bridge Street, Windsor.
- Option 2 - Replacement low-level bridge via Old Bridge Street, Windsor.
- Option 6 - Bypass of Windsor via a new bridge parallel to Palmer Street, Windsor and a new bridge over South Creek.

Additional preliminary investigations were undertaken to assess the relative advantages and disadvantages of each short-listed option, how each option performed against the project objectives and to identify opportunities to improve project outcomes. The results of preliminary investigations were used in the development and refinement of short-listed project options and ultimately in the selection of the preferred option for the project.

The preliminary investigations considered potential adverse impacts and benefits in relation to historic heritage, Aboriginal heritage, traffic and transport, landscape and town character, and socio-economic outcomes. Construction impacts and costs were also considered.

Rehabilitation Estimate – December 2009 by GHD

The purpose of this engagement was to prepare an updated cost estimate for the rehabilitation of the bridge. The cost estimate is to include the ongoing maintenance commitments for a 25 year period.

The work follows on from earlier work undertaken by GHD in 2005.

It involved the preparation of cost estimates including life cycle cost analyses for repairing the bridge in its entirety. The following three repair options were considered:

- Option 1 - Patch repair and coat the identified defects
- Option 2 - Application of re-alkalisation repair techniques to beams and headstocks, and patch repair and coat to other defects
- Option 3 - Cathodic protection and patch repairs.

It is noted that these repair options would only restore the bridge to its original “as new” rating that is less than current design standards. Strengthening to meet current T44 design standards was not included in the scope for this report and would cost significantly more.

The life cycle cost estimates for the three repair options for a 25 year service life in 2009 dollars were found to be around \$5.45 to \$6.43m for Option 1, \$4.36m for Option 2 and \$5.1m for Option 3.

The cost to repair the bridge in its current working condition for a five year life prior to replacement was estimated to be \$0.3m. It was noted that the cost estimate assumed the cast iron piers would not require strengthening and only allowed for repainting costs.

Review of Rehabilitation Estimate – January 2010 by RMS Bridge Technology and Practice

This involved a review of the GHD 2009 cost estimate for the rehabilitation of the bridge, including a review and update of the previous rehabilitation 25 year life cycle cost estimate for the three methods of repairs considered in the 2009 GHD report, namely:

- Option 1 - Patch repair and coat the identified defects
- Option 2 - Application of re-alkalisation repair techniques to beams and headstocks, and patch repair and coat to other defects
- Option 3 - Cathodic protection and patch repairs.

The review utilised cost rates obtained from recent similar rehabilitation projects undertaken by RMS.

The revised cost life cycle cost estimate over a 25 year period from this review in (2009 dollars) for the rehabilitation of the bridge deck to maintain current “as is” load rating were identified as \$2.89m to \$3.77m for the conventional patch repair and \$2.71m for re-alkalisation. Cathodic protection was not considered as previous cost estimates showed cathodic protection is more expensive than re-alkalisation.

Despite the higher costs, the review recommended conventional patch repair as a lower risk option due to the limited local experience with re-alkalisation within both the contracting and consulting sector in Australia.

The review recommended that in order to maintain the bridge deck in a serviceable condition for the next 25 years, the concrete elements that are suffering from corrosion induced deterioration should be rehabilitated by convention patch repair and coating application. The patch repairs should incorporate the installation of sacrificial zinc anodes.

Internal RMS Memo: Estimate for Windsor Bridge for Pedestrian Usage – February 2010 RTA Bridge Rehabilitation Projects Section

This involved preparation of a cost estimate for the rehabilitation of the bridge for pedestrian usage only.

The rehabilitation was aimed at reducing long term maintenance requirements given the current “as is” condition of the bridge is adequate for pedestrian loading. Under this approach the existing low level railing would need to be replaced with a pedestrian railing.

The cost of rehabilitating the bridge superstructure was estimated (2010 dollars) to be \$7m. The indicative cost to rehabilitating the substructure was estimated (2010 dollars) to be \$5m based on similar previous projects

The investigation concluded that further detailed investigation of the cast iron piers is required to understand the extent of deterioration due to graphitisation to confirm the scope of work required to rehabilitate the cast iron piers.

Dynamic Load Testing of Spans 1 to 4 – November 2010 UTS

In this investigation UTS undertook a dynamic frequency analysis (DFA) on span 1 to 4 of the existing bridge to assess the natural frequency and stiffness of the representative spans.

This involved attaching sensors to the bridge and striking the bridge with a modally tuned hammer. The signals picked up by the sensors are then processed to establish the modal analysis. This information is then used to establish the natural frequency, damping ratio and mode shapes. These results can then be compared against theoretical results from finite analysis modelling. The difference in the results can then be used to assess the impacts of deterioration of the bridge and its impact on the load carrying capacity of the bridge.

The test results indicated there has been a reduction in the stiffness of the span 1 of the deck by 16 per cent over the past seven years indicating a continuing deterioration of the deck. The natural frequency recorded for span 2 was similar to span 1. The results for span 3 and 4 were approximately 10 per cent less than the recorded results for span 1 and 2. These results are consistent with the visual inspections that show span 1 and 2 are in better condition than spans 3 and 4.

The investigation concluded that if RMS intends to decommission the bridge in the near future, the bridge in its present condition and loading would be safe for some time. However, if the RTA intends to maintain the bridge, further testing and employing parallel finite element analysis is recommended to translate this deterioration into a quantifiable load limit.

Graphitisation Investigation – July 2011 CTI Consultants Pty Ltd

In this investigation CTI Consultants undertook a detailed underwater graphitisation study for all piers to gain a thorough understanding of the extent of graphitisation of the cast iron piers. Commercial Diving Solutions undertook the underwater inspection and sampling under the supervision of CTI and RMS.

The underwater inspection involved cleaning, visual inspection and measurement of the extent of damage due to graphitisation to establish remaining structural cast iron thickness. The surface was cleaned using scraping and high pressure water. The cleaned areas were explored to identify the extent of graphitisation and measured using a pin profile gauge and photographed.

Small diameter (20mm) core samples were taken at selected locations to allow the residual wall thickness to be measured directly. One core sample taken from near the river bed at pier 5 was examined metallurgically for comparison with the samples analysed in the 2005 survey. Three water samples at different depths were also taken for chloride analysis.

The inspection identified that there is significant graphitisation evident in all piers. There are a significant number of locations with more than 20mm of graphitised material present resulting in an average residual structural thickness of 15mm (over 50 per cent loss of section).

The inspection also identified a full circumferential crack in the upstream and downstream columns at pier 5. A three quarter circumferential crack was identified in the downstream column of pier 6. A 100mm long vertical crack was also identified in the upstream column of pier 5.

The water samples indicated a low chloride content indicating the water is essentially fresh water with a low hardness (soft). While Commercial Diving Solutions provided a separate inspection report the key elements and photographs of the inspection report were included in the CTI report.

Horizontal cracking was identified in three of the cast iron columns and the cracks appear to be quite old. Nevertheless, the investigation concluded that such cracks would be expected to have a serious impact on the overall serviceability of the bridge, and a detailed structural analysis should be carried out to determine the probable impact on the bridge's capacity

Underwater Bridge Inspection, Follow up inspection June 2011, Commercial Diving Solutions

This assessment formed part of the assessment of Higher Mass Limit vehicles discussed below. It involved inspection of piers 5 and 6 of the existing bridge following the performance load tests undertaken in June 2011.

Twelve glass plate slides were installed across the circumferential cracks at pier 5 and 6 to identify if there is any movement of the cracks under existing traffic. Underwater inspection of the previously identified circumferential and vertical cracks at pier 5 and 6 was also undertaken. The installation of glass plate slides involved the cleaning of the cast iron surface adjacent to the crack to remove any soft graphitised material and gluing the 75x20x1mm glass plates to either side of the crack using a two part epoxy adhesive.

The inspection of the cracks following the load testing found no evidence that the existing circumferential cracks in the cast iron columns at pier 5 and pier 6 have changed, widened or shifted.

There was no evidence that the small vertical crack in pier 5 upstream had changed. The 12 glass slides were installed and the position of the slide recorded and photographed.

The glass slides on Piers 5 and 6 were inspected in June 2012 and found to be cracked at Pier 5 Upstream and Pier 6 Downstream.

Bridge over Hawkesbury River Load Testing Test Report – October 2012 Endurance Consulting

This inspection was also considered as part of the Higher Mass Limit assessment discussed below. It involved performance load testing of the cast iron piers for static loading (test truck), and measurement of ambient traffic (dynamic testing) for a minimum period of six months. A longitudinal braking test was also conducted to assess how the horizontal forces due to heavy vehicle braking abruptly on the bridge are transferred in to the cast iron piers.

Strain gauges were fixed to the both cast irons columns of piers for piers 4 to 7 just above the water level. Gauges were also fixed to pier 4 and 6 just above the riverbed level. The gauges were fixed to both sides of the columns to be able to measure bending strain (due to braking) as well compressive strains due to vertical loads.

A “dynamic displacement transducer” was installed across the joint at pier 4 to record relative movement of adjacent spans under the braking test loads. For the static load test, three configurations of the test truck were used:

- 42.4 tonne gross vehicle mass (GVM) semi trailer (ST).
- 47.4 tonne GVM.
- 52.4 tonne GVM.

The test report made the following findings:

- All strain gauges experienced compression under loading in all tests.
- Flexural strain was not the dominant strain in the braking load test indicating the horizontal forces are being shared amongst all piers and therefore to the abutments.
- There was no evidence of opening of the expansion joints under the braking load test indicating the deck is “locked up” via the dowel connection between the deck units and the headstock of the foundation. This behaviour is not consistent with the expected behaviour and may explain the cause of the diagonal cracks in the beams near each support location.
- Strain gauge recording from the ambient traffic monitoring recorded strains in the piers higher than the results from the ST42.4 tonne test vehicle (semi trailer) configuration.

RMS Bridge Evaluation and Assessment assessed the results as part of the assessment of Higher Mass Limit vehicles discussed below.

RMS Report – Assessment of Higher Mass Limit Vehicles Performance Load Testing & Investigation of Deck & Pier (2011 & 2012) Report – February 2013
RMS Bridge Assessment and Evaluation

This report drew on earlier findings to undertake an assessment to determine:

- The load capacity of the bridge.
- Extent of graphitisation of cast iron piers.
- Performance of the bridge to RMS test truck and ambient traffic.

It also involved undertaking the graphitisation study by CTI Consultants, load testing and load rating by RMS.

The review recommended allowing Higher Mass Limit (HML) ST45.5t and BD68t in the short-term until the planned replacement of the bridge subject to the following stringent management practices:

- Monitoring the graphitisation of pier columns.
- Monitoring the bridge deck where spans are in poor condition
- Remove any spalled concrete which could be a danger to public.
- Speed limit for heavy vehicles of 40 kilometres per hour